



**BHARATI VIDYAPEETH
(DEEMED TO BE UNIVERSITY), PUNE**

**FACULTY OF SCIENCE
M.Sc - Environment Science and Technology
New Syllabus**



BHARATI VIDYAPEETH
(DEEMED TO BE UNIVERSITY)
INSTITUTE OF ENVIRONMENT EDUCATION AND RESEARCH, PUNE
Faculty of Science

M.Sc (Environment Science and Technology)

Semester I, II, III, IV
effective from 2019-20



**BHARATI VIDYAPEETH (DEEMED TO BE) UNIVERSITY,
PUNE**

**Syllabus for
MASTER OF SCIENCE
M.Sc. in ENVIRONMENT SCIENCE AND TECHNOLOGY
Under
FACULTY OF SCIENCE**

**Course Structure and Detailed Syllabus
Semester I, II, III and IV
(UNDER CHOICE BASED CREDIT SYSTEM)
Effective from the Academic Year 2019-2020**

This document provides details of the rules and regulations, examination pattern and course details. Students are advised to read it carefully and refer to it from time to time during the course of their study at the Institute of Environment Education and Research, Bharati Vidyapeeth (Deemed to be) University, Pune.

The Bharati Vidyapeeth (Deemed to be) University is a multidisciplinary, multicampus University having 32 institutions imparting quality education in various disciplines. All programs of the University are approved by the University Grants Commission (UGC) and the respective statutory councils. The University has been re-accredited for the third time with an 'A+' grade by the National Assessment and Accreditation Council (NAAC) in 2017. The UGC has accorded the 12B status (UGC Act 1956) to the University. The Ministry of Human Resource Development, Government of India has awarded 'A' category to the University in 2012 based on several parameters that include innovative programs, research and infrastructure facilities. The University has maintained its rank in the top hundred universities of India consistently since 2012 and is presently ranked at 76th position by the National Institution Ranking Framework (NIRF) by the UGC for the year 2020.

The University is a member of the Association of Indian Universities (AIU) and also the International Association of Universities.

The Institute of Environment Education and Research of the Bharati Vidyapeeth (Deemed to be) University, is a constituent unit of the University established in 1993. The Institute is approved by the UGC to conduct post graduate courses in Environment Science, Geoinformatics and Wildlife Conservation Action as well as Doctoral programs in Environment Science and Geoinformatics. The Institute has excellent infrastructure and competent faculty who are nationally and internationally known. Through its collaborations with several international universities and organizations the Institute offers international student and faculty exchange programs as well as international internships.

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BHARATI VIDYAPEETH (DEEMED TO BE) UNIVERSITY, PUNE

FACULTY OF SCIENCE

Course Structure of Master of Science M.Sc. in Environment Science and Technology (Under Choice Based Credit System) effective from 2019-2020

INTRODUCTION

The course has a transdisciplinary approach that integrates the science of environmental studies with technical and social issues and includes courses on ecosystem studies, biodiversity conservation, natural resource management, geoinformatics, water and waste water engineering, green technology, environmental lab techniques, sustainable development, urban sustainability and environment and health. The course builds on a candidate's knowledge of chemistry, biology, statistics, computers, engineering, sociology and economics to develop a deeper understanding of applications in the environmental sector. It includes the cognitive aspects and technological skills necessary to further sustainable form of development and rational resource-use management. It trains the candidate in advanced laboratory skills required for pollution monitoring and abatement, to undertake environmental impact assessment(EIA), ecodevelopment, ecorestoration, implement green technology, assess biodiversity, etc. The program addresses environment management from the technical, social as well as the policy aspect to counter the effects of degradation of the ecosystem.

OUTCOMES

At the end of the course, each student will have acquired the following attributes;

1. Disciplinary Knowledge and Interdisciplinarity

Demonstrate disciplinary knowledge from ecological, social, physical, economic, legal fields; Appreciate the ethical, cross cultural and historical context of environmental issues and the links between human and natural systems; Apply systems concepts and methodologies to analyze and understand interactions between social and environmental processes; Demonstrate appropriate and advanced technical skills in investigating, analyzing and synthesizing information, problems, concepts and theories within environment science.

2. Quantitative Competence

Understand and apply essential mathematical and statistical approaches used to analyse environmental data; Accurately comprehend and draw appropriate inferences from numeric data, statistical analysis and predictive models; Use state-of-the-art software, hardware and analytical techniques to solve problems in environment science and management

3. Critical Thinking

Demonstrate the capability to apply analytic thought to a body of knowledge; analyse and evaluate evidence, arguments, claims and beliefs on the basis of empirical evidence; formulate coherent arguments; critically evaluate practices, policies and theories following the scientific approach to knowledge development.

4. Problem Solving

Identify environmental problems, evaluate problem solving strategies and develop science based solutions; understand the need to integrate relevant social sciences (eg: environmental planning, law, economics) in environmental problem solving; Use acquired knowledge, skills and ingenuity to solve complex problems.

5. Communication

Clearly communicate complex analyses, interpretations and significance effectively in writing and orally to varied audiences ranging from scientific to policy and the general public; be proficient in contemporary communication tools

6. Multicultural competence

Possess knowledge of the values and beliefs of multiple cultures and a global perspective; capability to effectively engage in a multicultural society and interact respectfully with diverse groups.

7. Moral and ethical awareness/reasoning

Identify ethical issues related to one's work; formulate a position/argument about an ethical issue from multiple perspectives and use ethical practices in their life and career; avoid unethical behavior; adopting objective, unbiased and truthful actions in all aspects of work.

5. Collaboration and Team work

Collaborate in teams with peers and mentors and work with others in diverse group settings, developing flexibility and leadership skills.

6. Lifelong learning

Ability to acquire knowledge and skills, including 'learning how to learn' for meeting changing demands of work place.

SCOPE

Contrary to the popular belief that 'green jobs' exist in specific sectors, green jobs today are found in all sectors as a large number of industries and organizations have today committed or make commitments to sustainability. These jobs have emerged in favor of greener, cleaner and more sustainable occupations. The UNEP Report on green jobs shows that green jobs are being generated in some sectors and economies largely resulting from the need to meet emission reduction targets. This has led to changing patterns of investment flows. Employment opportunities exist in diverse fields such as in government agencies, industries, manufacturing, energy, food, recycling, agriculture, business, policy, construction, forestry and conservation sectors all of which offer immense opportunities to environmental professionals.

The pace of green job creation is accelerating today. A global transition to a low-carbon and sustainable economy has already created a large numbers of green jobs across many sectors of the economy, and has indeed become an engine of development.

Climate deals are also supporting payments to countries for managing forests for their carbon absorption potential opening up new opportunities for green jobs in the forestry sector of the tropics. An agreement by 2010 under the Convention on Biological Diversity on Access and Benefit Sharing of Genetic Resources has triggered similar North-South funding flows with job implications in conservation and natural resource management.

The job profiles in green careers are as diverse as the problems they address. A degree in Environment Sciences definitely sets the pace in building a green career. One can be a researcher, a designer, a planner, an operator of pollution control facilities, a professor, a government regulatory agency official, a manager of programs, or be involved in professional society work. Potential employers can be private consulting engineering firms, universities, private research firms, testing laboratories, government agencies at different levels, or all types of major corporations and private businesses.

ELIGIBILITY FOR ADMISSION TO THE COURSE

Candidates satisfying the following criteria are eligible to apply for the M.Sc. Environment Science and Technology course.

- a. The candidate should have passed the Bachelor's degree in any Science subject such as Botany, Zoology, Chemistry, Physics, Statistics, Geography, Geology, Life Sciences, Environment Sciences, Microbiology, Biotechnology, Fisheries, Marine Biology, Horticulture,

- Agriculture, Computer Science, Data Science, Veterinary Science, Health Sciences or
- b. any branch of Engineering
- c. any relevant Social Science subjects and Management Studies
- d. The candidate should have secured at least 50% or 45 % aggregate marks for open and SC/ST/OBC category respectively at the graduate level.

DURATION OF THE COURSE

The duration of this course is two years consisting of four semesters. The medium of instructions and examination will be only English.

RULES AND REGULATIONS

1. **Commencement and Conclusion:** The University authorities shall determine the dates for the commencement and conclusion of each semester. Only duly admitted students can keep the terms. Each semester is of 14 weeks duration. Students must check the academic calendar for exact dates of commencement and conclusion.
2. **Credits:** The entire Course is of 107 credits and will be executed in 4 semesters. 22 and 28 credits are offered in Semester I and II respectively while 31 and 26 credits are offered in Semester III and IV.
One credit for the theory course is equivalent to 15 hours of interaction of student with facilitator, while one credit for the practical course is equivalent to 30 hours of practical work or 30 hours of field work.
3. The curriculum comprises of Core (Hard and Soft) and Value Added Courses. All Core courses are compulsory while the Value Added Courses are elective.
4. The Core courses are aimed at providing fundamental knowledge and skills relevant to the discipline while the Value Added Courses intend to develop relevant skills.
5. The respective elective course will be implemented only if atleast seven students enroll in the course.
6. Some of the core courses are common in the three Master's programmes: M.Sc. Environment Science and Technology, M.Sc. Geoinformatics, M.Sc. Wildlife Conservation Action.
7. The teaching and evaluation for these courses will be combined for both disciplines.
8. All hard core courses will be evaluated by the University Examination.
9. Four extra credit will be awarded to the student if there is any significant outcome (paper in Scopus or Web Of Science) indexed journals. The research outcome in terms of publication in indexed national / international journal; filing of patent will be considered for the award of credits.
10. The number of students for each elective should not be less than five.

11. **Dissertation:** The student will undertake dissertation in Semester III and continue the same in Semester IV for which 24 credits have been allotted. The topic for the research must be finalized by the end of Semester II after thorough literature review in consultation with your allotted guide.
12. **Field Work:** The fieldwork / industrial / academic Institute visits will be organized for demonstration of advance experimental techniques wherever necessary along with the courses. Attendance for these are mandatory and form part of internal assessment as indicated in the syllabus.
13. NSS Camps in the first year are mandatory as they provide a student with real life experiences of living in a village and understanding the problems faced therein.
14. **Internship:** The students may take up internship in the semester break between the second and the third semester to add to their work experience. While students are encouraged to take up short internship programs, these will not be assessed by the Institute and will not contribute to the overall credits. Formats of submission of internship report are attached in the relevant section of this document for reference.
15. **Attendance:** A student must attend every lecture, tutorial, and practical class. However, to account for late admission, sickness, or other such contingencies, the attendance requirement will be a minimum of 75% of the classes actually held. A student must have minimum 75% attendance in theory and 100% attendance in the practical courses to fulfill the term. A student who does not have the required attendance (less than 75%) will not be allowed to appear for the Continuous Assessment/ Term Examination.

A student with less than 75% attendance in a course during the semester, in lectures, tutorials, and practical's taken together (as applicable), will be debarred from taking the final test/examination in the course and will be awarded an Ab. grade.

If a student remains absent for more than 50 percent of the term due to illness as reported by a licensed medical practitioner, the student will have to repeat the term. Application for medical leave should be supported with test reports, hospitalization reports, prescriptions and certificate from a registered practitioner). The registration number of the medical practitioner should explicitly appear on the medical certificate. These will be reviewed by the management and it management retains the right to grant/ refuse the medical leave.

In order to maintain the attendance record of a particular course, course coordinators will record attendance in every scheduled lecture, tutorial, and practical class.

16. Leave Rules

Leave may be granted to students only in exceptional cases on approval of the Head of the Department/ Director. However, the period of leave would count as absence for the attendance requirements for a course.

A student must inform in writing/through an e-mail to the Course Coordinator with a copy to the administration office immediately of any instance of continuous absence from classes.

17. Maximum duration of the course

The student must complete all four semesters in a maximum of four years, failing which he/she will have to re-register for the course.

RULES FOR EXAMINATION

A. Nature of Examination

- i. Examination for the theory and practical courses will be conducted at the end of each respective semester or as continuous assessment as indicated in the syllabus.
- ii. Each course will have 40% marks for internal assessment and 60% marks for semester end examination.
- iii. The Internal Assessment (IA) will be conducted by the Institute and the end-of-the-term University Examination (UE) will be conducted by the University. The UE will be based on the entire syllabus. The internal assessment will be conducted throughout the semester in the form of tests/tutorials/seminars/oral presentations/assignments/debates, etc. as indicated in the syllabus.
- iv. Internal assessment for the practical course is through continuous assessment. Each practical is evaluated for fifteen marks. Of this, performance in the class is assessed for five marks and timely journal submission (within a week of the practical being conducted) as per instructions given by the concerned teacher is assessed for ten marks. The aggregate of the practical assessment will be averaged to 40 marks. Practical's missed by the student, need to be completed by the student themselves before appearing for the final examination.
- v. The general courses will be evaluated by the instructor on the basis of continuous assessment as indicated in the syllabus.

B. Ethical standards during the Examination

- i. The University maintains high ethical standards during examinations and there is a zero-tolerance policy in place regarding cheating and use of any unfair means in the examinations. The entire institution is under camera surveillance including classrooms and laboratories. Anyone found to be using unfair means will face a Disciplinary Committee immediately. Punishments for use of unfair means includes expulsion from the University.
- ii. The students shall occupy the seats allotted to them by the concerned Invigilator.
- iii. The student must be present inside the hall ten minutes before the commencement of the exam. Students coming late will be debarred from attending the examinations.
- iv. Students are not permitted to leave the examination hall during the examination period. However, in a very exceptional case, if the faculty invigilator allows such leave; a candidate not returning within 5 minutes shall be liable to cancellation of her/his paper.
- v. During the Continuous and University examinations, students are permitted to carry a transparent writing support pad, and a transparent pouch for pens, pencils, eraser. Calculator is permitted if needed. All books and notes, electronic gadgets including cell-phones, i-pads, i-pods, tablets, laptop, etc. must be deposited outside the classroom. Pockets must be empty during the exam.
- vi. Every candidate is expected to observe silence, decorum and abide by the instructions given by the faculty on invigilation during the examination.
- vii. Talking or discussing among themselves or sharing answers/hints in any form shall be punishable and will lead to disciplinary action.
- viii. Mobile phones are not allowed in the examination hall. Students have to switch off the mobile and submit it to the invigilator or put in the bags. Mobile phones should not be available with students or on their respective desk.
- ix. Internet access is not allowed during examination time.
- x. In addition to above, the students must adhere to any additional instructions from the supervisors from time to time.

STANDARD OF PASSING

A . Grading System

- i. A 10 point absolute grading system will be adapted for grading each head of passing. The details are given in the table below:

Table 1: The grading system under CBCS

Range of Marks (Out of 100)	Grade	Grade Point
$80 \leq \text{Marks} \leq 100$	O	10
$70 \leq \text{Marks} < 80$	A+	9
$60 \leq \text{Marks} < 70$	A	8
$55 \leq \text{Marks} < 60$	B+	7
$50 \leq \text{Marks} < 55$	B	6
$40 \leq \text{Marks} < 50$	C	5
Marks < 40	D	0

- ii. The grade point average (GPA) for a course shall be calculated by first finding the total marks out of 100 for the course. The corresponding GP (as per Table 2) shall be the GPA for the course.
- iii. Two kinds of performance indicators, namely the Semester grade Point Average (SGPA) and the Cumulative Grade Point Average (CGPA) shall be computed at the end of each term. The SGPA measures the cumulative performance of a learner in all the courses in a particular semester, while the CGPA measures the cumulative performance in all the courses up to and including the current semester. The CGPA of a student when he/she completes the programme is his/her final result.
- iv. The SGPA is calculated by the $\text{SGPA} = \frac{\sum C_k \times \text{GPA}_k}{\sum C_k}$ formula, where C_k is the credit value assigned to a course and GPA_k is the GPA obtained by the student in the course. In the above, the sum is taken over all the courses that the student has undertaken for the study during the semester, including those in which he/she might have failed or those for which he/she remained absent. The SGPA shall be calculated up to two decimal place accuracy.
- vi. The CGPA is calculated by the formula, $\text{CGPA} = \frac{\sum C_k \times \text{GPA}_k}{\sum C_k}$ where C_k is the credit value assigned to a course and GPA_k is the GPA obtained by the student in the course. In the above, the sum is taken over all the courses that the student has undertaken for the study from the time of his/her enrolment and also during the semester for which CGPA is
- vii.

calculated, including those in which he/she might have failed or those for which he/she remained absent. The CGPA shall be calculated upto two decimal place accuracy.

- viii. The CGPA, calculated after the minimum credits specified for the program are 'earned' and will be the final result. Grace marks of 1, 2 or 3 may be awarded to a candidate at UE as per the rules of the University.

B. Standards of Passing and ATKT Rules

- i. For all courses, both UE and IE constitute separate heads-of-passing (HoP). In order to pass in such courses and to 'earn' the assigned credits

The learner must obtain a minimum grade point of 5.0 (40% marks) at UE and also a minimum grade point of 5.0 (40% marks) at IA;

a. OR

If he / she fails in IA, the learner passes in the course provided he / she obtains a minimum of 25% in IA and GPA for the course is atleast 6.0 (50% in aggregate). The GPA for a course will be calculated only if the learner passes at the UE. The following examples illustrate this rule for passing in a course under.

- ii. A student who fails at UE in a course has to reappear only at UE as a backlog candidate and clear the HoP. Similarly, A student who fails in a course at IA has to reappear only at IA as a backlog candidate and clear the HoP.
- iii. A candidate shall be permitted to proceed further from the First Semester upto the Fourth Semester irrespective of his/her failure in any of the above semester examinations subject to the conditions that the candidates should register for all the backlog courses of the earlier semesters alongwith current (subsequent) semester courses.

Table 2: Illustration of Passing Rule specified

Case No.	UE Marks Out of 60	IA Marks Out of 40	Total Marks Out of 100	GP of UE	GP of IA	GPA	Remarks
1	24	16	40	5.0	5.0	5.0	Pass
2	40	10	50	7.0	0	6.0	Pass
3	40	06	46	7.0	0	5.0	Fails at IA
4	20	40	--	0	10.0	0	Fails at UE
5	34	12	46	7.0	0	5.0	Fails at IA
6	20	15	--	0	0	0	Fails at both UE & IA

C. Award of Honours

A student who has completed the minimum credits specified for the program shall be declared to have passed in the programme. The final result will be in terms of letter grade only and is based on the CGPA of all courses studied and passed. The criteria for the award of honours are given below.

Table 3: Criteria for the award of honours at the end of the program

Range of CGPA	Final Grade	Performance Descriptor	Equivalent Range of Marks (%)
$9.50 \leq \text{CGPA} \leq 10.00$	O	Outstanding	$80 \leq \text{Marks} \leq 100$
$9.00 \leq \text{CGPA} \leq 9.49$	A+	Excellent	$70 \leq \text{Marks} < 80$
$8.00 \leq \text{CGPA} \leq 8.99$	A	Very Good	$60 \leq \text{Marks} < 70$
$7.00 \leq \text{CGPA} \leq 7.99$	B+	Good	$55 \leq \text{Marks} < 60$
$6.00 \leq \text{CGPA} \leq 6.99$	B	Average	$50 \leq \text{Marks} < 55$
$5.00 \leq \text{CGPA} \leq 5.99$	C	Satisfactory	$40 \leq \text{Marks} < 50$
CGPA Below 5.00	F	Fail	Marks Below 40

PATTERN FOR ASSESSMENT

A. Pattern of Evaluation for Internal Assessment of Theory Courses

The weightage for Internal Assessment is 40%. Students of IA of every theory course will be assessed for a total of 40 marks for a 3 credit course for 20 marks for a 2 credit course which will be cumulative marks obtained in two/three separate assessments as specified in the individual course.

In case of hard core courses, the pattern will be as below:

- Two internal written examinations for 20 marks each for 3 credit courses. Average of the two tests will be considered.
- Two assignments of ten marks each as given by the concerned teachers. A total of the two assignments will be considered.

In case of soft core (electives), the pattern will be as below:

- One written examinations for 60 marks each for 3 credit courses.

- ii. Three assignments of a total of 40 marks (10 + 10 + 20) given by the concerned teachers. A total of the three assignments will be considered.

B. Pattern of Evaluation for Internal Assessment of Practical Courses

The Internal Assessment for every practical course will be of 40 marks for 2 credits. The students for IA will be assessed on the basis of:

- i. Performance for every practical: 5 marks each for every practical
- ii. Assignment: Timely submission of assignment with accuracy: 10 marks

The marks obtained in all the practical's will be added and averaged to out of 40.

C. Pattern of Evaluation of General Courses

- i. The Internal Assessment of General Courses for 2 credits will be done through two assignments, each of 25 marks.
- ii. For those with 3 credits along with continuous assessment as indicated in B (a and b) above, an end term examination of 60 marks will be conducted internally.

D. Pattern of question paper at the University Examination

University examination of 3 credit theory course will be of 60 marks.

The question paper will comprise of 6 questions. Any four questions may be answered from Q1 to Q5, while Q6 is compulsory. Q1 to Q5 will have two sub questions of 6 marks each. Q6 will comprise of three short notes of 4 marks each. The pattern of the question paper is given below. The questions will be based on Blooms Taxonomy (Remembering –Knowledge, Understanding-Comprehension, Applying-Application, Analyzing-Analysis, Evaluating-Evaluation and Creating-Synthesis)

Only Course No. EST 102: Environmental Chemistry and Microbiology will have two sections, Section I and Section II. Each section will contain four questions, a total of 8 questions. Of this, Q4 from each section will comprise of two short notes of 3 marks each and will be mandatory. Students have to attempt any two questions from the other three questions in each sub section respectively which will contain two sub questions of 6 marks each. Students shall attempt answers to Section I and Section II in separate answer books.

Pattern of question paper for 3 credit course of University Theory Examination of M.Sc. Environment Science and Technology 2019 CBCS Course

Total marks: 60

Time: 3 Hours

Instructions to the Paper Setter

Question paper pattern for all courses (except for EST 102).

Q6 is mandatory and students will answer any four of the remaining five questions.

Q.1	a		(06)
	b		(06)
Q.2	a		(06)
	b		(06)
Q.3	a		(06)
	b		(06)
Q.4	a		(06)
	b		(06)
Q.5	a		(06)
	b		(06)
Q.6.		Write short notes on any three of the following	(12)
	a		
	b		
	c		
	d		

Question Paper pattern for EST 102

SECTION I

(Answer any two questions from Q1 to Q3. Q4 is compulsory)

Q.1	a		(06)
	b		(06)
Q.2	a		(06)
	b		(06)

Q.3	a		(06)
	b		(06)
Q.4		Write short notes on any two of the following	(06)
	a		
	b		
	c		
		SECTION II (Answer any two questions from Q1 to Q3. Q4 is compulsory)	
Q.1	a		(06)
	b		(06)
Q.2	a		(06)
	b		(06)
Q.3	a		(06)
	b		(06)
Q.4		Write short notes on any two of the following	(06)
	a		
	b		
	c		

Pattern of question paper of University Practical Examination of M.Sc. Environment Science and Technology 2019 CBCS course

Total marks: 60 for 2 credit courses Time: 3 Hours

Q.1	Major Practical	(25)
Q.2.	Minor exercise	(15)
Q.3.	Minor exercise	(10)
Q.4.	Viva	(10)

IMPORTANT INSTRUCTIONS FOR STUDENTS

- Read carefully the entire Syllabus, making sure that all aspects of the course are clear to you, ie. Structure of the program, electives, details of assignments, internal and external examinations systems, marking systems, grading, attendance requirements as well as rules and regulations.
- Course coordinators are liable to change from those mentioned. Students will be informed about the change if any before the commencement of the semester.
- Familiarize yourself with the library and online resources for maximizing your learning experience. Be a self motivated learner.
- Faculty are always willing to accommodate interested and exceptional students in their on going research. If you are interested in volunteering your time on any of the projects to gain valuable work experience, do get in touch with them.
- Make sure that all assignments are submitted on time. Late submission of assignments may result in loss of a certain percentage of marks or rejection of your assignment.
- Every practical journal must be completed in the stipulated time.

Academic Integrity

Bharati Vidyapeeth University is committed to maintaining academic quality, excellence, and honesty. All faculty and students are expected to share the commitment to academic integrity, an essential component of a quality academic experience.

Students are expected to read and follow all policies, procedures, and program information guidelines contained in publications; pursue their learning goals with honesty and integrity; demonstrate that they are progressing satisfactorily and in a timely fashion by meeting course deadlines and following outlined procedures; observe a code of mutual respect in dealing with mentors, staff, and other students; behave in a manner consistent with the standards and codes of the profession in which they are practicing; keep official records updated regarding changes in name, address, telephone number, or e-mail address.

Payment of fees

Fees for the first term must be paid at the time of admission. Fees for the second term and fourth must be paid before 30 September of the same year. Fees for the third semester must be paid before 30 May. Students must meet financial obligations in a timely manner. The admission process for the term is not complete without payment of fees. If a student fails to pay the fees, the name of the concerned student will not reflect in the list of admitted students, affecting the attendance. Such a student will not be permitted to attend either the continuous / internal / external examination.

Academic Dishonesty

All students are expected to approach their education with academic integrity. Academic dishonesty undermines this objective. Academic dishonesty can take the following forms:

- Cheating

- Gaining or providing unauthorized access to examinations or using unauthorized materials during exam administration
- Submitting credentials that are false or altered in any way
- Plagiarizing (including copying and pasting from the Internet without using quotation marks and without acknowledging sources)
- Forgery, fabricating information or citations, or falsifying documents
- Submitting the work of another person in whole or in part as your own (including work obtained through document sharing sites, tutoring schools, term paper companies, or other sources)
- Tampering with the academic work of other students

Plagiarism

Plagiarism, is using the work and ideas of others without proper citation. This is strictly prohibited in all assignments and dissertation. Students should check their assignments through online antiplagiarism softwares (Eg. Grammarly, etc) before submission. Students are liable to lose marks or may find that their work is not assessed when they submit plagiarized content.

Plagiarism defeats the purpose of education. If you plagiarize, you are not educating yourself, and you are wasting your time on courses meant to improve your skills.

SEMESTER WISE COURSE INFORMATION

Semester I

Course Number	Course Title	Credit Value	Hours per week	Weightage (UE)	Weightage (IA)	EoTM
	Core Courses					
EST 101	Ecosystem Studies	3	3	60	40	University
EST 102	Environmental Chemistry and Microbiology	3	3	60	40	University
GEO 102	Fundamentals of Geoinformatics	3	3	60	40	University
EST 103	Sustainable development	3	3	60	40	University
EST 111	Field techniques - I	2	3	60	40	University
EST 112	Lab Analytical techniques - I	2	3	60	40	University
GEO 112	Techniques in Geographical Information Systems	2	3	60	40	University
	Pre-requisites					
EST 104	Basic Statistical Methods	2	3		100	Continuous
EST 105	Introduction to Data Analysis	2	3		100	Continuous
	Total Credits / Hours	22	27			

From the core courses:

Course Nos EST 101, EST 102, Geo 102, EST 103 are theory courses

Course Nos EST 111, EST 112, GEO 112 are practical courses

Total credits offered in Semester I : 22

Semester II

Course Number	Course Title	Credit Value	Hours per week	Weightage (UE)	Weightage (IA)	EoTM
	Core Courses					
EST 201	Biodiversity Assessment and Conservation	3	3	60	40	University
EST 202	Engineered Systems for Water and Waste Water	3	3	60	40	University
EST 203	Solid and Hazardous Waste Management	3	3	60	40	University
EST 204	Air and Noise Pollution Management	3	3	60	40	University
EST 205	Research Methodology	2	3		100	Continuous
EST 211	Field Techniques II	2	3	60	40	University
EST 212	Lab Analytical techniques II	2	3	60	40	University
EST 213	Field Work	2	60 (cumulative)		100	Continuous
	Electives (any two)					
EST 206	Natural Resource Management	3	3		100	Continuous
EST 207	Environment and Health	3	3		100	Continuous
EST 208	Climate Change Science and Strategies	3	3		100	Continuous
EST 209	Data Analysis with R	3	3		100	Continuous
EST 2010	Instrumentation and lab management for environmental analysis	3	3		100	Continuous
EST 2011	Environmental biotechnology	3	3		100	Continuous
	General Courses (any one)					
GEN 201	General English	2	2		50	Continuous
GEN 202	Project Management	2	2		50	Continuous
	Total	28	32			

From the core courses:

Course Nos EST 201, EST 202, EST 203, EST 204 and EST 205 are theory courses

Course Nos EST 211, EST 212, EST 213 are practical courses

Total Credits offered in Semester II : 28

Semester III

Course Number	Course Title	Credit Value	No. of hours per week	Weightage UE	Weightage IE	EoTM
	Core Courses					
EST 301	Integrated Impact Assessment	3	3	60	40	University
EST 302	Environmental Policies and Law	3	3	60	40	University
EST 311	Dissertation	12	14	60	40	University
EST 303	Technical Writing	2	3		100	Continuous
	Electives (any three)					
EST 304	Environment Management Techniques (includes optional certification for ISO 9001)	3	3		100	Continuous
EST 305	Water Management	3	3		100	Continuous
GEO 303	Applications of geospatial technologies	3	3		100	Continuous
EST 306	Urban Environment Management	3	3		100	Continuous
EST 307	Advanced Pollution Control Technology	3	3		100	Continuous
	General Courses (any one)					
GEN 301	Swaach Bharat Abhiyan Internship	2	2		50	Continuous
GEN 302	Education for Sustainable Development	2	2		50	Continuous
	Total	31	34			

Course Nos EST 301, EST 302, EST 303 are theory courses

Course Nos EST 311 is dissertation.

Total Credits offered in Semester III : 31

Semester IV

Course Number	Course Title	Credit Value	Hours per week	Weightage UE	Weightage IA	EoTM
	Core Courses					
EST 411	Dissertation	12	14	60	40	University
	Electives (any four)					
EST 401	Ecorestoration	3	3		100	Continuous
EST 402	Corporate Social Responsibility and Sustainability	3	3		100	Continuous
EST 403	Certification for ISO 14001	3	3		100	Continuous
EST 404	Urban Sustainability	3	3		100	Continuous
EST 405	Industrial Safety and Occupational Health (includes optional certification for ISO 45000)	3	3		100	Continuous
EST 406	Green technology and Management	3	3		100	Continuous
EST 407	Green Buildings	3	3		100	Continuous
	General Courses (any one)					Continuous
GEN 401	Entrepreneurship Development	2	2		50	Continuous
GEN 402	Soft Skills	2	2		50	Continuous
	Total	26	28			

Course Nos EST 411 is dissertation.

Total Credits offered in Semester IV : 30

SEMESTER I

COURSE NO: EST 101

Course Title: Ecosystem Studies

Number of Credits: 3

No. of Lectures-Tutorial: 36-07-02

Course Coordinator/Instructor: Dr. Sougata Sadhukhan

Course Outline

Ecosystems provide a vast range of services, from food and medicines to a stable climate, clean water and storm protection. This course provides an introduction to the functioning of ecosystems underlying these services, in particular looking at how ecosystems are structured and how they function. The course has a practical ethos and involves fieldwork and analysis of real data. The course looks at the dynamic nature of ecosystems, which often behave as complex systems. The course provides students with the core ecosystem knowledge needed for management.

Learning Outcomes

Student will develop:

- An understanding of the fundamental principles of ecosystem ecology including how ecosystem structure relates to function and the dynamics of ecosystems.
- Appreciation of the diversity of ecosystem functions across time, space and biomes.
- Appreciation of how ecosystems respond to global change drivers including climate change, land use change and biodiversity loss.
- An understanding of ecosystem services, principles of ecosystem valuation and its importance

Pre-requisite

None

Evaluation Procedure: 60/40: University/Internal Assessment

Assignment	2	20%	Internal Assessment
Minor Test	1	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1.	Natural Resources , Biogeography and evolution • Air , water, soil as resources • Patterns of species distribution – evolutionary relicts, climatic relicts, endemic organisms, environmental gradients, interaction of factors, species interactions	02	

	• Natural selection, Darwin's theory • Plate tectonics and evolution of biodiversity • Species diversity in the tropics		
2.	Ecological Concepts and Ecosystem • Evolution of natural environment: Biotic and abiotic factors • Ecosystem productivity • Food chains and food webs and trophic levels • Energy flows– pyramid of number, pyramid of energy and pyramid of biomass • Patterns and types of bio-geochemical cycles – oxygen, nitrogen, carbon, sulphur and phosphorus • Water cycle • Principles of limiting factors- Liebig's law of Minimum, Shelfords law of tolerance, Combining concepts of limiting factors, limiting factors in ecosystem context • Ecological indicators, Ecotones and concept of edge effect, successional patterns (grasslands to old growth) and response of wildlife	04	
3.	Biodiversity • Definition: species richness, species diversity, biological diversity • Levels of biodiversity: genes to landscapes • Values of biodiversity – direct and indirect • Biogeographic zones of India • Biodiversity conservation- in situ and ex situ	02	
	Assignment 1 Discussion and presentation of selected research paper in groups of 2/3 students.		3
4.	Ecosystems • Forests – Biogeography of forests in India, vegetation structure and functions, food chain and food webs, plant-animal interaction, productivity and nutrient cycling, biological diversity of tropical forests, limiting factors, gap theory, threats and conservation. • Grasslands – Biogeography of grasslands in India, structure and function, food chains and food webs, animal population dynamics, limiting factors, threats and conservation	08	

	• Deserts – Biogeography of deserts in India, structure and function, limiting factors, environmental factors and plant-animal distributions, threats and conservation • Mountains – Tropical mountains, structure and function, plant and animal ecophysiology, threats and conservation • Mangroves – structure and function, ecological adaptations of mangroves, plant and animal diversity and interactions, mangrove productivity, food chains and food webs, threats and conservation • Marine ecosystems – structure and function, plant and animal diversity with reference to India, food chains and food webs, threats and conservation • Coral reefs – Distribution, structure and function, coral reef biology, coral reef communities, coral reef biodiversity, threats and conservation • Wetlands/Rivers - Biogeography, structure and function, stratification, food chains and food webs, catchment area concept, threats and conservation.		
5.	Taxonomy • Classification of living organisms (kingdoms) Introduction to Protista, Plant and Animal Overview of Protista (Classification of microorganisms, ecology, uses with examples) • Overview of Plant Kingdom: Diversification and evolution of plant groups; Cryptogams: Characteristics of Algae, Bryophytes, Pteridophytes • Characteristics of Fungi and Lichens (distinguishing characters with examples, place in evolution, ecological importance, uses) • Phanerogams: Gymnosperms and Angiosperms, (distinguishing characters with examples, place in evolution, ecological importance, uses) Systematics and Phylogeny • Purpose of taxonomy, Concepts of Taxonomic characters, types of classification systems (artificial, phylogenetic, natural with examples) , basics of nomenclature (binomial classification) Introduction to APG III	10	

	- Study of identification and classification characters / Morphological features of selected angiosperm families: Angiosperms- Polypatales - Malvaceae, Leguminosae Gamopatales - Asteraceae, Lamiaceae / Bignoniaceae, Monocotyledons-(Liliaceae/Amaranthaceae); Use of flora for identification of angiosperms Animal taxonomy - Invertebrates – Protozoa, Porifera, Cnidaria, Platyhelminthes, Nemertean, Nematoda, Mollusca, Annelida, Arthropoda, Echinodermata- Distinguishing characters of each phyla with examples - Vertebrates - key characters of each class - fishes, amphibians, reptiles, birds and mammals. - Classification of mammals upto order level with key characters of each order and examples		
	Assignment 2 Critical review of a research paper by individual students.		5
6.	Ecosystem services and ecosystem dynamics Ecosystem services - Ecosystem functioning and ecosystem services provided by different ecosystems at present – provisioning services, regulating services, habitat or supporting services, cultural services - Species population and ecosystem services-the connections - Millennium Ecosystem Assessment, TEEB with case studies Ecosystem dynamics - Definition of ecosystem dynamics and its relevance - Changes in ecosystems over different time scales, drivers of ecosystem dynamics (natural and human induced), patterns and elements of ecosystem dynamics with examples	04	
7.	Valuation of Ecosystem Services - Overview of economic valuation of ecosystems - Key issues in valuation of economics of ecosystems- identifying key stakeholders, key development goals,	06	

	assessing the status and trends of key ecosystems, engaging stakeholders • Payments for ecosystem services • Case studies		
	Minor test 1		1
	Total	36	09

Suggested Readings

1. Alfred J. R.B, A.K.Das and A.K.Sanyal, Ecosystems of India, ZSI, 2001.
2. Banarjee A., 2010, Footprints in the forest, Winrock International India.
3. Botkin Daniel. B and Edward. A. Keller, Environment Science – Earth as a living Planet, John Wiley and Sons, 2005.
4. Carabias Julia and Kishore Rao, Capacity Needs to Manage Protected Areas, The Nature Conservancy, 2003.
5. Champion S., Seth S, (2005). Revised survey of forest types of India. Nataraj Publishers, New Delhi.
6. Clark T., Reading R., Clarke A., 1994. Endangered Species Recovery: Finding the Lessons, Improving the Process, Island Press.
7. Cleveland H., Larry R., Susan K., Allen L., David E., 2009, Animal diversity, McGraw Hill.
8. Dinerstein E. 2013. The Kingdom of Rarities. Island Press.
9. Enger, E.D., Ross, F.C., Bailey, D.B., 2003. Concepts in biology. McGraw-Hill Science / Engineering/Math.
10. Estuaries of India, ENVIS, 2002.
11. Gopal, R., 2011. Fundamentals of Wildlife Management. Natraj Publishers, New Delhi.
12. Grimmett R., Inskipp C. and Inskipp T. (2001) *Pocket Guide to the Birds of the Indian Subcontinent*, Oxford University Press, Oxford.
13. Groom M.J., Meffe G.K. and Carroll C.R. (2006) *Principles of Conservation Biology* (3rd edition), Sinauer Associates, Sunderland
14. Hunter Malcom. Jr, Maintaining Biodiversity in Forest Ecosystems, Cambridge University Press, 1999.
15. J. B. Lal, 1992, Forest ecology, Natraj publishers.
16. Kamaljit S. B., et. Al., 2011, Conservation Biology, Universities Press.
17. Keddy Paul. A, Wetland Ecology – Principles and Conservation, Cambridge University Press, 2000.
18. Mangroves of India, ENVIS, 2002.
19. Menon, V., 2014. Indian mammals: a field guide. Hachette India.
20. Michael S., Robert P., 2014, Early years in modern conservation biology, Island press.

21. Miller, G., Spoolman, S., 2007. Environmental Science: Problems, Connections and Solutions. Cengage Learning.
22. Nebel Bernard. J. and Richard. T. Wright, Environment Science, Pearson Custom Publishing, 8th Edition, 2003.
23. Owen Oliver. S, Daniel. D. Chiras and John. P. Reganold, Natural Resource Conservation, 7th Edition, 1998.
24. Parenti L., 2009, Comparative biogeography, Rawat Publishers.
25. Parenti L., Ebach M., 2009. Comparative Biogeography: Discovering and Classifying Biogeographical Patterns of a Dynamic Earth. University of California Press.
26. Peter R., George J., Jonathan L., Susan S., 2005, Biology, Tata McGraw Hill.
27. Primack R.B. (2006) *Essentials of Conservation Biology* (4th ed.), Sinauer Associates, Sunderland.
28. Puri, G.S., Gupta, R.K., Meher-Homji, V.M., Puri, S., others, 1989. Forest ecology. Volume 2. Plant form, diversity, communities and succession. Oxford & IBH Publishing Co. Pvt. Ltd.
29. Puri, G.S., Meher-Homji, V.M., Gupta, R.K., Puri, S., others, 1983. Forest ecology. Volume I. Phytogeography and forest conservation. Forest ecology. Volume I. Phytogeography and forest conservation.
30. Raphael M., Molina R. 2013. Conservation of Rare or Little-Known Species: Biological, Social, and Economic Considerations. Island Press.
31. Sahara V.B. (2001) *Wildlife in India*, Natraj Publishers, Dehra Dun.
32. Sawarkar, V.B., 2005. A guide to planning wildlife management in protected areas & managed landscapes. Natraj Publishers.
33. Sharma, B.D., Karthikeyan, S., Singh, N.P., Flora of Maharashtra State. Botanical Survey of India.
34. Sloomweg R., Rajvanshi A., Mathur V., Kolhoff A., 2009. Biodiversity in Environmental Assessment: Enhancing Ecosystem Services for Human Well-Being. Cambridge University Press.
35. Sustainable management of wetland, biodiversity and beyond. Jyoti Parikh & Hemant Date.
36. Sutherland, William J. 2006. Ecological Census Techniques: A Handbook. Cambridge University Press.
37. Townsend Colin. R, John. L. Harper and Michael Begon, Essentials of Ecology, Blackwell Science, 2000.
38. Vandana S., 2012, Biopiracy – the Plunder of nature and knowledge, Natraj Publishers.
39. Venkataraman K., 2012. Fauna of Maharashtra Part 1: Vertebrates Zoological Survey of India

Journals (to be accessed through JGATE)

1. Ecology
2. Conservation Biology

COURSE NO: EST 102

Course Title: Environmental Chemistry and Microbiology

Number of Credits: 3

No. of Lectures-Tutorial: 36-9

Course Coordinator/Instructor: Ms. Archana Kalyani and Dr. Bipin Raj

Course Outline

Part 1 of the course provides a detailed understating of various aspects of chemistry, with reference to environmental applications and lays the foundation for understanding in specialized areas of environment management and practices.

Part 2 of the course provides detail understating of various aspects of microbiology, with reference to environmental applications and lays the foundation for understanding in specialized areas of environment management and practices.

Learning Outcomes

Student will develop:

- An understanding of the fundamental principles of chemistry that is applicable to various aspects of environment management.
- A deep understanding of analytical techniques and environmental standards.
- Analytical and conceptual skills required for research in the field of environmental chemistry.
- An understanding of the fundamental principles of microbiology that is applicable to various aspects of environment management.
- A deep understanding of analytical techniques and applications in pollution control using microbiology.
- Analytical and conceptual skills required for research in the field of environmental microbiology

Pre-requisite

None

Evaluation Procedure: 60/40: University Exam / Internal Assessment

Assignment	2	20%	Internal Assessment
Minor Test	1	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
	PART I: ENVIRONMENTAL CHEMISTRY		

1.	- Green chemistry: Principles with examples - Effects of chemicals on environment and health	2	
2.	Introduction - General chemistry: classification of elements, theory of valence, gas laws - Basic concepts from quantitative chemistry; Colorimetry-Lamberts law, Beers law; Colorimeters, spectrophotometers	3	
2.	Organic chemistry Reaction mechanism of selected organic compounds, pharma, alcohol, dye.	2	
3.	Chemistry of the atmosphere - Chemical composition of atmosphere- particles, ions and radicals; formation of particulate matter; photochemical and chemical reactions in the atmosphere; chemistry of greenhouse gases and ozone layer depletion; gaseous transformations in the atmosphere and removal mechanisms; nuclear winter; chemistry of particulate and gaseous pollutants in air, fog and smog formation. - Basic principles involved in the analysis of various constituents present in the environment - Air quality standards	4	
	Assignment 1 Discussion and presentation of selected research paper in groups of two students.		3
4.	Chemistry of the Lithosphere - Chemical composition of lithosphere, water and air in soil; inorganic and organic components in soil - Acid, base and ion-exchange reaction in the soil; soil acidity, salinity and sodicity - Effects of ecological factors on the toxicity of soil	3	
5.	Chemistry of water - Chemical constituents present in water, standards for quality of water - Basic concept of colloidal and quantitative chemistry. Oxidation-reduction reactions and equations; Equilibrium and Lechatelier's principle, activity and coefficients, variations in equilibrium relationships, shifting chemical equilibrium, amphoteric	4	

	hydroxides, buffers and buffer index; solubility of salts, complex formation • Water structure and anomalous behaviour of water; concept of dissolved oxygen, biological oxygen demand, chemical oxygen demand • Chemistry involved in water treatment procedures like coagulation, disinfection, softening, fluoridation, defluoridation, iron and manganese removal, demineralization, corrosion and its control.		
6.	Analytical techniques • Principle and components • Neutron Activation Analysis • Atomic Absorption Spectroscopy • Gas Chromatography • Gas analysis • Polarography • Ion exchange electrodes • Inductively Coupled Plasma Atomic Emission Spectroscopy • Ion Chromatography • High Performance Liquid Chromatography • Potentiometry • Conductometry • Calorimetry • Viscosity	4	
	MINOR TEST 2		1
	PART II: ENVIRONMENTAL MICROBIOLOGY		
1	Introduction • Microorganisms in environment management • Diversity of microbial forms and mode of living • Extremophiles • Drug resistance in organisms • Composition of cell, biochemistry of proteins, fats and oils	2	
2	Population dynamics of micro – organisms • Exponential growth • Logistic growth • Tremostat model	2	

	• Competition and prey – predator dynamics • Methods of monitoring populations • Counting methods • Biomass estimation • Measurement of microbial diversity and productivity • Environmental factors affecting growth relationship of growth rate with nutrient concentration- temperature, pH, salinity and other factors		
	Assignment 2 Discussion and presentation of selected research paper in groups of two students.		5
5	Wastewater microbiology • Microbial flora involved in wastewater treatment – aerobic and anaerobic degraders • Micro organism in trickling filters, activated sludge process, oxidation ponds, anaerobic digestion • Domestic, rural and urban treatment of water	4	
6	Solid waste degradation • Composting – types of composting, micro organisms in composting	2	
7	Other environmental applications of micro organisms • Biogas production • Microbial leaching • Metal removal • Bio fertilizers • Bio control of pests and disease	2	
8	Environmental aspects of infectious disease • Epidemiological investigation • Public health and hygiene • Epidemiological modeling and predictions	2	
	Minor test 1		1
	Total	36	9

Reference Books

1. Anil Kumar De, 2003. Environmental Chemistry, New Age International Limited Publishers, 5th edition.
2. Atkins, P., 2010. Shriver and Atkins' inorganic chemistry. Oxford University Press. (free pdf available at <http://ondobook.com/dl/shriver-and-atkins-inorganic-chemistry-5th-edition-free-download.pdf>)
3. Burlage Robert, Ronald Atlas, David Stahl, Gill Geesey, Techniques in Microbial Ecology, OxfordUniversity Press, New York.
4. Chang Raymond, Chemistry, 1994. McGraw Hill, 5th Edition.
5. Christian Gary, 2001. Analytical Chemistry, John Wiley and Sons.
6. De A. K, 2000. Environmental Chemistry, New Age International Limited Publishers, 4th edition.
7. Deoray B.M. and A.E. Desai, Concepts in Molecular Biology, NiraliPrakashan, 1999.
8. Khopkar, S.M., 1998. Basic concepts of analytical chemistry. New Age International.
9. Ladd Mark, 1988. Introduction to Physical Chemistry, Cambridge University Press, 3rd Edition.
10. Lynch J.M. and J.E. Hobbie, Micro-organism in action – Concepts and Applications in Microbial Ecology, Blackwell Scientific Publications, 1979.
11. Mallick A., 2015, Chemistry for Engineers, Viva Books Pvt. Ltd.
12. Pelczar H.J, Jr., E.C.S. Chan, Noel. R. Krieg; Microbiology, Tata Mc.Graw – Hill 5th edition, 2002.
13. Philip Kuchel, Simon Easterbrook-Smith, Vanessa Gysbers, J. Mitchell Guss, Dale P. Hancock, Jill M. Johnston, Alan Jones, and Jacqui M. Matthews. 2011. *Schaum's Outline of Biochemistry, Third Edition*. US: McGraw-Hill.
14. Powar and Dagainawala, General Microbiology Volume – I, Himalaya Publishing House, 2nd Edition, 1986.
15. Powar and Dagainawals, General Microbiology Volume II, Himalaya Publishing House, 8th Edition, 1992.
16. Sharma B.K, 1985. Industrial Chemistry, Goel Publishing House.
17. Singh P. R, Microbiology, Kalyani Publishers, 2004.
18. Solomon's Graham and Craig Fryhle, 2002. Organic Chemistry, John Wiley and Sons, 7th edition.
19. Spiro G and William M. Stigliani, 2002. Chemistry of the Environment, Thomas, Hall of India Pvt. Ltd, 2nd edition.
20. Spiro T., 1996, Chemistry of the environment – 3rd Edition, Viva Books Pvt. Ltd.
21. Stanier Roger Y, John, L.Ingraham, Mark. L.Wheelis, Page R. Painter, General Microbiology, Macmillan Press ltd, 5th edition, 1987
22. Sullia S.B and S. Santharam, General Microbiology (revised), Oxford and IBH Publishing Co. Private Ltd, 1998.
23. Yadav L., Singh J., Srivastava J., 2014. Advanced practical's of chemistry Pragati Prakashan

COURSE NO: GEO 102

Course Title: Fundamentals of Geoinformatics

Number of Credits: 3

No. of Lectures-Tutorial: 36-9

Course Coordinator/Instructor: Dr. Shamita Kumar

Course Outline

The course provides a firm understanding of the conceptual and technical issues of geospatial technologies and an overview of applications in various aspects of wildlife, natural resource management, environment management, etc. It introduces the students to the fundamentals of geographic information systems, navigation systems, data models, data sources, cartography as well as multi-criteria analysis.

Learning Outcomes

Students will:

- Demonstrate a good understanding of the basics of geospatial technologies
- Demonstrate an understanding of building geo-databases.
- Develop abilities to think about and implement geographic data management and analysis for research and a variety of planning and management applications.

Pre-requisite

None

Evaluation Procedure : Evaluation Procedure: 60/40: University Exam / Internal Assessment

Assignment	2	20%	Internal Assessment
Minor Test	1	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Introduction to Geoinformatics • Introduction to the concept of geoinformatics and its applications	03	
2	Geographic data and data measurement • Data types and scales of data measurement, sampling methods Map basics	06	

	- History of cartography, basic characteristics of maps, categories of maps, map scale - Typography and lettering the map, elements of generalization-classification, simplification and exaggeration, symbolization-point, line, area, volume - Nature of geographic phenomena and measurement of geographical variables Basic geographic concepts Basic geodesy: Spherical, ellipsoidal and geoidal earth, geographical co-ordinates, Co-ordinate systems: Plane co-ordinate system, Geographic co-ordinate system - Map projections: Scale factor and transformation, distortions resulting from map transformations, properties of map projections, classification of map projections, aspects of map projections, some commonly used projections, selection of a particular projection, geo-referencing, relationship between co-ordinate systems and map projections - Geodetic datum-concept and types		
3	Data Models, data structures and data input - GIS data models: Raster data models-nature, characteristics of raster data, principles of raster data compression - GIS data models: Vector and raster data models-nature, characteristics - Concept of topology, topological relationships between spatial objects - Data input (raster and vector), metadata, data sources for GIS, input of methods of data input, digitization, error identification, types and sources of errors, correction, data editing, topology building.	06	
	Assignment 1 Discussion and presentation of selected research paper in groups of 2/3 students.		3
4	Global Navigation Satellite Systems (GNSS) Introduction, GNSS segments, GNSS satellite generations, current GNSS satellite constellation working principle	06	

	- GNSS working principle, GNSS signal structure, types of GNSS receivers, pseudorange measurements, carrier phase measurements, cycle slips - GNSS errors and biases - Methods of GNSS observations - GNSS applications		
4.	Database Management - Introduction to database and database management systems, importance of databases in GIS - Database structures - Database data models: Hierarchical model, network model, relational database model, object oriented data model - Database creation, linking spatial and attribute data, GIS database applications	03	
	Assignment 2 Critical review of research paper/ video poster		5
5.	Data analysis - Measurements - Queries - Buffering and neighbourhood functions - Map overlay - Spatial analysis - Multicriteria analysis - Network Analysis	06	
6.	Application of Geoinformatics - Applications in forestry and wildlife management - Applications in mining - Applications in urban planning - Applications in disaster management - Applications in health studies - Business applications	03	
7.	GIS project design and management - Identify the problem and its geospatial component - Data and data sources; GIS operations, spatial analysis.	03	

	Minor test 1		1
	Total	36	09

Suggested Readings

1. Burrough P. A., R. A MacDonneli, Principles of Geographical Information Systems, Oxford University Press, 2000.
2. Lo. C. P., A.W. Yeung, Concepts and Techniques of Geographical Information Systems, Prentice- Hall of India Pr. Ltd., 2002.
3. Heywood I., S. Cornelius, S. Carrer, An Introduction to Geographical Information Systems, Pearson Education Pvt. Ltd, 2002.
4. Kang-stung-Chang, Introduction to Geographical Information System, Tata McGraw Hill Pub. Comp, 2002.
5. Demers M.N, Fundamentals of Geographic Information Systems, John Wiley & Sons, 2000.
6. Roy P.S., Dwivedi R.S., Vijayan D., 2010 Remote Sensing Applications National Remote Sensing Centre, India
7. Reddy, M.A., 2008. Textbook of remote sensing and geographical information systems. BS publications.
8. El-Rabbany, A., 2002. Introduction to GPS: the global positioning system. Artech House.
9. Arthur Robinson, H., 1958. Elements of cartography, John Wiley and Sons Inc.

Websites (as mentioned from time to time in class)

Journals

1. International Journal of Geoinformatics
2. International Journal of Remote Sensing
3. ISPRS Journal of Photogrammetry and Remote Sensing
4. Journal of Indian Society of Remote Sensing

COURSE NO.: EST 103

Course Title: Sustainable development

Number of Credits: 3

No. of Lectures-Tutorial-Assignment: 36-9

Course Coordinator: Dr. Shamita Kumar and Samruddhi Patwardhan

Course Outline

The course aims to build the students' understanding of the concepts of sustainable development in all its dimensions, i.e. social, economic and environment to help correlate these factors to development and understand the need for sustainable development. It also explores the role of education for sustainable development from just awareness creation to the need for more action and implementation. The course provides insights into integrating sustainability in development issues.

Learning Outcomes

Students will:

- Develop a good understanding of the basics of sustainable development.
- Demonstrate an understanding of challenges in sustainable development.
- Understand the role of education for sustainable development.
- Develop skills in systems thinking.

Additional courseware

Students are encouraged to register for the following free online course:

<https://www.coursera.org/learn/sustainable-development>

Evaluation Procedure : Evaluation Procedure: 60/40: University Exam / Internal Assessment

Assignment	2	20%	Internal Assessment
Minor Test	1	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

Sr. No.	Topic	Time (Hours)	
		L	T
1.	Basic concepts of sustainable development • Understanding 'sustainability' and 'development'; different world views; the economic growth/GDP perspective. • Linkages between economic growth and quality of life; Causes and effects of unsustainable development-	06	

	consumerism, globalization, urbanization, ecosystem degradation, war, terrorism, disasters, inequity • Pillars of sustainable development-economic, social, environmental, political (governance) • Timeline of sustainable development; Agenda 21; Millennium development goals and sustainable development goals • The need for sustainable development across sectors		
2.	Challenges of Sustainable Development • Rapid population growth and food security • Poverty, Income inequality and gender disparity • Increasing urbanization and Energy transformation • Climate change and environmental degradation	06	
3.	Tools for achieving sustainable development • Inclusive development strategies • Technology innovation in energy, water and other sectors • Sustainable cities • Financing sustainable development including public private partnership • Reforms in environmental policies and regulations • Sustainable consumption	06	
	Assignment 1 Presentation in groups of two on a given research paper / case study		3
4.	Introduction to ESD • History of Environment Education, Indian Perspective • Emergence of the concepts of ESD • Inter linkages of ESD and sustainable development • ESD and Sustainability-transdisciplinary approach.	03	
5.	ESD and Social Learning • Introduction to social learning and how people learn • Transformative learning and change • Indigenous knowledge, traditional knowledge and sustainability including ESD	03	

6.	Systems thinking and Institutional approach • Introduction to systems thinking • Systems landscape • Whole institutional approach • Greening Curriculum : Need, challenges and practices	03	
	Assignment 2 Presentation in groups of 2/3 on a given research paper / case study		3
8.	ESD Competencies and Methods • Systems thinking, anticipatory, normative, strategic, interpersonal competencies • Traditional and transformative learning pedagogy; Constructivism, Inquiry based, reflective, collaborative, integrative	06	
	Minor test 1		1
	Total	36	9

Reference books

1. An Introduction to Sustainable Development-Peter P. Rogers, Kazi F. Jalal, and John A. Boyd
2. Understanding Sustainable Development-John Belwitt
3. Limits to Growth – The 30 year update by Donella Meadows, Dennis Meadows, Jorgen Randers
4. Cradle to Cradle Remaking the Way We Make Things by William McDonough and Michael Braungart North Point Press
5. Our Common Future -World Commission on Environment and Development Oxford Paperbacks
6. Education for Sustainable Development: Nature, School and Democracy Illustrated Paperback-by KlasSandell,JohanOhman and Leif Ostman
7. Sustainable Education: Revisioning Learning and Change (Schumacher Briefings) [Paperback] by David ORR and S.R.Sterling
8. Thinking in Systems: A Primer [Paperback] DonellaH.Meadows

Suggested Readings

1. Small is Beautiful- Economics as if people mattered by EF Schumacher
2. At the edge –Ann Dale UBC press
3. Collapse – How societies choose to fail or succeed by Jared Diamond Penguin publishers

4. Development as Freedom – Amartya Sen – Publisher Anchor
5. Resilience Thinking-Sustaining ecosystems and people in a changing world by Brian Walker and David Salt
6. Leadership for Sustainability –an action approach by Judi Marshall, Gill Coleman and Peter Reason

Journals

1. International Journal for Sustainable Development

COURSE NO: EST 111

Course Title: Field techniques I

Number of Credits: 2

Course Coordinator/Instructor: Dr. Sougata Sadhukhan

Course Outline

The course provides hand on expertise in identifying flora and fauna as well as in depth understanding of ecosystem structure and function through a combination of field visits and lab work.

Learning Outcomes

Students will:

- Develop skills in identifying birds, mammals and major plant species
- Develop an ability to analyze structure of ecosystems.
- Acquire competence in design and implementation of sampling techniques.

Pre-requisite

None

Evaluation Procedure: 60/40: University Exam / Internal Assessment

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed Journal submitted timely (within 7 days): 5 marks	Internal Assessment
Major exam	60%		University Assessment

Details of course content

1. Identification of terrestrial birds
2. Identification of wetland birds
3. Vegetation analysis using quadrats and analysis in excel
4. Vegetation analysis using line transects and analysis in excel
5. Vegetation analysis by using belt transect and analysis in excel
6. Calculation of plant diversity index
7. Study of planktons.
8. Converting study area into grids and mapping transects

9. Field work in forest ecosystem (Mulshi) (assessment for forest structure, measurement of GBH, canopy estimation, vegetation analysis) (This will be completed over two classroom sessions and one field session)
- 10.. Field work in grassland ecosystem (Rehekhuri) (grassland vegetation analysis, animal census techniques by using indirect signs). (This will be completed over two classroom sessions and one field session)
11. Field work in wetland ecosystem (Pashan) (Vegetation mapping, wetland bird analysis)

References

1. Vivek M., 2014, Indian Mammals – a field guide, Hachette book publishing India, Pvt. Ltd.
2. Brandis D., 2009, Indian Trees, Natraj Publishers.
3. Grewal B., 2017, A naturalists guide to the mammals of India, Prakash Books.
4. Sachdera P., 2017, A naturalists guide to the trees and shrubs of India, Prakash Books.
5. Grewal B., 2016, A Pictorial field guide to birds of India, Om book international.
6. Grimmett R., 1998, Birds of Indian Subcontinent, Oxford University Press.
7. Yiqi, Luo, Desharnais, Robert, 2015, Population Dynamics and Laboratory Ecology, Elsevier.
8. Rieger, John, Stanley, Traynor, Raymond, 2014, Plant Material, Washington, DC, Island Press/Center for Resource Economics

COURSE NO: EST 112

Course Title: Lab Analytical Techniques I

Number of Credits: 2

Course Coordinator/Instructor: Dr. Rashmi Mardikar

Course Outline

The course provides sound understanding of lab analytical techniques in environmental chemistry and microbiology and sets the foundation for application of these techniques in projects as well as further research.

Learning Outcomes

- Proficiency in use of analytical instruments.
- Ability to analyze samples using specific techniques
- Competency in interpretation of results.

Pre-requisite

None

Evaluation Procedure: 60/40: University Exam / Internal Assessment

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed assignment submitted timely: 5 marks	Internal Assessment
Major exam	20%		University Assessment

Details of course content

1. Study the water quality parameters such as pH, dissolved oxygen.
2. Study of water quality parameters such as hardness, conductivity.
3. Determination of Chemical Oxygen Demand of water.
4. Determination of iron from soil and water.
5. Determination of manganese from water.
6. Determination of nitrate from water.
7. Study the morphology of the organisms by monochrome/negative/gram staining.
8. Study of preparation of nutrient agar and study its composition.
9. Enumeration of coliform bacteria in water by Most Probable Number (MPN) method.
10. Study of isolation of bacteria by Streak plate/Spread Plate/ Pour Plate method.

COURSE NO: GEO 112

Course Title: Techniques in Geographical Information Systems

Number of Credits: 2

Course Coordinator/Instructor: Dr. Madhurima Dey

Course Outline

The course provides hand on expertise with use of open source as well as commercial GIS software through a series of well designed practical's related to cartography, building geo databases, querying data, use of GPS and multicriteria analysis.

Learning Outcomes

- Proficiency in use of open source and commercial software for basic GIS operations.
- Ability to use location based devices for data collection.
- Ability to build basic geo databases.
- Competence in querying and making GIS analysis.

Pre-requisite

None

Evaluation Procedure: 60/40: University Exam / Internal Assessment

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed assignment submitted timely: 5 marks	Internal Assessment
Major exam	20%		University Assessment

Details of course content

1. Introduction to ArcGIS tools
2. Introduction to QGIS (Assignment-self study with discussion)
3. Digital cartography and Story Maps
4. Defining co-ordinate systems and projecting data sets
5. Map registration
6. On screen digitization (Assignment using QGIS)
7. Error identification, rectification
8. Working with tables (Assignment using QGIS)

9. Using the analysis tools/ data query in ArcGIS (Assignment using QGIS)
10. Use of Mobile Navigation System and input of location data (Design of Survey Form)
11. Introduction to Google Earth
12. Performing multicriteria analysis

COURSE NO: EST 104

Course Title: Basic Statistical Methods

Number of Credits: 3

No. of Lectures-Tutorial-Practical: 13-3-22

Course Coordinator/Instructor: Dr. Sougata Sadhukhan

Course Outline

The course has been designed to help biologists/environmental scientists answer questions of applications of statistics in their field of work. The course focuses on techniques for generating informative data, extraction information from data and to analyze data to get meaningful interpretations.

Learning Outcomes

After the course the student will be able to:

- Apply the appropriate technique for extraction of information from data
- Analyze data using appropriate statistical techniques and software

Pre-requisite

Students are encouraged to join and complete the free online course offered by Harvard University at :<https://www.coursera.org/learn/basic-statistics#syllabus> (starts Sep 15. Enrollement is free. If you want a certificate, there is a small fee).

Evaluation Procedure : Continuous assessment

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed home assignment submitted timely: 10 marks	Practicals must be in the prescribed format	Internal Assessment
Major exam	60%	Theory cum practical examination		Internal Assessment

Details of course content and allotted time

Unit	Topic	Time (Hours)		
		Lectures	T	P
1	Basic concepts in biostatistics • Terms and Terminologies	01		

	• Sampling Vs Population; Types of sampling; Variables and derived variables • Concept of Frequency and Distribution • Data in Ecology and Environment Sciences and its types • Organization of data • Representation of data – tabular and graphic			
2	Basic elements and tools of statistical analysis • Measures of central tendency – arithmetic mean, geometric mean, harmonic mean, mode, median • Measures of dispersion – Standard deviation, Coefficient of variation, coefficient of correlation • Graphical representation of data	01		
3.	Practical 1 A: Graphical representation of data and calculation of different types of mean based on different types of data Practical 1 B: Calculation of mode and median based on different types of data by different methods.			02
4.	Practical 2: Calculation of standard deviation, coefficient of variation and coefficient of correlation of different data types by different methods.			02
5.	Concepts of probability • Basic laws – Examples from Ecology – Discrete probability distribution – expectation and variance	1.5		
6.	Distribution • Binomial distribution • Normal distribution	1.5		
7.	Practical 3: To calculate simple probability and solve examples based on binomial and normal probability distribution			02
8.	Categorical Variable Test Simple Proportion Test, Chi-Square Test Single Numerical variable Test Simple t-test, Wilcoxon Test for one Sample			2

9.	Practical 4: Solve example based on Categorical or Single Numerical Variable			2
10.	Test of Dependable or Independent Variable - Paired Test: t-test, Z-test, Wilcoxon Test - Unpaired Test: t-test, Z-test and Mann-Whitney U test	2		
11.	Practical 5: Calculation of Paired test			2
12.	Practical 6: Calculation of Unpaired Test			2
13.	Hypothesis and comparison of means - Hypothesis & testing of hypothesis - Comparison of means ANOVA - One sample; Two samples	03		
14.	Practical 7: Solve examples based on one-way ANOVA			02
15.	Practical 8: Solve examples base on two-way ANOVA			02
16.	Regression analysis - Correlation and Regression - Regression coefficient - Standard errors and significance tests	03		
17.	Practical 9: Calculation of Simple Regression and Regression Coefficient			02
18.	Practical 10: Calculation Standard error and significance test			02
	Final Assessment		3	
	Total	13	3	22

Suggested Readings

1. Clark, J. S. Models for Ecological Data: An Introduction. Princeton University Press Princeton, New Jersey, USA, 2007.
2. Legendre, P., and L. Legendre. Numerical Ecology. Vol. 20. Elsevier, 2012.
3. Ott, L., and M. Longnecker. An Introduction to Statistical Methods and Data Analysis. Duxbury press, 2010.
4. Sokal, R.R. and Rohlf, F.J. 1995. Biometry: the principles and practice of statistics in biological research. 3rd edition. New York.
5. Zar J.H. 1999. Biostatistical Analysis. Prentice Hall, New Jersey, 663 pp.

COURSE NO: EST 105

Course Title: Introduction to Data Analysis

Number of Credits: 3

No. of Lectures-Tutorial-Practical: 12-3-24

Course Coordinator/Instructor: Mr. Anand Shinde

Course Outline

The course will introduce basic data analysis fundamentals in excel, visualizing data in excel, math and statistics in excel

Learning Outcomes

At the end of the course the student will:

- Have an insight into the various features for analysis available in Microsoft Excel
- Develop the ability to prepare charts, tables, and professional reports that involve complex data.
- Develop the ability to analyze and summarize data.

Pre-requisite

Students are strongly encouraged to complete the following free online course:

<https://www.edx.org/course/introduction-to-data-analysis-using-excel-2>

Evaluation Procedure : Continuous

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed home assignment submitted timely: 5 marks	Practicals must be in the prescribed assignment format	Internal Assessment
Major exam	60%	Theory cum practical examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	T	P
1	Practical 1: Introduction to Data Analysis, Overview of Database, Structure for Storing, Cleaning and Normalizing Data	1		2

2	Practical 2: Introduction to Excel - Overview of Worksheet and Workbook; Tabs and Ribbons; Creating worksheets; Copying and moving worksheets Basic text and cell formatting; Editing: Cut; copy; paste; paste special; Freeze panes Entering numbers and Formatting numbers: Currency format; formatting dates; Custom and Special formats; Autocompletion of series; sort and filter	1		2
3	Practical 3: Working with External Data, importing Data from other sources, Importing Data from an Access Database, Text File, CSV files, Inserting a Hyperlink, Working with Existing Data Connections	1		2
4.	Practical 4: Introduction to formulas , Understanding cell references, creating and modifying formulas with cell references, reading a formula	1		2
5	Practical 5: Logic functions: Building standalone logical IF functions, and make them more complex by nesting AND and OR within them.	1		2
6	Practical 6: Text Functions, Date Functions and Time Functions <i>Text Functions:</i> Learn to break apart text with the LEFT, RIGHT, MID, FIND and SEARCH functions, and to combine text with the & character. <i>Understanding Dates:</i> Understand how dates work in Excel using the TODAY, YEAR, MONTH, DAY and DATE functions. <i>Understanding Time:</i> Understand how time works in Excel, and how to change from whole numbers into time increments and back again.	1		2
7	Practical 7:Data Management Basics Sorting and filtering data in a data list, using the database functions in excel, querying external databases (one to one, one to many relations), combining queries, use of power query editor			

8	Practical 8: Web and text data analysis Retrieving data from the web, retrieving data from text files			
9	Practical 9: Using the 3D Map feature in excel	1		2
10	Practical 10: Creating a pivot table, formatting a pivot table, sorting and filtering pivot table data, modifying a pivot table, creating pivot chart	1		2
11	Practical 11: Develop a automation module of worksheet using Macro	1		2
12	Practical 12: Problem analysis in excel (using all of the above to analyze a given dataset).	1		2
	Major Test 1		3	
	Total	12	3	24

Suggested Readings

1. Banfield, C., Walkenbach, J., 2010. Microsoft Excel 2010 for Dummies. New York: Wiley Publishing.
2. Harvey, G., 2010. Excel 2010 Workbook for Dummies. John Wiley & Sons.
3. Jackson, M., Staunton, M., 2006. Advanced modelling in finance using Excel and VBA. John Wiley & Sons.
4. Schmuller, J., 2013. Statistical analysis with Excel for dummies. John Wiley & sons.

SEMESTER II

COURSE NO: EST 201

Course Title: Biodiversity Assessment and Conservation

Number of Credits: 3

No. of Lectures-Assignments-Examination: 36-6

Course Coordinator: Dr. Sougata Sadhukhan

Course Outline

The course focuses on the essential concepts and skills related to biodiversity conservation and assessment. This includes understanding threats to biodiversity, assessing biodiversity at various levels, concepts of landscape ecology and habitat management. It elucidates the perspectives of science and management of biodiversity in the context of current and future strategies needed for biodiversity conservation.

Learning Outcomes

Students will :

- Develop a deep understanding of the threats to biodiversity
- Develop skills of assessing biodiversity with different methodologies
- Develop a comprehensive understanding of issues in planning conservation areas and managing habitats.
- Acquire the ability to construct a conservation action plan for a species or site

Pre-requisite

EST 101

Evaluation Procedure : Evaluation Procedure: 60/40: University Exam / Internal Assessment

Assignment	2	20%	Internal Assessment
Minor Test	1	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	A	T/E
1	Overview of biodiversity • Status of biodiversity • Biodiversity at regional and landscape levels • Biodiversity at ecosystem, community and population levels	04		
2	Threats to biodiversity			

	• Loss of biodiversity – past rates of extinction, human caused extinctions, extinction rates on islands, island biogeography and extinction rates, case studies • Vulnerability to extinction – Endemic species, case studies • Habitat destruction, fragmentation and degradation • Exotic species introductions and disease • Problems of small populations – loss of genetic variability, demographic variation, environmental variations	05		
3	Assessment of biodiversity • Types of sampling – Qualitative and quantitative assessment techniques for mammals, birds, butterflies, plants. • Indices associated with species diversity, species similarity, temporal and spatial rate of change in species population • Alpha, Beta and Gamma diversity • Statistical approach to assessment of biodiversity • Software for biodiversity assessment	09		
	Assignment 1: Discussion and presentation of selected research paper in groups of 2/3 students OR any assignment as given by the faculty		03	
4	Planning Conservation Areas • Criteria for conservation – Conservation status, generalists and specialists; population size, sex and age classes, species restricted in distribution, isolated populations, habitat specialists and habitat obligates, species under illegal trade; key ecological functions of species; utility of the species • Approaches to conservation – species approach (featured species), management indicator species, species guild approach, flagship species approach, keystone species, ecosystem approach • Tools used for conservation – Population assessments, Gap analysis, habitat evaluation, GIS • Design criteria – habitat constituents, reserve design, reserve shape and size, population size, need for buffers, wildlife corridors, landscape connectivity, administrative, political and economic considerations	10		

	Assignment 2: Discussion and presentation of selected research paper in groups of 2/3 students OR any assignment as given by the faculty		03	
5	Habitat Management • <i>Insitu</i> management – categories of biotic factors and their pressures- livestock grazing, fire wood collection, non wood forest produce collection, fires, encroachments, mining and quarrying, weeds and weed infestations (Invasive species), large scale monocultures, soil erosion, timber smuggling, poaching, development activities that are insensitive to ecological integrity, vandalism, unregulated tourism; • Eco-restoration- habitat restoration techniques and monitoring • Wildlife management plans.	08		
	Minor test 1			01
	Total	36	06	01

Suggested Readings

1. Alexander, M. Management Planning for Nature Conservation: a Theoretical Basis & Practical Guide. Springer, 2008.
2. Groves, C. Drafting a Conservation Blueprint: a Practitioner's Guide to Planning for Biodiversity. Island Press, 2003.
3. Margules, C., S. Sarkar, and C. R. Margules. Systematic Conservation Planning. Cambridge University Press, 2007.
4. McNeely, J. A. Expanding Partnerships in Conservation. Island press, 1995.
5. Postel, S. et al. Nature's Services: Societal Dependence on Natural Ecosystems. Island Press, 1997.
6. Smith, D. S., and P. C. Hellmund. Ecology of Greenways: Design and Function of Linear Conservation Areas. University of Minnesota Press, 1993.
7. Sutherland, W. J. Conservation Science and Action. Blackwell Science Ltd, 1998.
8. Sutherland, W. J., and D. A. Hill. Managing Habitats for Conservation. Cambridge University Press, 1995.
9. Sutherland, W. J., I. Newton, and R. E. Green. Bird Ecology and Conservation: a Handbook of Techniques. Oxford University Press, USA, 2004.
10. Kamaljit S. B., et. Al., 2011, Conservation Biology, Universities Press

COURSE NO: EST 202

Course Title: Engineered Systems for water and waste water

Number of Credits: 3

No. of Lectures-Assignment-Tutorial: 36-6

Course Coordinator: Dr. Rashmi Mardikar

Course Outline

The course focuses on the essential concepts and skills related to water and waste water assessment. This includes understanding of various technique involved in treating of water and waste water.

Learning Outcomes

At the end of the course students will develop:

- Basic understanding of the concepts involved in water and waste water management
- Understanding of design parameters in various units of water and waste water treatment.
- Comprehensive understanding of issues water and waste water management.
- Ability to read and make basic engineering drawings.

Pre-requisite

EST 102, EST 103

Evaluation Procedure: 60/40: University Exam / Internal Assessment

Assignment	2	20%	Internal Assessment
Minor Test	1	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	A	T/E
1	Introduction • Water availability, water distribution, Sources of water supply, general considerations for water supply schemes • Water usage, water demand from various sectors of society, calculation of water demand for developments	4		

	• Methods for population forecasting: Arithmetic, geometric, Incremental, graphical methods • Introduction to water reuse, conservation: requirement, current practices.			
2	Water treatment • Objectives; Physical, chemical and biological properties of water drinking water; Quality standards in India for major constituents. • Aeration: Theory of gas transfer, Henry's law, factors affecting aeration; Types of aeration systems: Cascade, spray, tray tower, diffused aeration • Sedimentation: Theory of plain sedimentation, Stokes law; Types of sedimentation tank; design considerations -design of circular and rectangular sedimentation tank • Coagulation and flocculation: Objectives, types of coagulants and flocculants; Advantages and disadvantages of aluminum and ferrous coagulants, chemical dosing, jar test; Design • Filtration: Objectives, mechanism, types of filters(Gravity, pressure, high rate, low rate, sand filter, dual media filter etc); Components of filter: Enclosure tank, Filtering media, under drainage system; Process of filtration, backwashing, Comparative study of slow and rapid sand filters; Design of rapid sand filter, including design parameters: loading rates, area, depth, backwash rates. • Disinfection: Necessary, theory of disinfection, Minor methods of disinfection: boiling, excess lime treatment, ozonation, silver treatment, UV treatment • Chlorination: mechanisms of chlorination, application of chlorine, Methods of chlorination: plain chlorination, pre and post chlorination, break point chlorination, super chlorination, dechlorination, advantages and disadvantages, design considerations for chlorine contact tank: C and T.	12		

	- Softening: Purpose, removal of temporary and permanent hardness, lime soda process, zeolite process, Demineralization, Desalination - Miscellaneous methods: Taste, colour and odour removal methods - Aeration, activated carbon method, iron and manganese removal, fluoridation and defluoridation			
	Assignment 1: Discussion and presentation of selected research paper in groups of 2/3 students OR any assignment as given by the faculty		03	
3	Wastewater treatment - Wastewater engineering: Terminology, Necessity, collection and conveyance of wastewater , Flow rates, flow measurement devices - Classification of treatment processes: Physical, chemical and biological processes, primary, secondary, tertiary treatment, advanced waste water treatment - Unit operations and unit processes for wastewater treatment: Screening, objectives, types of screens, disposal of screenings, design of screen chamber - Grit chamber: Purpose, functioning, design of grit chamber - Sedimentation tank: Purpose, mechanism, Types of sedimentation tanks, design of primary sedimentation tank - Oil and grease removal: skimming method, vacuum floatation - Secondary Treatment (Biological treatments): Purpose, theory, classification of the processes, attached growth and suspended growth processes, comparison of biological processes - Activated sludge process: Conventional process and modifications, oxygen requirement aeration systems, Trickling filters, components, mechanism principle and working of rotating biological contractor	13		

	• Low cost treatment processes and design criteria: Septic tanks, ponds and lagoons, design of pond and lagoon, root zone technology • Natural methods of wastewater disposal: Self-purification of streams, disposal by dilution, disposal by land treatment, dilution into sea, standards for land disposal, for irrigation, effluent and stream standards			
	Assignment 2: Discussion and presentation of selected research paper in groups of 2/3 students OR any assignment as given by the faculty		03	
4	Sludge treatment and disposal • Objectives, Sludge thickening (Gravity thickening, Air flotation, Centrifugation), • Sludge digestion (anaerobic digestion, Types of digester), sludge dewatering (Sludge drying bed, vacuum filtration) • Disposal methods for sludge.	07		
	Minor test 1			01
	Total	36	06	02

Reference Books

1. Abbasi S.A. and E.Ramasami, Biotechnical methods of pollution control, Universities Press, 1999.
2. Agrawal K.C, Environmental Pollution – Causes, effects and control, Nidhi Publishers, 2001.
3. B.S.N Raju, Water supply and waste water engineering, Tata Mc Graw Hill Publishing Company Ltd, 1995.
4. Bhatia S. C, Handbook of Industrial Pollution and Control, Volume 1, CBS Publishers & Distributors.
5. Cormack D, Response to oil and chemical pollution, Applied science Publishers,1983.
6. Dhamija Urvashi, Sustainable Solid waste Management – Issues, policies and structures, Academic Foundation, 2006.
7. Frank Kreith, Handbook of Solid Waste Management, McGraw-Hill, Inc.
8. Gaikwad, R.S. Sapkal Environmental Engineering Denett & Co. 2006.

9. Hosetti B. B, Prospects and Perspectives of Solid Waste Management, New Age International Publishers, 2006.
10. Kshirsagar S.R, Water supply engineering, Roorkee Publishing House, 1966.
11. Lal Banwari and M .P Reddy, Wealth from waste, TERI, 2nd edition, 2005.
12. Lal, Banwari, Sarma, Priyangshu M., 2011, Wealth from Waste: Third Edition, The Energy and Resources Institute (TERI).
13. Lund Herbert F, The McGraw – Hill Recycling Handbook, McGraw- Hill Inc., 1993.
14. Mathur R, Asha Mathur and Sanjay Sharma, Latest advances in environmental conservation, Scientific Publishers, 1998.
15. Metcalf and Eddy, Wastewater engineering treatment and reuse, Tata Mc-Grawhill Publishing Company Ltd, 4th edition, 2003.
16. Metcalf and Eddy, Wastewater engineering: Treatment, disposal and reuse, Tata Mc Graw Hill Publishing Company Ltd, 3rd edition, 1991.
17. Mhaskar A. K, Matter Hazardous, Enviro Media Publications.
18. Modak Prasad, Waste Minimization – A Practical Guide to Cleaner Production and Enhanced Profitability, Centre for Environment Education.
19. Nathanson Jerry A, Basic Environmental Technologies - Water supply, waste management and pollution control; Prentice Hall Inc., 4th edition, 2003.
20. Nazaroff William W and Lisa Alvarez Cohen, Environmental Engineering Science, John Wiley & Sons Inc, 2001.
21. Noyer Robert, Unit operations in environment engineering, JAICO publishing House, 2005.
22. Noyes Robert, Unit Operations in Environmental Engineering, Jaico Publishing House, 2005.
23. Paevy , Rowe and Tschobanoglous, Environmental Engineering , Tata Mc Graw Hill Publishing Company Ltd, 1995.
24. Pandey G.N and G.C. Carney, Environmental engineering , Tata Mc Graw Hill Publishing Company Ltd, 1994.
25. Pandey G.N and G.C. Carney, Environmental engineering, Tata McGraw- Hill Publishing company.
26. Plastics for Environment & Sustainable Development; Indian Centre for Plastics in the Environment, Central Institute of Plastics Engineering and Technology.
27. Punmia B.C. and Ashok Jain, Wastewater engineering, Laxmi Publications, 2005.
28. Ramchandra T.V, Management of Municipal Solid Waste, Capital Publishing Company, 2006.
29. Rangawala S.C., Water supply and sanitary engineering Charotar Publishing House, 2005.

30. Rao C.S, Environmental Pollution Control Engineering, New Age International (P) Ltd, 1991.
31. Sawyer, McCarty and Parkin, Chemistry for environment Forth edition, Tata Mc Graw Hill Publishing Company Ltd, 1994.
32. Sharma B.K, Environmental Chemistry, Goel Publishing House, 2004.
33. Shukla S.K and P.K.Shrivastav, Waste management and control, Common Wealth Publishers, 1992
34. Sinha Rajiv K and Sunil Heart; Industrial Wastes – Health impacts and management plans, Pointer Publishers, 2004.
35. Trivedi P. R and Gurdeep Raj, Solid Waste Pollution;, Akashdeep Publishing House.
36. Trivedi R.K and P.K.Goel, Chemical and biological methods for water pollution studies, Environmental Publications,1986.
37. Upadhyay, Rai and Mishra, Recent advances in waste management, BIS publication.

COURSE NO: EST 203

Course Title: Solid and Hazardous Waste Management

Number of Credits: 3

No. of Lectures-Assignment-Tutorial: 36-6

Course Coordinator: Ms. Anushka Kajbaje

Course Outline

This course builds a deep understanding of technical and social issues involved solid and hazardous waste management alongwith highlighting best practices and strategies that meet the public health and environmental concerns. It also focuses on financial and legal aspects of solid waste management through the evaluation of appropriate case studies.

Learning Outcomes

Students will develop:

- A deep understanding of the fundamental principles of solid waste management.
- Build capacity to evaluate the environmental, financial and legal concerns of solid waste management.
- Acquire skills to facilitate establishment of effective management system for solid waste.

Evaluation Procedure: 60/40: University Exam / Internal Assessment

Assignment	2	20%	Internal Assessment
Minor Test	1	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

Unit	Topic	Time (Hours)		
		L	T	P
1	Introduction to Solid Waste • Sources, quantities and composition of solid wastes; Physical characteristics (specific weight, moisture content, particle size and distribution, field capacity) Chemical characteristics (proximate analysis (volatile combustible matter, fixed carbon, ash), fusing point, ultimate analysis, energy content) and Biological characteristics (biodegradability of organic waste component, odour production)	2		

	Causes of generation of solid waste, consumerism and consumption patterns, health and environmental impacts of improper handling of solid waste, social aspects related to solid waste management			
2	Waste generation, collection, storage and transport Waste stream assessment, collection components, storage (containers, storage bins, collection vehicles), collection operation (movement of collection crew, collection vehicle routing) transfer station (types, capacity, viability).	04		
3	Source reduction and recycling - Purpose, implementation, monitoring, evaluation, - Significance of recycling, planning for recycling programme - Recycling programme elements: source separation, drop-off/buy-back, curbside programmes, storage and collection of recyclables, processing equipment's for recycling, Material recovery facilities (MRFs) - Commonly recycled materials and processes: paper and cardboard, glass, metals, plastics, batteries and tyres.	05		
	Assignment 1: Discussion and presentation of selected research paper in groups of 2/3 students OR any assignment as given by the faculty		03	
4	Composting Theory of composting, types of composting, factors governing composting, design of mechanical composting plant	04		
5	Energy recovery–Waste to energy - Combustion of waste material, incineration objectives, planning an incineration facility, types of incinerators, energy recovery, air emission and its control (gaseous pollutants, gas cleaning equipment's), pyrolysis and its products, environmental concerns. - RDF, fuel from plastic, biomass energy,	04		

	Biogasification: anaerobic processing, types of digesters, biogas plants in India			
6	Sanitary Landfill - Principle, landfill processes, methods of landfilling, - Landfill gas generation: Composition and properties, hazards, migration, control - Leachate formation: Composition and properties, leachate migration, control and treatment - Environmental effects of landfill - Landfill operation issues: Design and construction, operation, monitoring	04		
	Assignment 2: Submission of 2-3 page paper on pre decided topics (individual assignments)		03	
7	Integrated solid waste management (ISWM) - Characteristics of ISWM, planning for ISWM, implementation and benefits of ISWM, waste management modelling, Life Cycle Assessment (LCA); benefits, phases and stages of LCA - Cost economics of solid waste management	04		
8	Management and Treatment of Hazardous waste - Identification and classification of hazardous waste, hazardous waste management: generation, storage and collection, transfer and transport, processing, disposal. - Hazardous waste treatment: physical and chemical treatment, thermal treatment, and biological treatment - Hazardous waste management in India - Biomedical waste management- classification, collection, segregation, treatment and disposal, radioactive, Common Biomedical Waste Treatment Facilities	04		
9	E- Waste management Inventory management, production process modification, volume reduction, recovery and reuse,	3		

	sustainable product design, responsibilities of government, industries, citizens			
10.	Solid waste management rules 2016			
	Minor Test 1			01
	Total	36	06	01

Reference Books

1. Agrawal K.C, Environmental Pollution – Causes, effects and control, Nidhi Publishers, 2001.
2. Bhatia S. C, Handbook of Industrial Pollution and Control, Volume 1, CBS Publishers & Distributors.
3. Bhatia S. C, Handbook of Industrial Pollution and Control, Volume 2, CBS Publishers & Distributors.
4. Dhamija Urvashi, Sustainable Solid waste Management – Issues, policies and structures, Academic Foundation, 2006.
5. Frank Kreith, Handbook of Solid Waste Management, McGraw-Hill, Inc.
6. Hosetti B. B, Prospects and Perspectives of Solid Waste Management, New Age International Publishers, 2006.
7. Lal Banwari and M .P Reddy, Wealth from waste, TERI, 2nd edition, 2005.
8. Lund Herbert F, The McGraw – Hill Recycling Handbook, McGraw- Hill Inc., 1993.
9. Mahadeviya D., 2008, Solid waste management in Indian cities – status and emerging practices, Concept Publisher Companies.
10. Mhaskar A. K, Matter Hazardous, Enviro Media Publications.
11. Modak Prasad, Waste Minimization – A Practical Guide to Cleaner Production and Enhanced Profitability, Centre for Environment Education.
12. Nathanson Jerry A, Basic Environmental Technologies - Water supply, waste management and pollution control; Prentice Hall Inc., 4th edition, 2003.
13. Nazaroff William W and Lisa Alvarez Cohen, Environmental Engineering Science, John Wiley & Sons Inc, 2001.
14. Noyes Robert, Unit Operations in Environmental Engineering, Jaico Publishing House, 2005.
15. Pandey G.N and G.C. Carney, Environmental engineering, Tata McGraw- Hill Publishing company.

16. Patwardhan A. D., 2013, Industrial solid wasters, TERI
17. Plastics for Environment & Sustainable Development; Indian Centre for Plastics in the Environment, Central Institute of Plastics Engineering and Technology.
18. Ramchandra T.V, Management of Municipal Solid Waste, Capital Publishing Company, 2006.
19. Rao C.S, Environmental Pollution Control Engineering, New Age International (P) Ltd, 1991.
20. Sinha Rajiv K and Sunil Heart; Industrial Wastes – Health impacts and management plans, Pointer Publishers, 2004.
21. Trivedi P. R and Gurdeep Raj, Solid Waste Pollution;, Akashdeep Publishing House.

COURSE NO: EST 204

Course Title: Air and Noise Pollution Management

Number of Credits: 3

No. of Lectures-Assignment-Tutorial: 36-6

Course Coordinator: Dr. Rashmi Mardikar

Course Outline

The course focuses on the essential concepts and skills related to air and noise assessment. This includes understanding of various techniques involved in assessing air and noise as well as techniques for their control.

Learning Outcomes

At the end of the course, students should have:

- Basic understanding of the concepts involved in air and noise management
- Understanding of various assessment mechanisms of air and noise.
- Develop skills in management of air and noise pollution.

Evaluation Procedure: 60/40: University Exam / Internal Assessment

Assignment	2	20%	Internal Assessment
Minor Test	1	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	A	T/E
1	Introduction • Origin of the atmosphere, Structure, upper and lower atmosphere, temperature & pressure profile, chemistry of atmosphere, significance of troposphere, stratosphere, mesosphere, and thermosphere • Definition of pollution, difference between pollutant and contaminant, composition of air, history of air pollution, • Types of pollutants: Particulate matter, gaseous pollutants, aerosols, primary and secondary pollutants, chemistry of pollutants	08		

	- Sources of air pollution: natural and anthropogenic sources, domestic, industrial and automobile emissions point, line, area source - Effects of air pollutants on human health, vegetation and material with case studies and fact sheets, air pollution episodes, Occupational health hazards, personal protective equipments - Exhaust emissions, (CO, CO₂, Sox, Nox, HC, Smoke), status of vehicular pollution in Indian metro cities, control of vehicular emissions (catalytic converter, fuel change, lead phase out program, PUC, monitoring of vehicular emissions, air fuel ratio, awareness)			
2	Meteorology and air pollution dispersion - Motion of air: Planetary and Synoptic, mesoscale, microscale Land and sea breezes, hill and valley winds, Heat Island, measurement of wind speed and wind direction, representation and interpretation of wind data, wind rose - Concept of lapse rate, ambient, and adiabatic lapse rate, lapse rate and atmospheric stability, conditions Influence of meteorological factors on air quality: Plume behavior, mixing height, pressure and dispersion, wind and dispersion - Mathematical models for dispersion, estimation of ground level concentrations of pollutants, Gaussian dispersion model, design of stack, effect of air pollution on meteorological conditions - Environmental issues : Causes ,effects of climate change, green house effect, global warming, ozone depletion, acid rain preventive methods - Numerical excluding design	07		
	Assignment 1 Discussion and presentation of selected research paper in groups of 2/3 students OR any assignment as given by the faculty		03	
3	Air pollution control	07		

	• Air pollution control equipments - For particulate matter: Gravity settlers, Cyclones, fabric filters, Inertial separators, ESP, wet scrubber, Control equipments for gaseous pollutants: Combustion (after burner, flares, catalytic combustion) Absorption by scrubber, adsorption, close collection and recovery system, masking • Preventive techniques - Raw material and fuel substitution, process modification, alteration of equipment. good operating practices, Shifting of source Air pollution control at source: Proper disposal of effluents			
	Assignment 2 Discussion and presentation of selected research paper in groups of 2/3 students OR any assignment as given by the faculty		03	
3	Air quality monitoring and measurement • Objectives , Sampling principles, Sampling methods and procedures, • Sampling of Dust (Dust jar), SPM (High Volume Sampler) RPM(Respirable dust sampler) SO₂, Nox, CO, CO₂ (Impinger method) and lead (acid digestion), smoke monitoring (by Rengleman scale), handling and storage of samples, sampling precautions • Air quality monitoring: Ambient air monitoring, Stack monitoring, bio monitoring, air quality monitoring program in India • Air pollution status :Comparison of world and Indian situation, status of vehicular pollution in metro-cities of India Clean Development • Air quality management: Air quality criteria, air quality standards, air quality indices air quality management in India, Criteria siting of industries and green belts, zoning, Bio remediation for air pollution control • Air pollution legislations	06		
4.	Noise pollution • Introduction	05		

	• Definition of noise, Characteristics of sound, difference between noise and sound, measurement of sound pressure and intensity level, noise monitoring national and international standards (permissible limits) for noise, zoning based on noise levels • Sources of noise - industrial noise, transport noise, neighborhood noise, Noise during festivals • Structure of ear, acute and chronic effects of noise on human health, physical and psychological effects, Temporary and permanent threshold shift, noise induced hearing loss, audiometric test • Noise control measures: Control at source, control of transmission, protection of recipient			
5	Minor test 1			01
	Total	36	06	01

Reference Books

1. Rao M.N and H. V. N. Rao, Air Pollution, Tata Mc-Grawhill Publishing Company Ltd, 1989.
2. Trivedi R.K and P.K.Goel, Introduction to air pollution, ABD Publishers, 2003.
3. Trivedi P.R. and Gurdeep Raj, Nuclear and thermal pollution, Akashdeep Publishing House, 1997.
4. Shukla S.K. and P.K.Shrivastav, Environmental noise impact analysis, Common Wealth Publishers, 1992.
5. Kamboj N.S., Control of noise pollution, Deep & Deepa Publications, 1993.
6. Brown Paul, Global warming, Universities Press, 1996.
7. Christainson Galee, Green house, Universities Press, 1999.
8. Trivedi R.K and P.K. Goel, Introduction to air pollution, Technoscience Publications, 1995.
9. Sharma B.K, Environmental Chemistry, Goel Publishing House, 2004.
10. Paevy, Rowe and Tschobanoglous, Environmental Engineering, Tata Mc Graw Hill Publishing Company Ltd.
11. Gaikwad and R.S. Sapkal, Environmental Engineering, Denett & Co, 2006.

COURSE NO: EST 205

Course Title: Research Methodology

Number of Credits: 2

No. of Lectures-Assignments: 30

Course Coordinator: Mr. Venkatraman G

Course Outline

The course will provide students with a critical understanding of the research process and familiarize students with the main approaches, methods and techniques of qualitative and quantitative research. The course will enable students to undertake their own independent research and apply appropriate research methodologies in order to plan, conduct and evaluate basic research as part of their degree and provide a solid foundation for further advanced research.

Learning Outcomes

- Ability to identify various sources of information and write up a literature review
- Planning and conducting basic qualitative and quantitative research
- Ability to write an introduction and literature review

Evaluation Procedure: Continuous

Assignments	1. Write an introduction chapter (2500 words) 2. Write a literature review (2500 words)

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	A
1.	Research Design: Overview • Understanding research • The qualitative/quantitative divide • Overview of different research traditions – action research, case studies, documentary analysis, ethnographic research, experiments, grounded theory, surveys	02	
2.	Planning the research • Selecting a topic • Topic to research question – problem definition, research question, hypothesis, research objectives • Research question to research design –developing the design • Data gathering – primary and secondary	02	

3.	Literature Review • Introduction to literature review • Methodology of literature review • Literature sources – books and journals, electronic databases, government and industry, internet; searching on keywords • Information management – keeping records of searches • Writing a literature review • Referencing – systems, referencing websites, citations, use of software	06	
4.	Developing the methodology Types of research design structure: Experimental design structure, quasi experimental design, observational research Sampling: Sampling strategies, Probability sampling (simple, systematic, cluster stratified); Non-probability sampling (convenience sampling, quota sampling, targeted sampling, chain referral); sample size in qualitative and quantitative research	04	
5.	Qualitative Research • Collecting secondary data - journals, existing documents and records, etc.; • Collecting primary data through: Participant observation; Qualitative interviews (informal, unstructured, semi-structured, focus), interview techniques, sources of inaccuracy and dealing with them, recording data, triangulation; Questionnaires-drafting questions, building a coding list, field piloting; Documenting local environmental knowledge and change; PRA techniques; Participatory mapping	06	
6.	Preparing for fieldwork • Paperwork, permissions, equipment, travel; Role of the researchers; Ethical Considerations - Ethics committee, ethical guidelines – voluntary participation, informed consent, confidentiality and anonymity, plagiarism, academic fraud and misinterpreting results, conflict of interests, observation, permissions, video/audio taping	04	

7.	Processing and analysis of qualitative data Analysis during data collection- annotations, memos, coding; Quantitative Analysis: Descriptive statistics – tools and software, types of data, visualizing data (graphs), cluster analysis, measuring the spread Quantitative Analysis: Inferential statistics – significance levels and hypothesis testing, probability distributions, comparing single variable in two or more samples, relationship between variables	06	
	Assignment 1: Writing an introduction		
	Assignment 2: Writing a literature review		
	Total	30	

Assignments

The separate assignments will result in a single document – the research proposal of the student.

Suggested Readings

1. Becker, H. S. Writing for Social Scientists: How to Start and Finish Your Thesis, Book, or Article. University of Chicago Press, 2007.
2. Creswell, J. W., and V. L. P. Clark. Designing and Conducting Mixed Methods Research. Wiley Online Library, 2007.
3. Denzin, N. K., and Y. S. Lincoln. The Sage Handbook of Qualitative Research. Sage Publications, Incorporated, 2005.
4. The SAGE Handbook of Qualitative Research (3 Rd. Thousand Oaks, CA: Sage, 2005.
5. Hart, C. Doing a Literature Review: Releasing the Social Science Research Imagination. Sage Publications Limited, 1999.
6. Malmfors, B., P. Garnsworthy, and M. Grossman. Writing and Presenting Scientific Papers. Nottingham University Press UK, 2004.
7. Morrison, M. L., B. Marcot, and W. Mannan. Wildlife-habitat Relationships: Concepts and Applications. Island Press, 2006.
8. O'Connell, A. F., J. D. Nichols, and K. U. Karanth. Camera Traps in Animal Ecology: Methods and Analyses. Springer, 2010.
9. O'Leary, Z. The Essential Guide to Doing Research. Sage Publications Limited, 2004.
10. The Essential Guide to Doing Your Research Project. Sage Publications Limited, 2009.
11. Peat, J. et al. Scientific Writing: Easy When You Know How. BMJ books, 2007.

12. Ridley, D. The Literature Review: a Step-by-step Guide for Students. Sage Publications Limited, 2012.
13. Silverman, D. Doing Qualitative Research. Sage Publications Limited, 2009.
14. Torraco, R. J. "Writing Integrative Literature Reviews: Guidelines and Examples." Human Resource Development Review 4.3 (2005): 3

COURSE NO: EST 206

Course Title: Natural Resource Management

Number of Credits: 3

No. of Lectures-Tutorial: 36-6

Course Coordinator: Dr. Kranti Yardi

Course Outline

The course is intended to impart knowledge and skills considered crucial for natural resource managers to manage effectively in the dynamic and intricate environment. It enhances the students' understanding at diverse levels by maintaining the equilibrium between the occupation obligations and enduring growth requirements. The fundamental thrust of the course is to assist the students to obtain theoretical and logical abilities in relation to the field situations, necessary for managing natural resources efficiently.

Learning Outcomes

The student will be able to:

- Contribute in managing the resource in a comprehensive way as professionals working in this sector
- Balance the needs of people and the economy with protecting the ability of ecosystems to support soil, water, forests, wildlife, fish, recreation, and other resources

Evaluation Procedure: Continuous

Assignments	40 % (3)	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment • Completed home assignment submitted timely and excellent written presentation	Assignments must be in the prescribed format. All assignments to be submitted digitally.	Internal Assessment
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)

		L	A	T/E
1.	Natural Resources – overview - Natural Resources –global, national (role of environment ministry and congruent ministries, local (Panchayati raj)) - Land, water, air ,biodiversity, energy resources , Common property resources - Natural resource governance and policy – policy building, legislation, administrative action, judiciary - Role of NGOs and academics	05		
2.	Theoretical aspects of Natural Resource Management - Livelihoods and Natural Resources - Global natural resource issues (water conflicts, interstate conflicts) International collaboration to address complex natural resource issues - Natural Resource Economics - Society, Ethics and Participatory Development - Conflicts management - land, biodiversity, water	03		
	Assignment 1: Any assignment as given by the faculty		03	
3.	Integrated watershed management - Definition of watershed - Watershed development strategy - Socio-economic and natural resource information through PRA's - Land surveys through land class determination for area, slope, depth of soil, texture, erodibility; soil and water testing - Engineering surveys – topographical surveys, drainage line survey, contour survey - Ecological assessment of the area – A statement of significance; site description-significant habitat types, native species of wild plants and animals of conservation importance, significant corridors, biotic pressures and threats, significant ecological services. People and their relationship with natural areas (valid and invalid stakes). - Microplanning – microplanning process, difficulties faced during microplanning, advantages of microplanning	10		

	Principles of soil and water conservation			
	Assignment 2: Ecological assessment of a given area using GIS compatible technique		03	
	Assignment 3: Collection of data using GIS compatible participatory rural appraisal technique		03	
4	Analytical aspects of Natural Resource Management - Remote sensing and GIS application in NRM - Statistical analysis in NRM - Vegetation inventory and rapid assessment - Financial analysis and project management in NRM - Environmental Impact Assessment (EIA) and Auditing	05		
5	Managerial aspects of Natural Resource Management The role of communication in natural resource management; Facilitating discussions with multiple stakeholders, multiple perspectives; Conflict management; Policy negotiation; Collaborative planning for - Wildlife conservation and management - Wetland management - Watershed management - Urban forestry - Biodiversity and landscape - Climate change and carbon trading - Agro-ecosystems and Agro forestry - Environmental modeling - Eco-tourism and other environmental services - Bio-resources – Access and benefit sharing	11		
	Final Assessment			03
	Total	36	9	03

Suggested Readings

1. Francois Ramade 1984. Ecology of Natural Resources. John Wiley & Sons Ltd.
2. Harris, J.M. 2006. Environmental and Natural Resource Economics: A Contemporary Approach, 2nd edition. Houghton Mifflin.

3. Coastal Ecology & Management, Mann, K.H. 2000. Ecology of Coastal Waters with Implications for Management (2nd Edition).Chap. 2-5, pp.18-78 & Chap. 16, pp.280-303.
4. Global Change and Natural Resource Management, Vitousek, P.M. 1994. Beyond global warming: Ecology and global change. Ecology 75, 1861-1876.
5. Agarwal, K.C., 2001. Environmental Biology, Nidhi Publication Ltd. Bikaner.
6. Cunningham, W.P. Cooper, T.H. Gorhani, E & Hepworth, M.T. 2001,Environmental Encyclopedia, Jaico Publishing House.
7. Heywood, V.H. & Watson, R.T. 1995. Global Biodiversity Assessment. Cambridge Univ. Press.
8. Miller T.G.Jr. Environmental Science, Wadsworth Publishing Co. (TB)
9. Townsend C., Harper J, and Michael Begon. Essentials of Ecology, Blackwell Science.
10. Barber, E. 1989. Economics: Natural Resources Scarcity and Development. Earthscan.
11. Kamaljit S. B., et. Al., 2011, Conservation Biology, Universities Press.

COURSE NO. EST 207

Course Title: Environment and Health

Number of Credits: 3

No. of Lectures-Tutorial-Practical: 36-06

Course Coordinator: Dr. Thomas Krafft, University of Maastricht, Netherlands

Course Outline

The aim of this course is to provide the students with a comprehensive understanding and applicable knowledge of health geography as a scientific concept using tools like GIS for a holistic approach to public health that promotes the wellbeing of human populations through organizing data and understanding links between environment and health. The health of human population reflects the complex interplay between population characteristics and the environment. Genetic makeup can predispose certain populations to chronic or acute conditions. Cultural factors, such as stress, economic status, and access to health care, can play a significant part on disease onset. Students will learn how to assess environment and health related issues with different methodologies and they will be able to conduct a critical analysis on health and environment related research. The use of environmental health chain to study mechanism by which environmental hazards impacts health will be discussed as well as the aspect of the governance process to mitigate or eliminate environmental health hazards. Special focus will be laid on measuring health outcomes, mortality, incidence, prevalence etc.

Outcomes

Students will develop:

- Ability to apply the theoretical frameworks offered during the course to actual cases of environmental health problems.
- Ability to prioritize different interventions to manage environmental health risks.
- Ability to formulate simple research protocols for environmental measurements, exposure assessment or health effect assessment.
- Conduct simple analysis on health and environment using Geographic Information Systems and spatial cluster detection software.
- Discuss the suitability of various study designs and approaches in environmental and health research

Pre-requisite : None

Assessment: Continuous

Assignments	40 %	Marking pattern for every assignment	Assignments must be in the prescribed I	Internal Assessment

	(3)	- Innovativeness and accuracy in completing the assignment - Completed home assignment submitted timely and excellent written presentation	format and should be submitted digitally.	
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	T	P
1.	Outline of the course - Introduction to Health Geography and Environmental Health Introduction - Health Geography and Environmental Health Human Ecology Models - Theoretical approach to study the forces in a person's environment that affects and influences development and interaction between individuals. One Health Concept - Interconnectedness of the health of humans, animals and ecosystems; Application of a coordinated, collaborative, multidisciplinary and cross-sectoral approach to address potential or existing risks that originate at the animal-human-ecosystems interface. Emerging and Re-emerging diseases - Formerly unknown diseases that are increasing in time and a specific location; Emerging diseases and reemerging diseases . <u>Task:</u> background literature for reading till next session	3		2

2.	PBL Case 1: Environmental Health Hazards		4	2
3.	Global Environment Change, Human Health and Public Health Environmental Health Chain • Exploring relationships between environment and human health; Causes and effects, causal chain, showing the links between sources and impacts. Environmental Determinants of Health • Environmental determinants of health - external factors such as access to safe water, air pollution, droughts and others that can be causally linked to a change of health status. Social Determinants of Health • Social determinants of health - conditions, in which people were born, live, grow up and age. Social determinants of health and health inequities - the differences in health status within and between countries. Task: Answering questions during a group discussion round, prepare for presenting the results during the next session.	2		1
4.	Urbanization and Health Impacts Urbanization and Migration • Urbanisation and links to health, safe water, electricity and sewerage. • Urban – Rural Health Divide • Urban-rural divide in terms of infrastructure, environmental quality and health issues. Urban Health Models • Urban health models - challenge of communicating and modeling the complex relationships and interdependencies of various determinants of health in urban areas. Healthy City Concept	2		1

	- Political and social agenda of cities , movements for public health at the local level, equity, participatory governance and solidarity, intersectoral collaboration and action to address the determinants of health. Health and Wellbeing in the Changing urban environment - ICSU approach - Approach of the International Council for Science (ICSU) to study the causal chain and various complex interactions between different processes and factors that influence health and wellbeing in urban environments. Ambient Particulate Matter (PM) - Particulate matter and human health, exposure in urban, industrial areas and health issues. <u>Task:</u> Answering questions during a group discussion round, prepare for presenting the results during the next session.			
5.	PBL Case 2: Exposure to bad Air Quality		4	2
6.	Methodologies in the field of Health Geography and Environmental Health Health Impact Assessment - Economic sectors such as transport, agriculture and housing and health impacts; Health Impact Assessment - assessing the health impacts of policies, plans and projects in diverse economic sectors using quantitative, qualitative and participatory techniques. Geographic Field Work Methodologies - Quantitative and qualitative methodologies applied in the field of health geography. Pressure and Release model - Pressure and relief model - interactions that lead to an increase of vulnerability within a society and its relation to hazards that may become a disaster through the progression of vulnerability.	4	2	

	Introduction to Health GIS as a tool of health geography and environmental health research • Application of GIS to monitor health related data and evaluate contributing environmental factors on human health. <u>Task:</u> Paper (10 page) on one of the topics presented during the lectures or a topic of their own research interest. This paper needs to be handed before the symposium. The paper will be presented during the symposium via PowerPoint.			
7.	Vulnerability and Global Environmental Change Drivers of Change • Global environmental hazards to human health include climate change, stratospheric ozone depletion, changes in ecosystems due to loss of biodiversity and a wide range of other factor; . Drivers of global environmental change and its interdependencies. Concept of Vulnerability and Resilience • Societal response, particularly the societal capacity to adapt to climate change impacts and links to severity of impacts and the costs of adaptation. Vulnerable populations • Driving factors that contribute to the vulnerability of a specific population Risk Assessment • Conducting risk assessments through identification of potential hazards, vulnerable populations and measurement of the impact a potential hazard on vulnerable populations. Mitigation and Adaptation • Adaptation and mitigation with respect to climate change. Exposure • Exposure of populations to various hazards.	2		2

	<u>Task:</u> Practical Framing research question, design research and prepare a poster for presentation at the workshop			
8.	PBL Case 3: Exposed?		4	2
9.	Training Workshop on Health Geography and Environmental Health The training workshop will be designed including lectures on GIS application, spatial cluster detection using SaTScan, visualizing health data, design maps for health study and projection and using spatial data. The students have to present and discuss the findings of their practical tasks in a special session at the end of the training workshop. Students will learn how to address health-related challenges, from disease analysis to policy planning. During the training workshop the students will present their papers via Power Point. Further the students will present in a special session their research posters. The time duration for the training workshop will be 5 days.	8	6	8
	Total	36	09	

Assignments

Reading: The students have to get a broad overview of the topic by reading assigned background literature.

PBL elements: Answering research questions on environment and health issues in a group discussion and presenting the results during the class based on problem-based learning (PBL).

Paper: The students will be asked to prepare a paper on one of the topics presented during the lecture or a topic of their own research interest. The paper will be a 10 page document which will be need to be handed in up to a clear deadline and will be assessed by the teachers of the course.

Poster presentation: The students will be asked to prepare a poster on one of the topics presented during the lecture or a topic of their own research interest. This poster will be presented during the symposium. The students will have 10 minutes for presentation followed by a 5 minute open discussion. The goal of this exercise is to familiarize the students with poster presentation for conferences.

Research proposal exercise: The students will be divided in small groups, the groups will be asked to design a research proposal that address one of the research issues that were presented during the lectures. The results will be presented by the groups via PowerPoint during the symposium.

Methodologies: During the course there will be a focus on methodologies to assess Environment and Health related issues. During the symposium there will be an assignment for the students to carry out a cluster detection using SaTScan software. Further there will be a special session on Health GIS where students will learn basic application of GIS for health related research questions.

Suggested Readings

1. Brown T and Moon G. (2012) Commentary- Geography and global Health, *The Geographical Journal*, 178, 13-17.
2. McMichael A, Woodruff E, Hales S. (2006) Climate Change and human Health: present and future risks, *Lancet*, 367, 859-869
3. Haines A, Kovats R S, Campbell-Lendrum D, Corvalan C. (2005) Climate Change and human health: Impacts, vulnerability and public health, *Public Health*, 120, 585-596
4. Haines A, Kovats R S, Campbell-Lendrum D, Corvalan C. (2006) Climate change and human health: impacts, vulnerability, and mitigation, *Lancet*, 367, 2101-2109
5. Atul A, Khasnis, Nettleman M D. (2005) Global Warming and Infectious Disease, *Archives of Medical Research*, 36, 689-696
6. Patz J, Campbell-Lendrum D, Holloway T, Foley A. (2005) Impact of regional Climate Change and human health, *Nature*, 438, 310-317
7. Climate Change and Health: Research Challenges for Health in the Developing Countries, *Indian Journal of Occupational and Environmental Medicine*, 14,
8. Castello A et al. (2009) Managing the health effects of climate change, *The Lancet Commissions*, 373, 1693-1733
9. Kovats S, Akhtar R (2008) Climate, Climate Change and Human Health in Asian Cities, *Environment and Urbanization*, 20, 165-175
10. Allen D E, Donham R S, Bernhardt S A (2011) Problem-Based Learning, *New Direction for Teaching and Learning*, 128, 21-29
11. Thomas I (2009) Critical Thinking, Transformative Learning, Sustainable Education, and Problem-based Learning in Universities, *Journal of transformative Education*, 7, 245
12. Pawson E, Fournier E, Haigh M, Muniz O, Trafford J, Vajocki S (2011) Problem-based Learning in Geography: Towards a critical Assessment of its Purposes, Benefits and Risks, *Journal of Geography in Higher Education*, 30:1, 103-116

13. Dummer T (2008) Health Geography: supporting public health policy and planning, *Canadian Medical Association Journal*, 178:9, 1177-1180.
14. Curtis S E, Oven K J (2011) Geographies of health and climate change, *Progress in Human Geography*, 36, 654-666.
15. Smyth F (2007) Medical geography: understanding health inequalities, *Progress in Human Geography*, 32, 119-127.
16. Bei X, Nath I, Capon A, Hasan N, Jaron D (2012) Health and wellbeing in the changing urban environment: complex challenges, scientific responses and the way forward, *Current opinion in Environmental Sustainability*, 4, 465-472.

Journals

1. Lancet
2. Environment and urbanization
3. Indian Journal of Occupational and Environmental Medicine
4. Nature
5. BMC Public Health
6. International Journal of Health Geographic (<http://www.ij-healthgeographics.com/>)
7. Progress in Human Geography

COURSE NO: EST 208

Course Title: Climate Change Science and Strategies

Number of Credits: 3

No. of Lectures-Tutorial: 36-06

Course Coordinator: Ms. Aditi Lanke with inputs from external faculty

Course Outline

Global climate change is a planetary scale phenomenon that impacts upon all socioeconomic and natural systems. Despite the growing consensus about the fundamentals of climate warming, scientific understanding of the complex interactions of ocean, land, clouds, and atmosphere remains highly uncertain, particularly with respect to environmental, social, and economic disruptions affecting human societies. This course will provide students with the scientific literacy to understand the issue itself and consider existing solutions such as the Kyoto Protocol, voluntary measures, etc. The guiding principle will be to promote the understanding needed to evaluate, develop, and propose emerging and creative solutions at individual, campus, and local levels. This course will examine the dilemmas faced in climate science, politics, economics, management, and ethics – all with an eye to the implications for global and regional sustainability.

Learning Outcomes

The student will be able to:

- Think intelligently about the issue and to understand what processes are currently underway and what more can be undertaken.
- Understand the precarious feedbacks from the climate system that could create dramatic impacts.
- Understand, plan and propose creative solutions at temporal, spatial, political, scientific, and social scale.

Evaluation Procedure: Continuous

Assignments	40 % (3)	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment • Completed home assignment submitted timely and	Assignments must be in the prescribed format and be submitted digitally.	Internal Assessment

		excellent written presentation		
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	A	T/E
1	Climate science and impacts • Introduction: overview of the topic • Climate change: cause and effect • Climate disruption • Impact analysis: freshwater sources and oceans • Impact analysis: food and forests • Economic impacts of climate change	10		
	Assignment 1: Discussion and presentation of selected research paper in groups of three students.		05	
2	Policies and market issues • International treaties • Carbon trade and taxation • Strategies for low cost carbon abatement • Climate policy: global scenario • Climate policy: Indian scenario • Green business initiatives	10		
	Assignment 2: Discussion and presentation of selected research paper in groups of three students.		05	
3	Climate solutions • Energy solutions: past and present • Transportation • Building and habitation • Industry and waste management • Land use, agriculture and forestry • Adaptation and tropical forest sequestration • Geo-engineering of earth's atmosphere • Smart Cities	15		

	Assignment 3 : Discussion and presentation of selected research paper in groups of three students.		10	
4	Future direction • Mobilizing the world to action • Trends and futures of food scarcity solutions • Trends and futures of green and clean energy supply and consumption • The negotiating challenges ahead	10		
	Final Assessment			03
	Total	45	20	03

Assignments

In the assignments the students will be expected to express their view on promise and limitations of sustainability ideas and practices for dealing with climate threats. They will also be expected to understand and illustrate the nature of climate controversies and the positions of various stakeholders. The assignments will also help to create an interdisciplinary understanding of climate interactions with human and natural systems.

Suggested Readings

1. Stephen Schneider, Armin Rosencranz, Michael Mastrandrea, eds., 2010. Climate change science and policy. Island Press.
2. Bert Metz, 2010. Controlling climate change, Cambridge University Press.
3. Lester Brown, 2009. Plan b 4.0: mobilizing to save civilization. W.W. Norton.
4. Kerry Emanuel, 2007. What We Know About Climate Change. Boston: Boston Review/MIT Press
5. Tim Flannery, 2006. The Weather Makers. New York: Atlantic Monthly Press
6. Bill McKibben, 2010. Earth. NY: Times Books,
7. David Blockstein and Leo Weigman 2010. The Climate Solution Consensus NCSE/Island Press.
8. Monty Hempel, 1996. Environmental Governance: The Global Challenge. Washington, DC: Island Press.
9. Arnold J. Bloom, 2009. Global climate change: convergence of disciplines. Sinauer Associates.

COURSE NO: EST 209

Course Title: Data Analysis with R

Number of Credits: 3

No. of Lectures-Practical: 20-25

Course Coordinator/Instructor: Dr. Shamita Kumar

Course Outline

The course will introduce data analysis using R. The students will be introduced to the R language fundamentals and basic syntax along with data analysis in R

Learning Outcomes

At the end of the course the student will:

- Have an insight into the various features for analysis available in R
- Develop the ability to prepare charts, tables, and professional reports that involve complex data.
- Develop the ability to analyze and summarize data using R

Pre-requisite

Students are strongly encouraged to complete the following free online course:

<https://www.edx.org/professional-certificate/microsoft-excel-fundamentals>

Evaluation Procedure : Continuous

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed home assignment submitted timely (within 7 days): 10 marks	Practicals must be in the prescribed format and be submitted digitally.	Internal Assessment
Major exam	60%	Theory cum practical examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	T	P

1	Practical 1: Introduction to Basics R and R Studio; Basic data types in R and assign variables.	1		2
2	Practical 2: Data wrangling Working with tables: Filtering observations, arranging observations and adding/changing columns.	1		2
3	Practical 3: Data Visualisation 1 Data visualization using the ggplot2 package, using the dplyr and ggplot2 packages for creating graphs	1		2
4	Practical 4: Grouping and Summarising Using the group by and summarize verbs, visualizing summarized data	1		2
5	Practical 5: Data visualisation Create line plots, bar plots, histograms, and boxplots using different methods of data manipulation and preparation.	1		2
6	Practical 6: Exploring your data in tidyverse Using readR and exploring data	1		2
7	Practical 7: Taming the data Basics of data taming: taming the variable types, names, and values.	1		2
8	Practical 8: Tidying the data Tidying data and combining multiple tidying functions together in a chain using the pipe operator.	1		2
9	Practical 9: Transforming the data Taming specific types of variables such as dates, strings, and factors.	1		2

10.	Practical 10: Case Study Use all the tools learnt above to solve a problem.			
	Major Test		3	
	Total	12		30

1. Chang, W., 2018. R graphics cookbook: practical recipes for visualizing data. O'Reilly Media.
2. Grolemund, G., Wickham, H., 2018. R for data science.
3. Hadley, W., Garrett, G.R., 2017. R for data science: Import, tidy, transform, visualize, and model data. O'Reilly Media.
4. Villanueva, R.A.M., Chen, Z.J., 2019. ggplot2: Elegant graphics for data analysis. Taylor & Francis.
5. Wickham, H., 2016. ggplot2: elegant graphics for data analysis. springer.
6. Wickham, H., Averick, M., Bryan, J., Chang, W., McGowan, L.D., François, R., Grolemund, G., Hayes, A., Henry, L., Hester, J., 2019. Welcome to the Tidyverse. Journal of Open Source Software 4, 1686.
7. Wickham, H., Grolemund, G., 2016a. R for Data Science: Import. Tidy, Transform, Visualize, and Model Data.
8. Wickham, H., Grolemund, G., 2016b. R for data science: import, tidy, transform, visualize, and model data. O'Reilly Media, Inc.

COURSE NO: EST 2010

Course Title: Instrumentation and lab management for environmental analysis

Number of Credits: 3

No. of Lectures-Practical: 12-24

Course Coordinator: Dr. Rashmi Mardikar

Course Outline

The course is designed to develop sampling and analytical skills of the students which are required in environmental monitoring. Through this course, the students will be able to perform quantitative analysis of various physical, chemical and biological parameters involved in water, air, soil and microbiology research. The students will be exposed to various standard protocols used in environmental monitoring.

Learning Outcomes

The student should be able to:

Understand the principle and working of the various instruments

Pre-requisite

EST 102, EST 103

Evaluation Procedure: Continuous

Assignments	40 % (3)	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment • Completed home assignment submitted timely and excellent written presentation	Assignments must be in the prescribed format and submitted digitally.	Internal Assessment
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Introduction	4	

	Introduction of various equipments of environmental monitoring and analysis: High volume air sampler, Atomic absorption spectrophotometer, Flame photometer, Infrared gas analyzer, UV spectrophotometer, H.P.L.C, scanning electron microscope, transmission electron microscope. Cooling centrifuge, growth chamber, Autoclave, polarograph, nuclear magnetic resonance.		
	Practical 1		6
2	Machines involved in various equipments, working principles of all the equipments used in environmental monitoring and analysis.	2	
	Practical 2		6
3	Environmental analysis Air pollution analysis, monitoring of SO ₂ , NO ₂ , CO ₂ and analysis of SPM, sampling methods for aerosol, organic gases and vapor analysis. Water pollution analysis, Physical analysis, chemical analysis, Biological Analysis, analysis of minor components, Industrial and domestic effluent analysis, Primary, Secondary and tertiary treatment of water.	3	
	Practical 3		6
4	Soil pollution and pesticide analysis, agricultural pollution, Role of micronutrient in soil, trace elements in soil, pesticide and soil pollution ,chromatography characterized zones, polarographic spectroscopic analysis. Soil pollution and crop health, soil microbes and plants diseases. Physical, chemical and biological analysis of soil.	3	
	Practical 4		6
	Total	12	24

Suggested Readings

1. Kim Y.J. and Platt U. (Eds.) (2008) *Advanced Environmental Monitoring*, XXII, 420 p. Springer.
2. Laboratory Analytical Techniques Series (LATS), published by CPCB.
3. Roa M. (2008) *Environmental Science Activities Kit*, Jossey-Bas.
4. Wagner T.P. and Robert S. (2009) *Environmental Science: Active Learning Laboratories and Applied Problem Sets*, 2nd Edition, Wiley.
5. Wells E. (2009) *Lab Manual for Environmental Science*, Cengage Learning.

COURSE NO: EST 2011

Course Title: Environmental biotechnology

Number of Credits: 3

No. of Lectures-Tutorial: 36-07-02

Course Coordinator: Dr. BipinRaj

Course Outline

This course aims to help the student understand the theoretical bases of some biotechnological applications in the environmental sciences. Specialized tools and techniques used in such applications, as well as case studies are included to illustrate the development and application of general principles in a context-dependent manner. Contemporaneous topics such as biosafety, food security and bioenergy will be used to highlight societal concerns raised by these applications.

Learning Outcomes

The student will:

- Develop a broad understanding of the applications of biotechnology in the environmental sector.
- Clearly debate and reflect on the pros and cons of using biotechnological techniques.

Pre-requisite

None

Evaluation Procedure: Continuous

Assignments	40 % (3)	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment • Completed home assignment submitted timely and excellent written presentation	Assignments must be in the prescribed format and submitted digitally.	Internal Assessment
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)

		L	T
1	Introduction • The scope of environmental biotechnology • Biodegradation of macromolecules • Biodegradation of xenobiotics; Vermicomposting. Heavy metal pollution; Bioremediation of metal contaminated soils, spilled oil and grease deposits and synthetic pesticides. • Biosensors to detect environmental pollutants. Microorganisms and organic pollutants;	08	
	Assignment 1		03
2	Agriculture and biotechnology interface • Introduction to history of agriculture, food security and sustainable development • Plant breeding and crop improvement: perspectives from green revolution, contemporary plant biotechnology and its promise. • Transgenic plants for food security, nutrition and healthcare: Case Studies • Transgenic technology, principle, tools, techniques and methodologies • Imparting tolerance to abiotic and biotic stresses, nutritional enhancement, molecular farming for plantibodies and biomolecules of pharmaceutical and therapeutic value.	08	
	Assignment 2		03
3	Applications in plant genetics • Basic concept of genetic engineering of plants and its applications- herbicide and stress tolerant plant • Biotechnology strategies in forestry and wasteland management. • Biotechnology in biodiversity conservation: gene banks, germplasm conservation and DNA Banks. • Genetically modified organisms and Biosafety- a general account. Biotechnology for germplasm conservation and marker assisted breeding. • Fundamentals of molecular markers, DNA fingerprinting for conservation and management of	12	

	genetic resources, marker assisted breeding and selection for crop improvement		
	Assignment 3		3
4	Environmental applications • Bioenergy, ethanol fermentation. • Liquid waste treatment; Biofilters, activated sludge • systems; membrane bioreactors. • Biotechnological approaches for solid waste management, Phytotechnology-terrestrial phytosystems, metal phytoremediation, Phytotechnology-aquatic phytosystems, nutrient film techniques, algal treatment systems.	07	
	Total	36	09

Suggested Readings

1. Buchanan B.B., Gruissem W. and Jones R.L. (2000) Biochemistry and Molecular Biology of Plants, American Society of Plant Physiologists.
2. Cornish W.R. (1999) Intellectual Property (4th edition), Sweet & Maxwell, London.
3. Divan S. and Rosencranz A. (2005) Environmental Law and Policy in India, (2nd edition), Oxford, New Delhi.
4. Erbis F.H. and Maredia K.M. (eds.) (2004) Intellectual Property Rights in Agricultural Biotechnology (2nd edition), CABI Publishing, Oxon.
5. McMannis C., (ed.) (2007) Biodiversity and the Law, Earthscan, London.
6. National Biotechnology Development Strategy (Draft), Department of Biotechnology, Ministry of Science and Technology, Government of India.
7. Prescott L.M., Harley J.H. and Klein D.A. (1999) Microbiology (4th edition), McGraw Hill.
8. Report of the Task Force on Application of Agricultural Biotechnology, Ministry of Agriculture, Government of India, (2004).
9. Sankaran K. and Singh U.K. (eds.) (2008) Towards Legal Literacy: An Introduction to Law in India, Oxford University Press.
10. Stern K.R. (1997) Introductory Plant Biology, WM Brown Publishers.
11. Useful Web sites/notes/handouts (to be provided by instructors).
12. Watal J. (2001) Intellectual Property Rights in the WTO and Developing Countries, Oxford, New Delhi.

COURSE NO: GEN 201

Course Title: General English

Number of Credits: 2

No. of Lectures-Tutorial: 18-12

Course Coordinator:

Learning Outcomes

The student should be able to:

- Construct sentences with correct grammar
- Write simple reports correctly

Evaluation Procedure: Continuous

Assignment	1	100%	Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Basic language skills: grammar and usage The ability to fill in blanks, correct errors, choose correct forms out of alternative choices, join clauses, rewrite sentences as directed, replace indicated sections with single words/opposites/synonyms, etc. Skills such as punctuation of passages, changing between direct and indirect speech, expanding points into complete sentences.	08	
	Comprehension This implies (a) an understanding of the passage in question and (b) a grasp of general language skills and issues with reference to words and usage within the passage and (c) the power of short independent composition based on themes and issues raised in the passage.	08	
	Composition: Paragraph-writing Formal training in composition and précis/summary writing through instruction, discussion and written work. Letter writing, Basic report writing	08	
	Assignment		4
	Total	24	8

COURSE NO: GEN 202

Course Title: Project Management

Number of Credits: 2

No. of Lectures-Tutorial: 18-12

Course Coordinator: Mr. Parag Khatavkar/ Dr. Girish Jathar

Course Outline

The course provides an overview of techniques of project management with an emphasis on project management, organizational structures, teams, functions, planning, scheduling, cost controls, trade-offs, risk management and other related topics. The course prepares students to conceptualize, implement, monitor and evaluate the project.

Learning Outcomes

The student will:

- Construct, organize and explain project management.
- Devise, plan and compile work breakdown structures (WBS) and understand life cycle phases as quantitative tools in project management.
- Design, generate and explain scheduling techniques.

Pre-requisite

None

Evaluation Procedure: Continuous

Assignment	1	100%	Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	A
1	Introduction to project management • Definition and attributes of project and project management • Strategy in project management – establishing objectives, scoping the boundaries, priority setting, strategic development • Understanding project management and resistance to change • Project management life cycle • Critical success factors in project management • Best practices in project management	06	

	• Project monitoring		
2.	Project management methodologies • Modeling the project system – WBS, responsibility, communication plan • Estimations in projects – basic, time, cost, resources, techniques, guidelines • Developing project plans – Gantt charts, evaluating and constructing networks • Overcoming development and implementation barriers • Critical components of project management • Implementing a methodology • Strategic planning for project management	06	
3.	Issues in project management • Management Styles • Project Management Skills • Involvement of senior managers and stakeholders • Identification of projects • Project management information systems • Risk management • Change management • Role of culture in project management	06	
	Assignment		15
	Total	18	20

Assignments

In the assignment the students will be expected to design WBS, review of best practices in project management, role of change management, etc.

Suggested Readings

1. Baker, B. N., D. C. Murphy, and D. Fisher. "Factors Affecting Project Success." Project Management Handbook, Second Edition (2008): 902–919.
2. Dyball, R., and M. Keen. Social Learning in Environmental Management: Towards a Sustainable Future. Routledge, 2012.
3. Kerzner, H. Advanced Project Management: Best Practices on Implementation. Wiley, 2003.
4. Project Management: a Systems Approach to Planning, Scheduling, and Controlling. Wiley, 2009.
5. Strategic Planning for Project Management Using a Project Management Maturity Model. Wiley, 2002.

COURSE NO: EST 211

Course Title: Field Techniques II

Number of Credits: 2

Course Coordinator: Dr. Sougata Sadhukhan

Course Outline

The course provides hand on expertise with using various quantification techniques and tools for wildlife assessment including use of advanced equipment's like camera traps, bat detectors, mobile mappers, etc.

Learning Outcomes

Students will develop:

- Proficiency in using quantitative assessment techniques
- Ability to use mobile mappers, camera traps and other equipment for data collection.

Evaluation Procedure: 60/40: University Exam / Internal Assessment

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed assignment submitted timely : 5 marks	Internal Assessment
Major exam	60%		University Assessment

Details of course content

1. Estimating bird density by distance sampling –line transect/ point count methods
2. Use of DISTANCE software to analyse ecological data.
3. Occupancy Modeling
4. Conducting Participatory Rural Appraisal using household surveys (structured interview technique) and analyzing data (quantitative methods) (use two sessions if needed)
5. Conducting informal interviews and Analysing interview data (qualitative methods) (use two sessions if needed)
6. Conducting Participatory Rural Appraisal using participatory mapping/ matrix scoring/ seasonality calendar (in groups)
7. Scat Analysis
8. Animal call analysis
9. Use of camera traps and data analysis

COURSE NO: EST 212

Course Title: Lab Analytical Techniques II

Number of Credits: 2

Course Coordinator: Dr. Rashmi Mardikar

Course Outline

The course provides sound understanding of lab analytical techniques in water and water engineering and air and noise assessment and management and sets the foundation for application of these techniques in projects as well as further research.

Learning Outcomes

Students will develop:

- Proficiency in use analytical instruments.
- Ability to analyse samples using specific techniques
- Competency in interpretation of results.

Pre-requisite

None

Evaluation Procedure: 60/40: University Exam / Internal Assessment

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed assignment submitted timely 5 marks	Internal Assessment
Major exam	60%		University Assessment

Details of course content

1. Estimation of Suspended Particulate Matter (SPM) and Respirable Particulate Matter (RPM) using high volume sampler.
2. Construction of calibration curve for SO_x.
3. Construction of calibration curve for NO_x.
4. Estimation of SO_x and NO_x in ambient air (including sampling).
5. Monitoring of wind speed and wind direction using anemometer and construction of wind rose.

6. Measurement of ambient noise using noise meter.
7. Determination of acidity and alkalinity (carbonate, bicarbonate and hydroxide).
8. Determination of turbidity and optimum alum dose by jar test.
9. Determination of fluorides in given water sample.
10. Determination of chlorides in given water sample.
11. Determination of chlorine demand and residual chlorine for potable water.
12. Determination of phosphates in water / wastewater sample.
13. Determination of sulphates in water / wastewater sample.
14. Determination of BOD of wastewater sample.
15. Determination of Sludge Volume Index and Mixed Liquor Suspended Solids.
16. Determination of total solids and its fractions (Suspended, dissolved, volatile and fixed solids)
17. Determination of Total Organic Content, nitrogen, phosphorus and potassium from soil.

COURSE NO: EST 213

Course Title: Field Work

Number of Credits: 2

Number of Hours: 60

Course Coordinator: Dr. Shamita Kumar / Dr. Sougata Sadhukhan/Dr. Rashmi Mardikar/Dr. Aravindh R

Course Outline

The course provides field experience in analyzing conservation problems around Protected areas through a combination of natural science and social science research techniques.

Learning Outcomes

Students will develop:

- Proficiency in use of field methods
- Ability to analyse conservation problems.
- Competency in interpretation and presentation of results.

Pre-requisite

None

Evaluation Procedure: 0.6/0.4 University

Continuous assessment	100 %	Participation and submission of field work report	Internal Assessment

Details of course content

The field work to a National Park will be done through a twelve day block course that will involve pre field work sessions and post field work sessions. The fieldwork will focus on use of field techniques, bird identification as well as surveys to analyse resource use, tourism related problems, conservation problems, etc.

SEMESTER III

COURSE NO: EST 301

Course Title: Integrated Impact Assessment

Number of Credits: 3

No. of Lectures-Tutorial: 36-07-02

Course Coordinator: Dr. Rashmi Mardikar

Course Outline

There is growing realization that the multi-dimensional nature of sustainable development targets requires the use of different disciplinary approaches, in an integrated framework, to the impact assessment of development projects/programmes. Integrated Impact Assessment (IIA) provides such a framework for a balanced consideration of the economic, environmental, social and health impacts of development interventions at the project, sector and economy levels. The course in Integrated Impact Assessment (IIA) is designed to build detailed knowledge, understanding and skills among students for conducting IIA, so that they are able to identify sustainable modes of environmental operation. The course starts with an overview of IIA—the different methodologies on which it draws the state of the art, current practices, constraints and future directions.

Pre-requisite

None

Evaluation Procedure : 60/40: University Exam / Internal Assessment

Assignment	2	20%	Internal Assessment
Minor Test	1	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

Sr. No.	Topic	Time (Hours)	
		L	T
1.	Introduction and overview of Integrated Impact Assessment (IIA) Defining IIA; Sustainable Development challenges and need for IIA; Key Approaches of IIA: Environment, Social, Health and Economic; Current Practices, Changing Perspectives and Debate in IIA	2	
2	Assessing Environmental Impacts: The EIA Approach • Concept, purpose, evolution of EIA	10	

	• Systematic Environmental Clearance (EC) and EIA procedure in India, Environmental Impact Statement (EIS), impact indicators • EIA Notification including Form 1, Schedule I, authorities/committees and stages. • Project screening including categorization • Project scoping including Terms of reference (TOR), consideration of alternatives, establishing the study area and environmental baseline, impact identification, prediction and evaluation and impact mitigation • Public Consultation including purpose, procedure, participants • Appraisal process • EIA methodologies - ad hoc, overlays, checklists, matrices, networks; strategies for selection of EIA methodologies, methodologies for prediction: judgmental approach, mathematical models, simulation, and physical models. • EIA Report – Purpose and Contents including Executive Summary, Project Description, Description of the Environment, Anticipated Environmental impacts and mitigation measures, Environmental Monitoring Programme, Additional Studies, Project Benefits, Environment Management Plan (EMP) • EMP - purpose, scope, TOC. • Case studies of EIA for few Indian industries – eg: oil, metallurgical, petrochemical, iron and steel, fertilizer, projects of roads / dams etc.		
	Assignment 1 Impact assessment using the methods studied above of a given case study (individual assignment)		03
3	Biodiversity in Environmental Impact Assessment • Role of BIA in the existing EIA process • Identification, prediction and evaluation of impacts on biodiversity • Techniques of biodiversity impact assessment and monitoring, threat reduction methods; Case study	05	-
4.	Strategic Environmental Assessment (SEA) • Defining an SEA and its importance	08	

	• Comparing SEA and EIA • SEA aims, principles and elements of approach • Case studies of SEA		
5.	Integrative Approaches to Impact Assessment and Planning • Horizontal integration of impacts in EIA • Vertical integration of EIA and Environment Management Systems • Integration of wider sustainability issues • Integrative methods and tools • Links between EIA/SEA and sustainability analyses • Indicators for SEA/SA	6	
6.	Monitoring and Evaluation Basic concepts of monitoring and evaluation, guidelines tool for M&E (logic model, monitoring plan, evaluation plan), measures and indicators.	6	
	Assignment 2 Designing an integrated impact assessment strategy for any given problem. (assignment in groups of three students each).		3
	Minor Test 1		1
	Major Test		3
	Total	36	09

References

1. Bathwal R.R. (1988) *Environmental Impact Assessment*, New Age, International
2. Baumgartner Ruedi, 2004. The search for sustainable livelihood system sage Publications.
3. Biswas A.K, 1987. Environmental Impact Assessment, Tycooly International.
4. Canter L.W. (1996) *Environmental Impact Assessment*, 2nd Edn. New York, McGraw Hill.
5. Dale R. (2004) *Evaluating Development Programme and Project*, Second Edition, Sage Publication.
6. Desh Bandhu, 1981. Environment management, Indian environment Society.
7. Eccleston, Charles H., 2011. Environmental Impact Assessment : A Guide to Best Professional Practices, CRC Press.

8. Environmental Impact Assessment, Selected reading, Wildlife Institute of India, 1991.
9. Environmental Impact study for Bongaigain refinery and petrochemicals, Ltd, Engineers India Ltd.
10. Kulkarni and Ramchandra, 2006. Environment Management, Capital Publishing Company,
11. Lee N. and Kirkpatrick C. (Eds) (2000) *Integrated Appraisal and Sustainable Development in a Developing World*, Cheltenham, Edward Elgar.
12. Natarajan Banerjee, 1985. Environment impact assessment and control measures adopted in Neyvelli lignite project, N.L.C Printing Press.
Publishers.
13. Shukla and Shrivastav, 2000. Concepts in environmental impact analysis, Common wealth Publication.
14. SINAR MAS pulp and paper (India), Ltd. Engineering Projects Pvt, Ltd. February, 1997
15. Trivedi, 2004. Environmental Impact Assessment, A P H Publishing Corporation.
16. Tyler Miller, 2017, Environmental Science: Working With The Earth.
17. Vanclay F. and Bronstein D.A. (1995) *Environmental and Social Impact Assessment*, Wiley Publishers.

COURSE NO: EST 302

Course Title: Environmental Policies and Laws

Number of Credits: 3

No. of Lectures-Tutorial: 36-06

Course Coordinator: Adv. Gouri Joshi

Course Outline

The course aims at enhancing awareness about existing conservation / protection legislations and pollution control mechanisms. Participants will gain a deeper understanding of governance structures, process of legislation and the role of different legislative mechanisms in protection of natural resources. This course will enable participants to use the law as a tool in environment management.

Learning Outcomes

Students will :

- Understand the structure of Constitution, Government, and institutional setup useful for conservation and protection of environment
- Interpret the legal language of law
- Understand the function of law in solving problems presented to society through the natural sciences.

Pre-requisite

None

Evaluation Procedure: 60/40: University Exam / Internal Assessment

Assignment	2	20%	Internal Assessment
Minor Test	1	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

Sr. No.	Topic	Time (Hours)	
		L	T
1.	Concept of Rule Law • Historical development • Jurisprudence- Sources of environmental law • Basic concepts and principles • Civil Law • Criminal Law	4	

	• Law of Torts		
3	Constitutional Law • Magna Carta • Salient features of Constitution including institutions of law • Important provisions related to Environment	6	-
	Assignment 1 A 5 page paper on a predecided topic to be submitted as per guidelines given by faculty. Work must be original.		1
4.	Forest Laws • Indian Forest Act, 1927 • Forest (Conservation) Act, 1980 • Forest Rights Act, 2006 • International development on forest governance	6	
5.	Other Conservation Legislations • Wildlife Protection Act, 1972 • Indian Biological Diversity Act, 2002, National Biodiversity Strategy and Action Plan and related development • Wetland Conservation • Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), India • TRAFFIC	6	
	Assignment 2 Seminar presentation by individual students on predecided topics based on NGT cases		3
6.	Pollution Control Laws • Water (Prevention and Control of Pollution) Act, 1972 • Water (Prevention and Control of Pollution) Rules, 1973 • Water Issues and allied developments • Air (Prevention and Control of Pollution) Act, 1981 • Air (Prevention and Control of Pollution) Rules, 1982 • Noise Pollution Control Rules, 2002 • Water Issues and allied developments	8	

	• Soil pollution and soil conservation – with reference to land use change laws and EPA		
7.	Environment Protection Act • Environment (Protection) Act, 1986 • Different Notifications Ex. EIA, CMZ • Different Rules thereunder Ex. Waste Management Rules, Hazardous waste Handling and Disposal Rules etc.	6	
	Minor Test 1		
	Total	36	04

Reference Books:

1. Mohanty S. K., Environment and Pollution Law Manual, Universal Law Publishing Vompny Ltd., 3rd edition, 2002.
2. Environment and Pollution Laws, Law Publishers, 2000.
3. Leelakrishnan P, Environmental Law in India, Butterworths, 2000.
4. Singh Kuldeep, Environmental Jurisprudence, Modern Law House, 2nd edition 2002.
5. Choudhuri S.K, Environmental Legislations in India, Oxford and IBH Publishing 1996.
6. Pollution Control Acts, Rules and Notifications, Pollution Control Law Series – Volume – I, Central Pollution Control Board, 1992.
7. Conserving Life – Implications of Biodiversity conservations for India, Kalpavriksh, 1994.
8. Convention of Biological Diversity, World Wide Fund for Nature India 1992.
9. Singh Kuldeep, Handbook of Environment, Forest and Wildlife Protection Laws in India Natraj Publishers, 1998.
10. The Environment (Protection) Act and Rules 1986, Law Publishers.
11. Traffic Bulletin, Traffic International.
12. Vanguri Kishore, Environmental Laws in India – A guide, C.P.R. Environmental Education Centre, Madras, 1994.
13. The Water (Prevention and Control of Pollution) Act, 1974 and Rules 1975, Akalank Publications, 1999.
14. The Air (Prevention and Control of Pollution) Act, 1981 Akalank Publication 1999.
15. The Indian Forest Act, 1927 along with Forest (Conservation) Act 1980, Indira Gandhi National Forest Academy, Natraj Publishers 2002.
16. The Wildlife (Protection) Act 1972, Natraj Publishers, 1994.

17. Understanding Biodiversity Law Module, Center of Environmental Education Research and Advocacy (CEERA)
18. Trivedy R.K., Handbook of Environmental Law, Acts, Guidelines, Compliances and Standards, Volume Environment Media, 1996.
19. Nair Manju, The Montreal Protocol – in the Indian Context, Centre for Environmental Law, WWF India, 1996.
20. Environmental Legislation in India – A guide for Industry and Business, Environment Management Division, Confederation of Indian Industry, 1999.

COURSE NO: EST 311

Course Title: Dissertation

Number of Credits: 12

Evaluation Procedure: 60/40: University Exam / Internal Assessment

Assessment 1	Internal	10%	<i>Presentation on introducing the topic and its feasibility (literature review to justify the gap)</i>
Assessment 2	Internal	15%	<i>Detailed literature review, methodology with data collection protocols</i>
Assessment 2	Internal	15%	<i>Mid-course review. Presentation of results and preliminary analysis</i>
Major Exam (Phase 1)	External	60%	University Assessment (Phase 1)

Guidelines for dissertation

Topic: Candidates will write a dissertation on issues related to environmental/geospatial issues under the guidance of their respective guides. Each student will work independently on the topic. The dissertation must consist of review of literature and produce a deep insight of the subject on the basis of personal research.

Initiation of work: Dissertation work will be initiated during the second semester during the course of the paper on Research Methodology. During the Research Methodology course in Semester II, students will be allotted guides (from within the faculty associated with the Institute) based on their area of interest. As part of their assignments in the Research Methodology course students will write their introduction and literature review. **Guides will be from empaneled faculty only.**

Evaluation of thesis: The thesis will be evaluated in **two phases** over two semesters (third and fourth). **For the first phase** (in the third semester), 12 credits are allotted. The schedule for evaluation (internal and external) is given in the table above. **The guidelines given below only pertain to the first phase.**

Submission for Phase I: For the University presentation the student is expected to submit one **spiral bound copy** of the thesis consisting of introduction, literature review, aims and objectives, methodology, data and preliminary analysis along with a content page and interim certificate signed by the guide. (See attached certificate format below).

The dissertation should be typed on A4 size bond paper with 1.5 line spacing. Illustrations and photographs should be of high quality. Font to be used is Times New Roman or Arial with the text not less than in 12 pt. Referencing must be done in Zotero or any other referencing software strictly in standard referencing style (Vancouver). The report should be flawless without any

spelling mistakes and grammatical errors etc. If the dissertation contains such mistakes, the student will have to resubmit their dissertation after the necessary corrections.

Guidelines for the preliminary presentation (first): The first presentation should cover gap analysis (supported with literature review), justification for the study, aim, objective and proposed methodology. A document covering the above points should be submitted.

Guidelines for the interim presentation (second): For every presentation students will prepare a power point presentation highlighting the objectives, research question, methodology and key findings and defend the same. The presentation must not be texty. It should be aesthetically appealing and contain relevant graphs and analysis. Wordy presentations are likely to get marked down. Students should be smartly dressed and speak in a clear voice. Do ensure that your presentations are loaded as per the given deadlines.

The student will be permitted to appear for the second phase of the thesis ONLY if he/she has cleared the first phase.

FORMAT OF INTERIM CERTIFICATE

This is to state that Mr./Ms. _____ has worked under me for his dissertation from _____ till date. During this period he/ she has completed the following tasks.

- 1.
- 2.
- 3.
- 4.
- 5.
- 6.
- 7.

I have verified the authenticity of the data that he is using for his/her presentation.

Name of guide

Signature of guide

COURSE NO: EST 303

Course Title: Technical Writing

Number of Credits: 2

No. of Lectures-Tutorial: 24-8

Course Coordinator: Mr. Venkatnarayan Ganpathi

Course Outline

The course provides an outline of how to develop communication skills with an emphasis on scientific writing, proposal preparation and scientific but attractive way of presentation of research findings along with proper means of audio-visual documentation. The course prepares students to think, read and write scientific papers; conceptualize, frame and prepare complete project proposals and also will help them to realize the basics of audio-visual communication systems.

Learning Outcomes

The student will be able to:

- Think, read and prepare scientific manuscripts
- Conceptualize, frame and prepare project proposals
- Prepare oral presentations and posters
- Document, edit and publish findings in field and related topics

Pre-requisite

None

Evaluation Procedure : Continuous

Assignment	1	50%	Internal Assessment
Assignment	2	50%	Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Technical writing Outlining content • Organizing content: Checklist for components of journal articles and research papers • Difference between Abstract and Executive Summary • Writing an Introduction and Conclusion • Using logic to present content: the building blocks of analytical writing	8	

	- Using graphics to represent data: making data more readable and using graphics to present analysis - Using keywords to enhance search: Effective use of keywords to enhance online reach of your articles Using language effectively - Using effective words and editing content: Using a tool kit for writing; what to avoid when writing - Creating flow of information: understanding the difference between listing or cataloguing details and analyzing and interpreting them for your reader Submitting papers - Understanding submission guidelines - Using appropriate resources - Handling manuscript rejections		
	Assignment 1		
2	Preparing project proposals - Mapping the donor needs to organisational needs - Structuring content - Specifying deliverables and timelines - Asking for commitment - Checklist for a complete proposal	6	
3	Oral and Poster Presentations - Designing the presentation and flow of content - Communicating with the audience: verbal and non-verbal soft skills - Using visuals effectively: basics of using graphics, illustrations and copyright issues	4	
	Assignment 2		
4	Visual Documentation Methods	6	

COURSE NO: EST 304

Course Title: Environment Management Techniques

Number of Credits: 3

No. of Lectures-Tutorial: 36-07-02

Course Coordinator: Mr. Mahesh Kulkarni

Course Outline

The course provides an indepth insight into the various environment management techniques embedded in the concept of sustainability. Tools such as certification, life cycle analysis, cost benefit analysis as well as various aspects of environmental design are dealt with in details. The course is designed to build detailed knowledge, understanding and skills among students about the concepts and technical skills for environment management so that they are able to identify sustainable modes of environmental operation.

The student will also complete the certification for internal environment auditor (**ISO 14001: 2015) conducted by Bureau Veritas.**

ISO 14001:2015 specifies the requirements for an environmental management system that an organization can use to enhance its environmental performance. ISO 14001:2015 is intended for use by an organization seeking to manage its environmental responsibilities in a systematic manner that contributes to the environmental pillar of sustainability. This module will be conducted as a three day workshop. A payment of Rs. 3000/- needs to be made for the certification process to Bureau Veritas.

Learning Outcomes

At the end of the course, the student will:

- Develop an indepth understanding of the various environment managemmen techniques including enhancement of environmental performance in an organisation, and fulfilment of compliance obligations.
- Identify sustainable modes of environmental operation.
- Develop a problem solving approach towards environment management.

Pre-requisite

None

Evaluation Procedure : Continuous

Assignments	40 % (3)	Marking pattern for every assignment	Assignments must be in the prescribed I	Internal Assessment

		- Innovativeness and accuracy in completing the assignment - Completed home assignment submitted timely and excellent written presentation	format and submitted digitally.	
Certification		Continuous assessment and final evaluation	This will be conducted by Bureau Veritas	Assessment by Bureau Veritas
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1.	ISO 14000 and 14001 - Environment Management System: Definition, general requirements, why do we need EMS, EMS technology, Elements of EMS. - Implementation and Documentation: General information, essential documents, environment related legal requirements, implementation of EMS. - ISO 14000 and ISO 14001: About ISO, background of ISO 14000, ISO 14000, ISO 14001, management principles for adopting ISO 14000, correlation between ISO 9000 and ISO 14000	06	
2.	Environment Management tools Environmental auditing: Definition and scope, types of audits, Audit methodology (basic structure of EA, EA steps), Elements of audit process, waste audit and pollution prevention, assessment of EA in industrial projects, auditing of EMS (audit objectives, roles, responsibilities, scope and	06	

	review, preparing the audit, conducting the audit, content of audit report		
	Assignment 1: Develop a format to conduct and environment audit for a selected industry (sector)(Work in groups of three students)		3
3.	Life Cycle Assessment (LCA): Definition, stages in product LCA, procedure for LCA (defining the goal, scope, analyzing the inventory, assessing environmental impact, evaluating environmental profiles, Applications of LCA (private sectors and government applications)	07	
	Assignment 2: Life cycle Assessment of packaged drinking water		3
4.	Environmental Design (ED): Scope and principles of ED, benefits of ED, ED for manufactured products (ED considerations in product life stages, ED tools for products (checklists, LCA, matrices, eco-indices), concept of eco-labeling; ED for buildings (green buildings, principles of green buildings, ED strategies for building construction), examples of ED	08	
	Assignment 3: Using the MET (materials, energy, toxicity) matrix perform an assessment of environment design for a given product/ Using a structured format analyze cost benefit aspect for a given project/product.		2
5.	- Cost Benefit Analysis - Environmental taxes (carbon emission taxes) - Environmental marketing (green marketing)	5	
6.	Sustainability Reporting	4	
7.	ISO 14001: 2015 certification - Environmental Issues - Environmental Management Systems overview - What to look for in Context of the organisation - What to look for in Implementation and Operation. - What to look for in Leadership. Planning and Support. - What to look for in operation, performance evaluations and improvements - Environmental legislation & auditing for the process of implementation and compliance - Audit management and techniques.	24	

	• Accreditation & Certification processes (ISO 17021, IAF MD1) • Auditor Competence (ISO 19011, CQI-IRCA norms) • Practical Exercises workshops and Feedback.		
	Major Test 1		2
	Total	36	09

Suggested Readings

1. Bandyapadhyay A, 2002. Town Planning, Books and Allied Ltd.
2. Bhatt S, 2004. Environment Protection and Sustainable Development, A.P.H. Publishing Corporation.
3. Bucur, Voichita, 2007, Urban Forest Acoustics, Springer Science & Business Media.
4. Cerver Francisco, Urbanismo – Urban Planning, Axis Books
5. Eccleston C. H., 2011, Environmental Impact Assessment, CRC Press.
6. Hiraskar G. K, 1997. Fundamentals of Town Planning, Dhanpat Rai Publications Ltd.
7. Khosla P.K, D.K.Uppal, R.K.Sharma, R.K.Kohli, Y.C.Jain, 1996. Ecofriendly Trees for Urban Beautification. Indian society of tree scientists, Jolan and National Horticulture Board, Gurgaon.
8. Koperdekar and Diwan, 1994 Urban and Regional Planning – Principles, Practice and Law, Sudhanwa Kopardekar Publishers.
9. Ohri M. L, 1995. Water Supply and Sanitary Engineering, India Publishing House.
10. Palazzo, Danilo, Steiner, Frederick R., 2012, Urban Ecological Design: A Process for Regenerative Places, Island press.
11. Rangwala, 2003. Town planning, Charotar Publishing House, Eighteenth Edition.

COURSE NO: EST 305

Course Title: Water Management

Number of Credits: 3

No. of Lectures-Tutorial: 36-07-02

Course Coordinator: Dr. Rashmi Mardikar

Course Outline

This course will expose the students to (i) Introduction to water resources evaluation and assessment - SPAC, WUE, methods of assessment, sectoral water use and demand, assessment of water stress and need for water conservation and (ii) Water resources conservation and management including institutional and policy aspects such as rainwater harvesting, conjunctive water use, catchment planning, watershed management, irrigation use and efficiency, advanced treatment systems and zero discharge, participatory irrigation management including methods of minimizing evaporation losses, water pricing, river basin organizations, collective action and decentralization etc.

Learning Outcomes

Students will:

- Develop the technical skills for methods of assessment and demand of water resources
- Technical skills in setting up water harvesting mechanisms

Pre-requisite

None

Assessment: Continuous

Assignments	40 % (3)	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment • Completed home assignment submitted timely and excellent written presentation	Assignments must be in the prescribed format digitally.	Internal Assessment
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Introduction to water conservation and assessment, Severity of water crisis, importance of conservation • Soil, Plant, Atmosphere Continuum (SPAC); Water use efficiency (WUE) • Methods of water resources assessment (hydrology cycle, surface flow assessment, groundwater recharge assessment) • Water stress: principles and indicators for assessing water stress • Water quality assessment: indicators for assessing water quality	08	
	Assignment 1: Assessment of water resources		5
2	• Water resources conservation and management, Water conservation measures • Soil moisture retention and conservation (cover crop, mulching, etc) • Traditional systems and man-made structures (ponds, tanks, reservoirs, Minimizing evaporation loses • Rainwater harvesting and groundwater recharging • Irrigation: types, scheduling, efficiency and designing	07	
	Assignment 2: Setting up rain water harvesting systems		2
3	• Water auditing; Water treatment, recycling and reuse leading to water conservation, Industrial and urban water management leading to cleaner production, Institutional mechanisms for water management, programmes and policies for integrated water management	07	
	Assignment 3: Conducting a water audit		2
	Major Exam		
	Total	36	09

Suggested Readings

1. Larry M. (2003) *Urban Storm Water Management Tools*, McGraw Hill Publication.
2. Michael A.M. (2008) *Irrigation Theory and Practices*, 2nd Edition, Vikas Publishing House Private Limited, Noida.
3. Suresh R. (2005) *Soil and Water Conservation Engineering*, 2nd edition, Standard Publishers Distributors. GEN@)

COURSE NO: GEO 303

Course Title: Applications of geospatial technologies

Number of Credits: 3

No. of Lectures-Tutorial: 36-6

Course Coordinator: Dr. Lakshmi KantaKumar

Pre-requisite

GEO 102

Evaluation Procedure : Continuous

Assignments	40 % (3)	Marking pattern for every assignment - Innovativeness and accuracy in completing the assignment - Completed home assignment submitted timely and excellent written presentation	Assignments must be in the prescribed format digitally.	Internal Assessment
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Remote sensing and GIS applications in ecosystem, forest studies and conservation - Key concepts in ecosystem studies: ecosystem services, threats to ecosystems, management of ecosystems, classification levels - Key concepts of forest types, distribution, forestry practices, forest management - Satellites commonly used in forest studies	07	

	• Satellites commonly used in ecosystem studies: global, national, regional, local, micro levels • Vegetation Indices used- NDVI, SAVI, Tassel Capped Index • Agencies involved (ancillary data sources) Case studies • Biodiversity characterization • Monitoring ecosystems (forests, wetlands) • Landuse/landcover classification (state level) • Human - Wildlife conflicts • EIA using GIS & RS • Habitat evaluation, Corridor mapping • Eco-tourism using advanced techniques like PDA • Forest fire risk zone mapping • Forest / vegetation classification and mapping. • Forest inventory and sampling technique. • Forest carbon management/sequestration • Using LIDAR data in forestry management • Wildlife Habitat Suitability Analysis with respect to : Statement of problem, feasibility of RS and GIS, methodology (flow chart) for each case study, RS needs (satellite, resolution, seasons, method of classification, vegetation indices), field studies needed and methodology used for the same, GIS database building (layers-sources, methods), analysis tools (GIS, statistical).		
	Assignment 1 Hands on session with any one application (demo followed by an exercise and presentation)		3
2	Remote sensing and GIS applications in agricultural applications • Key concepts in agriculture: problems in agriculture, agricultural impact on the environment, sustainable agriculture, global significance of agriculture • Satellites commonly used for agricultural studies • Vegetation Indices - NDVI, SAVI, TasselCapped Index, remote sensing properties of soil • Agencies involved (ancillary data sources)	07	

	Case studies • Crop yield estimation • Crop disease monitoring • Crop water requirement • Soil Mapping • WebGIS for agriculture • Precision farming with respect to : Statement of problem, feasibility of RS and GIS, methodology (flow chart) for each case study, RS needs (satellite, resolution, seasons, method of classification, vegetation indices), field studies needed and methodology used for the same, GIS database building (layers-sources, methods), analysis tools (GIS, statistical).		
	Assignment 2 Hands on session with any one application (demo followed by an exercise and presentation)		3
3	Remote sensing and GIS applications in urban application • Satellites commonly used for urban studies • Agencies involved (ancillary data sources) Case Studies • Urban Sprawl • Land Information Systems • Utilities management (water, sewage) • Fringe Area Development • Planning of facilities (green spaces, hospitals, etc) • Emerging Technologies • Urban heat islands with respect to : Statement of problem, feasibility of RS and GIS, methodology (flow chart) for each case study, RS needs (satellite, resolution, seasons, method of classification, vegetation indices), field studies needed and methodology used for the same, GIS database building (layers-sources, methods), analysis tools (GIS, statistical).	07	

4	Remote sensing and GIS applications in water resources and related applications • Satellites used • Agencies involved (ancillary data sources) Case Studies • Groundwater modeling • Bathymetric mapping • Watershed development and management • Water Resource Assessment and Preparation of Management Planning Strategy • Water pollution monitoring/assessment • Vulnerability assessment of rivers/ waterbodies with respect to : Statement of problem, feasibility of RS and GIS, methodology (flow chart) for each case study, RS needs (satellite, resolution, seasons, method of classification, vegetation indices), field studies needed and methodology used for the same, GIS database building (layers-sources, methods), analysis tools (GIS, statistical).	07	
	Assignment 3 Hands on session with any one application (demo followed by an exercise and presentation)		3
5	Remote sensing and GIS applications in health studies • Key concepts: causes of epidemics, basic concepts of epidemiology-transmission of diseases, responsible environmental factors, challenges in disease / health management • Agencies involved (ancillary data sources) Case studies • Disease mapping (3 case studies from different parts of the world) • WebGIS for human health issues • GIS as a tool for monitoring Health Management Information System • Environment Mapping for Viral Disease Survey	07	

	- Emergency Medical Systems - Access to health care with respect to : Statement of problem, feasibility of RS and GIS, methodology (flow chart) for each case study, RS needs (satellite, resolution, seasons, method of classification, vegetation indices), field studies needed and methodology used for the same, GIS database building (layers-sources, methods), analysis tools (GIS, statistical).		
6	Remote sensing and GIS applications in Utilities Case studies - GIS in management of electricity distribution network - GIS for power plant site selection (hydro, thermal) - GIS in telecommunications - GIS in transportation design and management - Managing sewage/water supply systems through GIS - GIS in monitoring of infrastructure projects - GIS in business applications (2 case studies) with respect to : Statement of problem, feasibility of RS and GIS, methodology (flow chart) for each case study, RS needs (satellite, resolution, seasons, method of classification, vegetation indices), field studies needed and methodology used for the same, GIS database building (layers-sources, methods), analysis tools (GIS, statistical).	07	
	Hands on session with any one application (demo followed by an exercise and presentation)		3
	Major Exam		
	Total	36	9

Reference Books

- Subudhi A P, B. S. Sokhi, P. S. Roy, Remote Sensing and GIS Application in Urban and Regional Studies, IIRS, 2001
- Roy. P. S, Natural Disaster and their Mitigation, IIRS, 2000.
- Roy P S, Biodiversity Characteristics at Landscape Level in North East using satellite Remote

And Geographical Information System, IIRS, 2002.

- Roy P S, Forest Cover Assessment in Asia, IIRS, 2002.
- Roy P S, Biodiversity and Environment, IIRS, 2000.
- Sudershana R, D Mitra, Mishra , P.S Roy., D.P Rao, Subtle Issues in Coastal Management, IIRS, 2000.
- Deekshatulu B. L., Description and use of Landuse/ Landcover, NRSA, 1990.
- Remote Sensing for Sustainable Development, Proceedings of National Symposium organized by ISRS and RSAC, ISRS, Nov 1992.
- Proceeding of National Symposium on RS for Agricultural Application held at New Delhi, ISRS/IARI, Dec 1990.
- Proceedings of ISPRS Commission VII Symposium Resource and Environmental Monitoring, Hyderabad, Dec 2002.
- Pre-Symposium Tutorial on Sustainable Agriculture (Volume of Lectures), Dec 2002, NRSA
- National Agricultural Drought Assessment and Monitoring System, India, Summary Report, Sept 2001.
- ISPRS Technical Commission VII Symposium on Resource and Environmental Monitoring and ISRS Annual Convention- ABSTRACTS, NRSA, Dec 2002.
- Spatial Technologies for Natural Hazards Management (Proceedings of ISRS National Symposium Nov 21-22, 2000, IIT Kanpur)
- Application of RS and GIS in Disaster Management, Lectures notes by CSSTEAP, IIRS.
- Forest Resource Management, Lectures notes by CSSTEAP, IIRS.
- Application of RS and GIS in Marine Sciences, Lectures notes by CSSTEAP, IIRS.
- Application of RS and GIS in Urban Mapping, Lectures notes by CSSTEAP, IIRS.
- Application of RS and GIS in Geosciences, Lectures notes by CSSTEAP, IIRS.
- Application of RS and GIS in Water Resources, Lectures notes by CSSTEAP, IIRS.

COURSE NO: EST 306

Course Title: Urban Environment Management

Number of Credits: 3

No. of Lectures-Tutorial: 36-6

Course Coordinator/Instructor: Ms. Samruddhi Pathak

Course outline

With increasing urbanisation all across the world there are rapid changes in quality of life and living space. This course provides an overview of present management of urban areas both nationally as well as internationally with special reference to the environmental aspects. The course will provide a practical insight into the development process of an urban area keeping in mind open spaces, basic needs like water supply and sanitation, protection from disasters, traffic issues and overall governance of a city. Various economic and social policies involved in urban housing and slums and importance of environment laws and management in today's urban areas will be discussed.

Learning Outcomes

At the end of the course students will :

- Develop an understanding of the urban environment.
- Develop an understanding of the process of urban planning and governance in India
- Develop skills of analysis of urban issues especially housing – formal and informal, disasters affecting urban areas, transportation issues, green spaces, open spaces and zoning and bye laws in urban areas
- Develop an insight into the importance of development plans and their processes.

Evaluation Procedure : Continuous

Assignments	40 % (3)	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment • Completed home assignment submitted timely and	Assignments must be in the prescribed format digitally.	Internal Assessment

		excellent written presentation		
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Urbanization and its impacts • Definition of urban, urbanization and urban growth • Urban concentration and its impacts on natural and urban resources • Causes of degradation • Globalisation and urbanisation • Consumptive changes and its impacts on cities • Core and peripheral area developments Planning development and its impacts Urban climatology • Urban form and energy usage • Climate responsive interventions, Resilient city Ancient and contemporary case-studies	05	
2	Introduction to urban environmental planning • Basic concepts of planning and development planning, development plans, master plans, bye-laws, surveys, landuse etc. levels of planning, participatory planning • Planning as a tool for development and control • Historical planning and environmental concerns from ancient times to contemporary developments • Environmental incorporation through planning principles, infrastructural provisions and utility layouts • Urban public finance • Concept of Smart city	05	
	Assignment 1 Analysis and written presentation (individual) and oral presentation (in groups of three students) of the environmental problems in the urban fringe OR as given by the faculty		4
3	Disasters and urbanization	03	

	• Impacts of disasters on urban areas • City collapse – trends from ancient to modern times		
4	Housing • Brief introduction to various concepts of demand, need, supply, tenures, densities, income groups etc. • Characteristics of urban housing • Urban forms of housing • Indian housing scenario • Housing economics	04	
5	Slums • Introduction • Causes of slums, characteristics of slums • Impacts of slums on the urban city image, slum improvements and prevention of slums	03	
	Assignment 2 Analysis and written presentation (individual) and oral presentation (in groups of three students) of the environmental problems in informal housing sector OR as given by the faculty.		5
6	Urban traffic • Concerns • Types of roads • Requirement of good roads • Traffic management • Urban traffic problems • Mass vs individual transportation systems • Impacts of roads and vehicles over environment	03	
7	Urban utility planning • UDPFI guidelines • Water, solid waste, waste water, garbage etc. • Norms and standards, CPHEEO, urban housing and poverty alleviation • Spatial, social, economic and environmental considerations, SLB Open space provisions • Requirement and needs	4	

	• Hierarchy and importance • Urban social infrastructure planning • Urban environment and environmental status • Public private partnerships • Role of various non-governmental agencies and organizations in environmental upkeep		
	Assignment 3 Analysis and written presentation (individual) and oral presentation (in groups of three students) of water management in the urban sector. OR Analysis and written presentation (individual) and oral presentation (in groups of three students) of urban green spaces OR as given by the faculty.		5
9	Planning laws and environment • Historical perspective • Mega projects and developmental control and concerns • New town developments Planning agencies • Duties and responsibilities • Environmental agendas • Efforts undertaken for environmental conservation and upgradation • Globalisation and urbanisation • Consumptive changes and its impacts on cities	6	
	Major Test		2
	Total	36	09

Suggested Readings

1. Bhatt S, Environment Protection and Sustainable Development, A.P.H.Publishing Corporation, 2004.
2. Rangwala, Town planning, Charotar Publishing House, Eighteenth Edition, 2003.
3. Bandyapadhyay A, Town Planning, Books and Allied Ltd, 2002.
4. Koperdekar and Diwan, Urban and Regional Planning – Principles, Practice and Law, Sudhanwa Kopardekar Publishers, 1994

5. Hiraskar G. K, Fundamentals of Town Planning, Dhanpat Rai Publications Ltd, 1997.
6. Khosla P.K, D.K.Uppal, R.K.Sharma, R.K.Kohli, Y.C.Jain, Ecofriendly Trees for Urban Beautification. Indian society of tree scientists, Jolan and National Horticulture Board, Gurgaon, 1996.
7. Cerver Francisco, Urbanismo – Urban Planning, Axis Books
8. Ohri M. L, Water Supply and Sanitary Engineering, India Publishing House, 1995.

COURSE NO: EST 307

Course Title: Advanced Pollution Control Technology

Number of Credits: 3

No. of Lectures-Tutorial: 36-06

Name of the faculty: Dr. Rashmi Mardikar

Course Outline

The course provides an indepth insight into the various pollution control technologies and also green technologies. Various technologies to ensure air,water, waste water will be discused in detail. The course is designed to build detailed knowledge, understanding and skills among students about technologies for pollution abatement and control.

Pre-requisite

None

Evaluation Procedure : Continuous

Assignments	40 % (3)	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment • Completed home assignment submitted timely and excellent written presentation	Assignments must be in the prescribed format digitally.	Internal Assessment
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1.	• Advances in air pollution control, standards for air quality, types of pollution control devices. • Air pollution control in industries: Fertilizer, cement manufacturing, paint booths(Manufacturing process, sources and control) • Design: Gravity settler, cyclone, Fabric filters, ESP	06	

	Assignment 1: Design of one unit		4
2.	Advanced wastewater treatment • Significance; Nutrient removal theory (Nitrification and de-nitrification), phosphorus removal (Biological and chemical) , nutrient removal technologies (ASP modifications, biological aerated flooded filters, MBBRs) • Membrane processes: Objectives, Principle and working mechanism of ultrafiltration, reverse osmosis, electrodialysis, desalination	05	
	Assignment 2: Design of one unit		4
3.	Industrial effluents • Common Effluent Treatment Plant: Sources of waste water and specific pollutants from different industries (Sugar, dairy, pharmaceutical industry), characterization of industrial effluents, significance of treatability analysis	10	
4	Wastewater treatment plant • Significance of Equalization and Neutralisation process, • Design of bar screen, grit chamber with respect to dimensions, cleaning mechanisms, solids disposal frequency • Design of biological process: Design criteria for conventional and modified ASP (including oxygen requirement and sludge return). Determination of tank volume, dimensions, recycle and air supply equipment • Design of anaerobic digester, principle and working mechanism of up-flow anaerobic sludge blanket process • Design of septic tank and disposal field: dimensions, cleaning frequency; Layout of effluent treatment plant, general considerations for location of sewage treatment plant; Layout of effluent treatment plant, general considerations for location of sewage treatment plant	12	

	Assignment 3: Design of one unit		4
5	Optimization Techniques • Waste minimization • Reduction of wastewater quantity (reuse, recycling) • Strength reduction by recovery • Case studies	3	
	Major Exam		
	Total	36	9

Suggested Readings

1. Bhatiya S.C., Hand book of industrial pollution and control, Volume I and II, CBS Publishers & Distributors, 2002.
2. Gaikwad, R.S. Sapkal Environmental Engineering Denett & Co. 2006
3. Metcalf and Eddy, Wastewater engineering treatment and reuse, Tata Mc-Grawhill Publishing Company Ltd, 4th edition, 2003.
4. Metcalf and Eddy, Wastewater engineering: Treatment, disposal and reuse, Tata Mc Graw Hill Publishing Company Ltd, 3rd edition, 1991.
5. Noyer Robert, Unit operations in environment engineering, JAICO publishing House, 2005.
6. Paevy, Rowe and Tschobanoglous, Environmental Engineering, Tata Mc Graw Hill Publishing Company Ltd, 1995.
7. Pandey G.N. and G.C. Carney Environmental engineering, Tata Mc Graw Hill Publishing Company Ltd, 1994.
8. Punmia B.C and Ashok Jain, Wastewater engineering, Laxmi Publications, 2005
9. Rangawala S.C, Water supply and sanitary engineering, Charotar Publishing House, 2005.
10. Rao M. N. and H. V. N. Rao, Air pollution, Tata Mc-Grawhill Publishing Company Ltd, 1989.
11. Shukla S.K. and P.K.Shrivastav, Waste management and control, Common Wealth Publishers, 1992.

COURSE NO: GEN 301

Course Title: Swachh Bharat Abhiyan Internship

Number of Credits: 2

No. of Lectures: 30

Course Coordinator:

Evaluation Procedure : Continuous

Submission of Report Submission of certificate from the host organisation

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
	15 days (100 hours) Summer Internships under Swachcha Bharat Abhiyan Activities. In this summer internship, it is expected that the students will not only participate in the overall cleanliness in the villages/slums but would also help in setting up systems for sustaining cleanliness / sanitation efforts under Swachcha Bharat Abhiyan. The certificate given by the concerned host organization will be the basis for the credits .		

COURSE NO: GEN 302

Course Title: Education for Sustainable Development

Number of Credits: 2

No. of Lectures: 30

Course Coordinator: Dr. Rashmi Mardikar / Kimberley Colaco

Evaluation Procedure : Continuous

Submission of Report Submission of certificate from the host organisation

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
	15 days (100 hours) Summer Internships with schools implementing ESD programs. Students will design and implement ESD programs with their stakeholders..		

SEMESTER IV

COURSE NO: EST 411

Course Title: Dissertation

Number of Credits: 12

Evaluation Procedure: 0.6/0.4 University

Assessment by guide	40%	Internal Assessment
Major Exam	60%	University Assessment

This course is the second phase of the dissertation. A student cannot appear for the exam of this course unless he/she has cleared Phase I.

Evaluation of thesis: The second phase of the thesis will be evaluated for 14 credits. The internal and external assessment will be as indicated in the table above. Students have to appear for a final external viva to defend their thesis after submission of the thesis.

The dissertation will have to be submitted as per the dates indicated in Academic Calendar for appraisal and acceptance by the University. The students should submit their dissertation in the following format.

Thesis Organisation

Cover Page

Inner Cover Page

Certificate duly signed by guide and head of institution

Acknowledgements

Abbreviations

Contents

Chapter 1 – Introduction

A background with historical information and a review of existing material or data on the subject.

Chapter 2- Aims and Objectives

This chapter must contain the overall study design and aims and objectives of the study.

Chapter 3 – Literature Review

Detailed review of all existing literature related to the topic justifying the topic with a comprehensive bibliography generated using Zotero.

Chapter 3 –Methodology

Description of the issues, environmental setting and methodology adopted for the study etc.

Chapter 3 – Results

Presentation of results.

Chapter 4 – Discussion

Discussion on the data and results obtained and presentation of method suggested to solve the problem.

Chapter 5 – Summary and Conclusions

A summary of the dissertation and important conclusions drawn at the end of the investigation and a list of references cited in the text.

Chapter 6 - Bibliography

The dissertation should be typed on A4 size bond paper with 1.5 line spacing. Illustrations and photographs should be of high quality. Font to be used is Times New Roman or Arial with the text not less than in 12 pt. Referencing must be done in Zotero or any other referencing software in standard referencing style (Vancouver) for both intext citing and bibliography. The report should be flawless without any spelling mistakes and grammatical errors etc. If the dissertation contains such mistakes, the student will have to resubmit their dissertation after the necessary corrections. The dissertation should be bound in hard black mounted cover. Dissertations with spiral binding and paper cover will not be accepted. The front matter should be embossed and not on a sticker.

The students are expected to prepare 3 copies (4 in case of a co-guide). If the guide gives a written consent that he/she does not need a hard copy a soft copy may be provided. The soft copy must contain a sticker with the cover page information. **The thesis will only be accepted after the relevant data used has been submitted to the faculty nominated and verified by them. It is mandatory that all data collected be submitted to the Institute for verification.**

Students must submit the plagiarism report before submission. Students making special efforts to present their papers at conferences or publishing it will receive marks as below:

1.	Poster presented at a National level UGC recognized conference	5 marks
3.	Paper presented at a national level conference	10 marks
4.	Paper published in a SCOPUS/ WEB of SCIENCE indexed journal ONLY	25 marks

Guidelines for final presentation: The final presentation must consist of gap analysis (inbrief), aim, objectives, research question, methodology and key findings and action plan (if any) and defend the same.

The presentation must not be texty. It should be aesthetically appealing and contain relevant graphs and analysis. Wordy presentations are likely to get marked down. Students should be smartly dressed and speak in a clear voice. Do ensure that your presentations are loaded as per the given deadlines.

Guidelines for poster (to be submitted digitally)

For the final presentation students will prepare a poster as per the guidelines given below.

Poster size: 2ft (W) x 3ft (H)

Content: Aim, Objective, Method (in brief in a flow chart), findings (key graphs to be included), publications (if any), conclusion, suggestion

Name of the student and guide as well as institutional affiliation should be included.

FORMAT OF FINAL CERTIFICATE (Times New Roman 12 pt; Line spacing 1.5)

CERTIFICATE (14 pt)

This is to certify that **NAME OF STUDENT**, final year student at the Bharati Vidyapeeth (Deemed to be University) Institute of Environment Education and Research, Pune has successfully completed the dissertation titled, '**Topic**' under the guidance of **Guide name**, in partial fulfilment of the Master Degree in Environment Science And Technology during the academic year **2019-20**.

The work has been completed to our satisfaction and standards. The said dissertation has not been submitted for any other degree or diploma and any such material which has been obtained from other sources has been duly acknowledged in the dissertation.

Guide name and designation

Prof. Dr. Erach Bharucha
Director
Bharati Vidyapeeth (Deemed to
be University) Institute of
Environment Education and
Research, Pune Satara Road,
Pune 43

COURSE NO: EST 401

Course Title: Eco-restoration

Number of Credits: 3

No. of Lectures-Tutorial/Assignment: 36-06

Course Coordinator: Dr. Rahul Mungikar

Course Outline

The course will introducing learners to the principles, concepts, methodologies and key challenges in the field of ER. The course will give an understanding of key topics including identifying degradation, its causes and ecological impacts and restoration methodologies and their application. It will make students familiar with the restoration methods of different fragile ecosystems such as wetlands as well as develop an understanding of restoring degraded waste land in urban landscape. principles and concepts of ER, including international standards and protocols. The course includes two local field trips.

Learning Outcomes

The student will develop:

- Analyze causes of degradation
- A deep understanding of eco-restoration including different approaches applicable for the restoration practices of different landscapes.
- Ability to design and implement an ecorestoration program for a specific ecosystem

Pre-requisite

None

Evaluation Procedure : Continuous

Assignments	40 % (3)	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment • Completed home assignment submitted timely and excellent written presentation	Assignments must be in the prescribed I format digitally.	Internal Assessment
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T/A
1	Introduction to ecological restoration (ER) • Definition(s) of ER, Difference between ER and other rehabilitation approaches; Aim of restoration • Importance of ER in the contemporary conservation context • Policies and programs for restoration of ecosystems in India	02	
2.	Concept of Degradation • Causes of land degradation; Macro-level indicators of degradation; Methods of identifying factors causing degradation; Assessing level of degradation severity; Presentation of degradation profile from a real-life project • Ecological Succession: Principles and types of ecological succession	02	
3.	Assignment 1: Participants' group work on analyzing degradation profiles in diverse ecosystems e.g. lakes, dry deciduous forests, grasslands, etc. and present results.		02
4.	Key concepts in ecological restoration • Ecosystem approach; Species Approach; Landscape Approach • Restoration of populations and communities; Minimum viable populations; metapopulation theory and its implications for restoration; • Application of community ecological theory to restoration • Principle of least possible intervention; Principle of assisted regeneration; Understanding biodiversity in the ecological restoration context	04	
5.	Understanding soil for restoration • Introduction to soil science; Role of soil in ecosystem functioning and resilience; • Soil types and characteristics: Physical, chemical, biological, etc., Biotic interface with the soil: role of soil microbes, fungi, insects and plants in maintaining soil health • Restoring degraded soil: Types of soil degradation with causes; Physical indicators of degraded soil; Methods of assessing soil health using tests; Soil restoration techniques	06	

	- Relationship between soil and hydrology - Soil water conservation practices and measures		
6.	Assignment 2: Analysis of a restoration site (Pashan Lake)		03
7.	Restoring sites with degraded vegetation - Characteristics of sites with degraded vegetation; - Factors causing vegetation degradation; - Restoration principles; Restoration methods: spontaneous regeneration, assisted natural regeneration techniques, active intervention techniques; Collection or raising of plant material - Importance of plant material in restoration; - Basics of seed science; Seed collection techniques; - Raising plants in nurseries: nursery establishment and development ; Techniques of nursery operations in semi-arid areas; Seedling production; Nursery Level Operations Planting methods - Revegetation and regeneration; Natural regeneration-important principles; planting techniques; Selection of tree and shrub species - Post planting activities; Stepwise establishment and management techniques of plantations - Types of plantation: Windbreaks and shelterbelts; Forest and grassland plantation; Sand dune plantation; River side plantation	08	
	Field Visit to a Nursery		02
8	Role of fauna in restoration Role of fauna in restoration: soil enrichment, pollination, seed dispersal, nutrient recycling, biological control, etc.; Leveraging on fauna for accelerating restoration progression.	02	
9	Human Dimension of Ecological Restoration - Role of people in ecological restoration; Developing a volunteer base; Collaboration and public participation in a restoration project; Grazing and fire management - Eco-cultural restoration; - Role of education and awareness in restoration	04	

11.	Planning and project design Key steps in designing a restoration project; Deciding desired outcomes; Deciding project scale ; Estimating resource requirements; Cost considerations and using low-cost ; restoration options; Funding avenues for ER; ROAM Method (WRI) Project implementation Activity planning and scheduling; Managing uncertainties and risks; Project monitoring Survey and documentation techniques; Use of satellite imaging and similar techniques Project management case studies Forest restoration; Restoration of mined out areas; Lake restoration; Grassland restoration	06	
12	Assignment 3: Restoration Project Design The report should include details on: Site selection criteria, Site description and problem identification; Developing restoration goals (using reference conditions/sites, consultation, etc.); Formulate a plan for achieving restoration goals (activities, interventions, etc.); Budget and Timeline; Monitoring plan		04
	Final assessment exam		
	Total	36	09

Suggested Readings

1. Hammitt, W.E. & Cole D.N. 1998. Wildland Recreation: Ecology and Management, 2nd Ed. New York: John Wiley & Sons. 361 pp. (ISBN: 0-471- 19461).
2. Liddle M. 1997. Recreation Ecology: The Ecological Impact of Outdoor Recreation and Ecotourism. New York: Chapman & Hall. 639 pp.
3. Higgs, E. 1997. What is Good Ecological Restoration? Conservation Biology, pp. 338-348.
4. Egan, B. 1998. Ecological Restoration for British Columbia. British Columbia Environmental Report, pp. 7-9.
5. B.K. Tiwari, Surendra Singh 1995. Ecorestoration of degraded hills.
6. Robert U Ayres, Paul M Weaver. Eco restructuring: Implications for sustainable development. IN-05457.

COURSE NO: EST 402

Course Title: Corporate Social Responsibility

Number of Credits: 3

No. of Lectures-Tutorial: 36-06

Course Coordinator: Dr. Shamita Kumar

Course Outline

This module provides an overview of the legal framework of corporate social responsibility (CSR) as well as its implementation, focusing on the interplay between large corporations and governments and non-governmental organizations (NGOs). The module provides case studies, conceptual frameworks and tools to help students understand the opportunity that CSR records in implementing sustainability projects.

Learning Outcomes

The student will:

- Understand the conceptual framework and components of CSR.
- Assess the effectiveness of different CSR programs.
- Design innovative CSR programs.

Pre-requisite

None

Evaluation Procedure : Continuous

Assignments	40 % (3)	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment • Completed home assignment submitted timely and excellent written presentation	Assignments must be in the prescribed format digitally.	Internal Assessment
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T

1	Introduction to CSR and responsible investment • Introduction of Corporate Social Responsibility (CSR) : Evolution and present status; The Triple Bottom Line approach • Drivers of CSR • Why CSR? The issues: resources, people, climate, and natural resources. The environmental impacts of global economic growth • Moral and economic arguments on CSR; CSR expectations in rich and in poor countries • Repercussions of failed corporate responsibilities: Landmark cases, economic fallout, regulatory response • Key challenges in doing good • The regulatory framework in India	12	
	Assignment 1		03
3	Engaging the stakeholder • Who are the stakeholders? Role of stakeholders in CSR; consumer awareness and willingness to pay for socially responsible corporate behaviour • Communications revolution and its impact on CSR • CSR as a balance between organizational means and ends; driving social responsibility throughout the organisation	10	
	Assignment 2		03
4	Sustainability indicators and reporting • Frameworks for CSR reporting • Global Reporting Initiative Guidelines • The future of CSR • Sustainability Reporting: case study analysis	08	
	Assignment 3		03
	Final Assessment		
	Total	36	09

Suggested Readings

1. What is a Business for? Charles Handy, Harvard Business Review, December 2002
2. The Competitive Advantage of Corporate Philanthropy, Michael E Porter and Mark R Kramer, Harvard Business Review, pp 6-16, December 2002
3. Green and Competitive: Ending the Stalemate, Michael E Porter and Class van der Linde,

Harvard Business Review, pp 120-133, September-October 1995

4. What Matters Most: Corporate Values and Social Responsibility, Jeffrey Hollender, California management Review, pp 111-119, Volume 46(4), 2004

5. Corruption in International Business, Harvard Business Case 9-701-128, December 2001

6. Corporate Social Responsibility: Whether or How? N. Craig Smith, California Management Review, pp 52-76, Volume 45(4), Summer 2003

7. The Discipline of building character, Joseph L. Badaracco Jr., Harvard Business Review, pp 115-124, March – April 1998

8. Accounting Fraud at Worldcom, Robert S Kaplan and David Kiron, Harvard Business School Case study 9-104-071, May 2005, Management Lessons from Enron, B. Bowonder, TMTC, 2006

9. The Parable of the Sadhu, Bowen H. McCoy, Harvard Business Review, May-June 1997

10. Corporate Social Responsibility: the WBCSD, Geneva, 2004

General Reading:

1. Changing Course, Stephan Schmidheiny & BCSD, MIT Press, 1992

2. Harvard Business Review on Business & the Environment, Harvard Business School Press, 2000

3. The fortune at the Bottom of the Pyramid, C.K. Prahalad, Wharton School Publishing, 2005

4. The Skeptical Environmentalist: Measuring the real estate of the World, Bjorn Lomborg, Cambridge University Press, 2001

5. Cradle to Cradle: Remarking the Way We Make things, William KcDonough and Michael Braungart, North Point Press, 2002

6. Natural Capitalism: Creating the next Industrial Revolution, Paul Hawken, Amory Lovins & L. Hunter Lovins, 1999

7. The Sustainability Wave: Building Boardroom Buy-in (Conscientious Commerce), Bob Willard, 2007.

COURSE NO. EST 403

Course Title: EMS ISO 14001:2015-Lead Auditor

Number of Credits: 4

No. of Lectures-Tutorial-Practical: 36-09

Course Coordinator: Bureau Veritas

Course Outline

The course discusses the key principles and practices of effective EMS audits in accordance with ISO 14001:2015 and ISO 19011 “Guidelines for auditing management systems”. Using a step-by-step approach, the student will be guided through the entire audit process from initiation to follow-up. Over the duration of the course the student will gain knowledge and skills required to undertake and lead a successful environmental management systems audit; learn to describe the purpose of an ISO 14001:2015 EMS audit and how to satisfy third-party certification.

A payment of Rs. 10000/- towards certification charges to Bureau Veritas will need to be made.

Learning Outcomes

At the end of the course, students will:

- Develop the knowledge and skill required to conduct a full audit of an organization's Environmental Management System (EMS) to ISO 14001:2015.
- Acquire the certification for a certified environment auditor

Assignments	40 % (3)	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment • Completed home assignment submitted timely and excellent written presentation	Assignments must be in the prescribed format digitally.	Internal Assessment
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	T	P
1.	• Environment and OHS Issues • System Integration background • Requirements of Integrated System • Process approach in IMS • Reviewing IMS documentation • Auditing techniques • Audit planning • Reporting of audit findings • Conducting IMS audits • Certification & Accreditation process • Practical Exercises, Workshops and Feedback			
	Total	36		09

COURSE NO. EST 404

Course Title: Urban Sustainability

Number of Credits: 3

No. of Lectures-Tutorial-Practical/Assignment: 36-06

Course Coordinator: Ms. Samruddhi Patwardhan

Course Outline

The aim of the course is that the students understand urbanization processes on a global scale and the challenges and opportunities for sustainable development arising from the urban turn. Students will develop an understanding of measuring sustainability with different indicators and as well as an ability to analyse strengths, weaknesses, opportunities and threats of urban developments.

Evaluation Procedure : Continuous

Assignments	40 % (3)	Marking pattern for every assignment - Innovativeness and accuracy in completing the assignment - Completed home assignment submitted timely and excellent written presentation	Assignments must be in the prescribed format digitally.	Internal Assessment
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	T	P/A
1.	Introduction The idea and history of urbanization and sustainable developments (definition, historical use, our common future, the Rio process etc.)	2		
2.	Urbanization on a global scale	2		

	Problems in defining “the urban”, urbanization on a global scale in a historic perspective, drivers of current urbanization, differences in the urbanization patterns between different country groups			
	Assignment 1	2		5
3.	Risks and chances of urbanization Risks and chances of urban development in the four dimensions of sustainable development: Ecology, economy, politics and society; scenarios of future urban growth	2		
4.	Dimensions of urban sustainability Concepts and definition of sustainable development, urban sustainability: definition and targets, dimensions of urban sustainability, good urban governance: municipal, regional and national governance, law, order and conflicts, urban finance and taxation, utility planning and SDGs Social aspect- urban poverty, affordable and adequate housing, poverty reduction, concept of inclusive cities Improving human development in cities, education and employability, skill development , gender and safety Environmental sustainability- infrastructure provision, environmental services- transport, agriculture, power, climate impact, and disaster risk management.	4		
	Assignment 2: Field trip: from core to fringe: Pune megacity	6		5
5.	Concepts of sustainable urban development Different concepts urban and urban sustainable development, strategies: efficiency, consistency and sufficiency, programs on urban sustainable development (UN, EU, etc.). Role of public and local leadership	4		
	Assignment 3: Group work with different texts: different approaches towards urban sustainability Presentation and discussion of group work results	2		5
6.	Indicators for urban sustainability Introduction to tools of analysis and research methods	4		

	Relevance of indicators, concepts for sustainability indicators, sustainability indicators Group discussion based on text			
7.	Sustainable urbanization on a global scale Analysis of different case studies from countries with different backgrounds. Introduction to tools of analysis	4		
	Major Exam		3	
	Total	36	3	20

Textbooks

Hardoy, J., Mitlin, D., Satterthwaite, D.: Environmental problems in an urbanizing world. Finding solutions for cities in Africa, Asia and Latin America, London 2001.

Suggested Readings

1. Hust, E.: Introduction: Problems Of Urbanization And Urban Governance In India, In: Hust, E., Mann, M.: Urbanization And Governance In India, Neu Delhi 2005, S. 1-26.
2. Kennedy, C., Cuddihy, J., Engel-Yan, J.: The Changing Metabolism Of cities, In: Journal Of Industrial Ecology 11 (2) (2007), S. 43–59.
3. Kraas, F.: Urban Sustainability – Sustainability In Urban Areas: Basic Considerations., In: Gaese, H., Kraas, F., Mi Mi Kyi: Sustainability In Rural And Urban Environments. Proceedings Of The First German-Myanmar Workshop In Yangon/Myanmar, 17-21 November 2003, Köln 2005.
4. Mcgranahan, G., Satterthwaite, D.: Urban Centres: An Assessment Of Sustainability, In: Annual Review Of Environment And Resources 28 (2003), S. 243–274.
5. Meadows, D.: Indicators And Information Systems For Sustainable Development. A Report To The Balaton Group, Hartland 1998.
6. Satterthwaite, D.: Sustainable Cities Or Cities That Contribute To Sustainable Development?, In: Satterthwaite, David. The Earthscan Reader In Sustainable Cities, London 1999, S. 80-106.
7. Satterthwaite, D.: The Scale Of Urban Change Worldwide 1950-2000 And Its Underpinning, London 2005.
8. Unhabitat (2008): State Of The World's Cities 2010/2011: Bridging The Urban Divide.
9. International Journal Of Urban Sustainable Development
10. Urbanization And Environment

COURSE NO. EST 405

Course Title: Industrial Safety and Occupational Health

Number of Credits: 3

No. of Lectures-Tutorial-Practical: 36-06

Course Coordinator: Mr. Mahesh Kulkarni

Assignments	40 % (3)	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment • Completed home assignment submitted timely and excellent written presentation	Assignments must be in the prescribed format digitally.	Internal Assessment
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	T	P
1.	Principles of accident prevention • Definitions: Accident, injury, hazard, Risk, Danger, unsafe acts, unsafe conditions, dangerous occurrences etc. • Accident prevention: H.W.Henrich, Frank bird & Multiple Causation theories of accident occurrences. Principles of accident prevention, Models of accident prevention.	5		
2.	Planning for safety • Definition, purpose, nature, scope and procedure. Range of planning. Variety/forms of plans.	5	2	3

	• Strategic planning and process of implementation. Management by objectives and its role in • safety. Policy formulation and effective planning for safety.			
3.	Organizing for safety • Definition, need, nature and principles. • Organization for Safety: Organization structure and safety department • Safety Officer: Role, responsibility, authority. Power and qualifications/attributes. • SAFETY COMMITTEE: Structure & functions. Line & Staff functions in safety department.	5	1	3
4.	Directing for safety • Direction: Definition, Process, Principles & Techniques. • Leadership: Role, functions & attributes of a leader. Leadership styles and safety management. • Communication: Fundamentals, importance, process, types & channels. • Five essential rules for communication. • Two-way communication. • Barriers and break-downs in communication. Communication with management, employees & • union. • Communication and group-dynamics. • Managerial Communication: A tool for management of frustrations, conflicts and attitudes towards safety & health.	10	2	3
6.	Safety Management Information System • Sources of information on Safety , Health, and Environment. Compilation, • Processing retrieval and analysis of information. • Status and future scope of computer utilization in Safety. Health and Environment • (SHE) Services in Industries.	5	3	3

	Introduction to national & international SHE Management Systems • Total Quality Management and its application to SHE, occupational Health & safety • appraisal system 18001 and 15001			
	Final Assessment			
	Total	36	9	15

COURSE NO. EST 406

Course Title: Green Technology and Management

Number of Credits: 3

No. of Lectures-Tutorial-Practical: 36-06

Course Coordinator: Dr. Rashmi Mardikar

Course Outline

The course aims to provide students with a strong foundation in science and technology to contribute effectively in the green industries, with a focus on environmental & waste management and energy optimization. Students will be equipped with skills, knowledge and attributes necessary in this sector.

Learning Outcomes

At the end of the course, students will:

- Be able to find sustainable solutions for environmental issues without compromising economic development.
- Will be able to provide scientific advice for policy development and decision-making.

Assignments	40 % (3)	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment • Completed home assignment submitted timely and excellent written presentation	Assignments must be in the prescribed format digitally.	Internal Assessment
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	T	P
1.	Need for sustainability	05	2	5

	The inseparable linkages of life supporting systems, biodiversity and ecosystem services and their implications for sustainable development; global warming; greenhouse gas emissions, impacts, mitigation and adaptation			
	Greening in different sectors Green Energy: Sustainable energy sources and alternative technologies, strategies and case studies Green IT and communication technologies, strategies and case studies Greening the transport sector, strategies and case studies Greening waste management, strategies and case studies Greening building, strategies and case studies	10		
2.	Assignment 1			10
3.	Green innovation and sustainability - Eco/green technologies for addressing the problems of Water, Energy, Health, Agriculture and Biodiversity- (eco-restoration/ phyto-remediation, ecological sanitation, renewable energy technologies) - Design for sustainability; Criteria for choosing appropriate green energy technologies, life cycle cost; the emerging trends – process/product innovation-, technological/ environmental leap-frogging Green Energy and sustainable development - Future energy Systems- clean/green energy technologies; International agreements/conventions on energy and sustainability	15		
	Assignment 2			
3.	Green Management - Environmental reporting and ISO 14001; ISO 14064; greenfinancing; financial initiative by UNEP; - Green tax incentives and rebates (to green projects and companies); green project management in action; Sustainable supply chain management	15		5
	Assignment 3			4
	Final Assessment			
	Total	36		09

Suggested readings

1. Green Management and Green Technologies: Exploring the Causal Relationship by Jazmin Seijas Nogarida, 2008.
2. Green Marketing and Management: A global Perspective by John F. Whaik, 2005
3. The Green Energy Management Book by Leo A. Meyer
4. Green Project Management by Richard Maltzman And David Shiden
5. Green Marketing by Jacquelin Ottman
6. Green and World by Andrew S. Winston

COURSE NO: EST 407

Course Title: Green Buildings

Number of Credits: 4

No of Lectures– Assignments: 36-07-02

Course Coordinator: Adv. Gouri Joshi

Course Outline

The course aims at achieving deeper understanding of the concept of green building and the various components involved in green building certification. Along with this the course provides and indepth understanding of the laws, schemes, codes and guidelines adopted by the Nation for sustainable, energy efficient, solar passive buildings having greater functional value and reduced resource consumption.

Learning Outcomes

At the end of the course, the student will:

- Develop an appreciation of the concept and role of 'green buildings' in sustainable development
- Understand the technical aspects of green building, and national and international certifications
- Acquire the ability to assess and explore techniques to improve building exterior, site, water, energy consumption, remodeling, waste management, and procurement of materials for green building.
- Develop a deep understanding of the regulations and government schemes directly or indirectly influencing the field of 'green buildings' necessary for a certified green building practitioner.
- Be prepared to appear for certification for a green building accredited professional.

Sr No	Topic	Time (Hour)	
1	Green Buildings • Construction industry and use of resources,, Concept of green buildings; History and evolution of the concept; Benefits of Green New Buildings; National Priorities Addressed in the Rating System; IGBC Green New Buildings Rating System • Climate responsive construction; IGBC, LEED and GRIHA accreditations; National Building Code and ISO standards • Green Building policies adopted by different states	08	

	Assignment 1: Comparison between a conventional building and green building through site visits		06
2	Laws related to Energy conservation • Draft National Energy Policy of India • Energy Conservation Act, 2001 • Energy Conservation (the form and manner for submission of report of the status on energy consumption by the Designated Consumers), Rules 2007 • Renewable energy sources and policies in India • Overview of Energy Conservation Building Code, 2017	07	
3	Water conservation and Green Buildings • Legal aspects of water resource management • Evolution of National Water Policy, 2012 • Drinking Water standards by Bureau of Indian Standards, 2012 • The Groundwater (Sustainable Management) Bill, 2017 • Guidelines to regulate and control Ground Water Extraction in India, 2018 • Water conservation aspect of green buildings	07	
4	Green Buildings and other resources • Green building materials • Zero net emission buildings • Zero waste buildings • Indoor air quality standards • Ambient Air Quality Standards	07	
	Green Building Certification requirements • Sustainable architecture and design: integrated design approach, site preservation, passive architecture; transport and resource footprint • Site selection and planning: local building regulations, soil erosion control, basic amenities, natural topography/vegetation, heat island reduction • Water conservation: Roof and non roof rainwater harvesting, water efficient plumbing, landscape design, waste water treatment and reuse, water metering • Energy Efficiency: Minimum energy efficiency, ozone depleting substances, use of renewables • Building materials and resources: sustainable building materials, handling of construction waste, use of	15	

	certified green building materials, segregation of waste post occupancy		
	Indoor environmental quality: minimum fresh air ventilation, daylighting, outdoor views, minimize indoor and outdoor pollutants, indoor air quality testing (before, during and after construction)		
	Assignment 2: Assessment of a building for green certification		3
	Total	36	9

Reference Books:

1. Guide to International Environmental Law, Alexandre Charls Kiss, Dinah Shelton 2007
2. International Environmental Law and Policy for 21st Century, by Ved P. Nanda, George (Rock) Pring, 2nd Edition, 2012, Martinus Nijhoff Publications;
3. Axelrod, Regina S. [not related to your professor], David L. Downie, and Norman J. Vig, eds. 2011. The global environment: institutions, law, and policy, 3rd edition. Washington: CQ Press. (subsequently noted as —Axelrod et al.))
4. Benedick, Richard Elliot. 1998. Ozone diplomacy: new directions in safeguarding the planet. Cambridge, MA: Harvard University Press.
5. Chasek, Pamela S., David L. Downie, and Janet Welsh Brown. 2010. Global environmental politics, 5th edition. Boulder, CO: Westview Press. (subsequently Chasek et al.))
6. Brown Weiss, Edith, and Harold K. Jacobson, eds. 1998. Engaging countries: strengthening compliance with international environmental accords. Cambridge, MA: MIT Press

COURSE NO. GEN 401

Course Title: Entrepreneurship Development

Number of Credits: 2

No. of Lectures-Tutorial-Practical: 15-15

Course Coordinator: External Inputs coordinated by Dr. Rashmi Mardikar

Course Description

This course is designed to help students evaluate the business skills and commitment necessary to successfully operate an entrepreneurial venture and review the challenges and rewards of entrepreneurship. Students will learn about themselves, their decisions, and their goals to determine how entrepreneurship can play a role in their lives. Students will also be introduced to entrepreneurship from an economic perspective and the concepts of environmentally sustainable practices and social entrepreneurship.

Learning Outcomes

On completion of this course, the student will:

- Develop an understanding of personal attributes and skills that characterize the 'successful' entrepreneur.
- Be able to assess and compare their personal characteristics and interests to that of the 'successful' entrepreneur.
- Be able to identify and assess sources of support for small businesses and entrepreneurs. Be able to research and explain issues relevant to entrepreneurs such as 'green' business practices, environmental sustainability.
- Be able to identify the financial, marketing, legal, human resource, operations, and general management skills that are necessary to successfully launch and operate a successful new venture.

Evaluation Procedure: Continuous

Assignment	1	100 %	Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	• Entrepreneurship-Enterprise: Conceptual issues. Entrepreneurship vs. Management. Roles and functions in relation to the enterprise and in	05	

	relation to the economy. Small business as seedbed of Entrepreneurship.		
2	• Opportunity scouting and idea generation: role of creativity and innovation and business research. Sources of business ideas. • Entrepreneur opportunities in contemporary business environment, for example opportunities in net-workmarketing, franchising, business process outsourcing in the early 21 century. • The process of setting up a small business: Preliminary screening and aspects of the detailed study of the feasibility of the business idea and financing/non-financing support agencies to familiarize themselves with the policies/programs and procedures and the available schemes. • Preparation of Project Report and Report on Experiential Learning of successful and unsuccessful entrepreneurs.	05	
	Assignment 1		08
3.	• Issues in small business marketing. The concept and application of product life cycle, advertising and publicity, sales and distribution management. • The idea of consortium marketing, competitive bidding/tender marketing, negotiating with principal customers. • The contemporary perspectives on Infrastructure development, Product and Procurement Reservation, Marketing Assistance, Subsidies and other Fiscal and Monetary Incentives. National state level and grass-root level financial and non-financial institutions in support of small business development.	05	
	Assignment 1		07
	Total	15	15

COURSE NO: GEN 402

Course Title: Soft Skills

Number of Credits: 2

No. of Lectures: 30

Course Coordinator: External Consultant

Evaluation Procedure : Continuous

Assignment	1	50%	Internal Assessment
Assignment	2	50%	Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Introduction to Personality a) Basic of Personality b) Human growth and Behavior c) Theories in Personality d) Motivation Communication skills and Personality Development a) Intra personal communication and Body Language b) Inter personal Communication and Relationships c) Leadership Skills d) Team Building and public speaking	07	
	Assignment 1		4
2	Techniques in Personality development I a) Self confidence b) Mnemonics c) Goal setting d) Time Management and effective planning	07	
3.	Techniques in Personality Development II a) Stress Management b) Meditation and concentration techniques c) Self hypnotism d) Self-acceptance	08	
	Assignment 2		4
	Total	22	8

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BHARATI VIDYAPEETH
(DEEMED TO BE UNIVERSITY)
INSTITUTE OF ENVIRONMENT EDUCATION AND RESEARCH, PUNE
Faculty of Interdisciplinary Studies

Syllabus

M.Sc. (Wildlife Conservation Action)

Semester I, II, III, IV

effective from 2019-2020

in collaboration with

WILDLIFE TRUST OF INDIA



**BHARATI VIDYAPEETH (DEEMED TO BE) UNIVERSITY,
PUNE**

Faculty Of Interdisciplinary Studies

M.Sc. (Wildlife Conservation Action)

**COURSE STRUCTURE AND DETAILED SYLLABUS
OF
SEMESTER I, II, III and IV (UNDER CREDIT SYSTEM)
EFFECTIVE FROM 2019-2020 AT SEMESTER I**

At the
INSTITUTE OF ENVIRONMENT EDUCATION AND RESEARCH
BHARATI VIDYAPEETH UNIVERSITY, PUNE
In collaboration with
WILDLIFE TRUST OF INDIA, NEW DELHI

This document provides details of the rules and regulations, examination pattern and course details. Students are advised to read it carefully and refer to it from time to time during the course of their study at the Institute of Environment Education and Research, Bharati Vidyapeeth (Deemed to be) University, Pune.

The Bharati Vidyapeeth (Deemed to be) University is a multidisciplinary, multicampus University having 32 institutions imparting quality education in various disciplines. All programs of the University are approved by the University Grants Commission (UGC) and the respective statutory councils. The University has been re-accredited for the third time with an 'A+' grade by the National Assessment and Accreditation Council (NAAC) in 2017. The UGC has accorded the 12B status (UGC Act 1956) to the University. The Ministry of Human Resource Development, Government of India has awarded 'A' category to the University in 2012 based on several parameters that include innovative programs, research and infrastructure facilities. The University has maintained its rank in the top hundred universities of India consistently since 2012 and is presently ranked at 76th position by the National Institution Ranking Framework (NIRF) by the UGC for the year 2020.

The University is a member of the Association of Indian Universities (AIU) and also the International Association of Universities.

The Institute of Environment Education and Research of the Bharati Vidyapeeth (Deemed to be) University, is a constituent unit of the University established in 1993. The Institute is approved by the UGC to conduct post graduate courses in Environment Science, Geoinformatics and Wildlife Conservation Action as well as Doctoral programs in Environment Science and Geoinformatics. The Institute has excellent infrastructure and competent faculty who are nationally and internationally known. Through its collaborations with several international universities the Institute offers international student and faculty exchange programs as well as international internships.

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BHARATI VIDYAPEETH (DEEMED TO BE) UNIVERSITY, PUNE

Faculty Of Interdisciplinary Studies

Course Structure of Master of Wildlife Conservation Action (Under Credit System) effective from 2019-2020

INTRODUCTION

The course has a transdisciplinary approach that integrates the science of wildlife conservation with social issues in managing and mitigating wildlife conflict and natural resource management. The course provides in depth knowledge of ecosystem and biodiversity conservation and management along with wildlife rescue and rehabilitation as well as legal instruments for wildlife conservation. It includes the cognitive aspects and technological skills necessary to further a career in the wildlife field. It trains the candidate in skills required for assessment and monitoring of biodiversity as well as wildlife management through a combination of course work, intensive field work and internships. The program also builds skills in conducting research and communicating for wildlife conservation. The course provides multiple exit points. The course is administered by the Faculty of Interdisciplinary Studies.

This course is implemented in close collaboration with the Wildlife Trust of India, a premier organization involved in action based wildlife research and advocacy.

OUTCOMES

At the end of the course, each student will have acquired the following attributes;

1. Disciplinary Knowledge and Interdisciplinarity

Demonstrate disciplinary knowledge from ecological, social, physical, economic, legal fields; Appreciate the ethical, cross cultural and historical context of environmental issues and the links between human and natural systems; Apply systems concepts and methodologies to analyze and understand interactions between social and environmental processes; Demonstrate appropriate and advanced technical skills in investigating, analyzing and synthesizing information, problems, concepts and theories within environment science

2. Quantitative Competence

Understand essential mathematical and statistical approaches used to analyse environmental data; Accurately comprehend and draw appropriate inferences from numeric data, statistical analysis and predictive models; Use state-of-the-art software, hardware and analytical techniques to solve problems in environment science and management.

3. Critical Thinking

Demonstrate the capability to apply analytic thought to a body of knowledge; analyse and evaluate evidence, arguments, claims and beliefs on the basis of empirical evidence; formulate coherent arguments; critically evaluate practices, policies and theories following the scientific approach to knowledge development.

4. Problem Solving

Identify environmental problems, evaluate problem solving strategies and develop science based solutions; understand the need to integrate relevant social sciences (eg: environmental planning, law, economics) in environmental problem solving; Use acquired knowledge, skills and ingenuity to solve complex problems.

5 . Communication

Clearly communicate complex analyses, interpretations and significance effectively in writing and orally to varied audiences ranging from scientific to policy and the general public; be proficient in contemporary communication tools

6. Multicultural competence

Possess knowledge of the values and beliefs of multiple cultures and a global perspective; capability to effectively engage in a multicultural society and interact respectfully with diverse groups.

7. Moral and ethical awareness/reasoning

Identify ethical issues related to one's work; formulate a position/argument about an ethical issue from multiple perspectives and use ethical practices in their life and career; avoid unethical behavior; adopting objective, unbiased and truthful actions in all aspects of work.

5. Collaboration and Team work

Collaborate in teams with peers and mentors and work with others in diverse group settings, developing flexibility and leadership skills

6. Lifelong learning

Ability to acquire knowledge and skills, including 'learning how to learn' for meeting changing demands of work place.

SCOPE

The course has a rapidly expanding horizon in both national and international level. Government and Non-Governmental organizations such as Wildlife Trust of India, World Wide Fund for Nature, ATREE, WII, IUCN, etc. employee candidates with these qualifications as wildlife researchers as well as wildlife managers. The transdisciplinary foundation prepares the student to pursue a career in a variety of conservation related jobs and produces a broad based scientist. It also provides opportunities for people who are already working in the field to further their career through a formal Diploma course and a Master's program.

ELIGIBILITY FOR ADMISSION TO THE COURSE

- a. The candidate should have obtained the Bachelors degree in any Science subject such as Botany, Zoology, Chemistry, Physics, Statistics, Geography, Geology, Geography, Life Sciences, Environment Sciences, Microbiology, Biotechnology, Fisheries, Marine Biology, Horticulture, Agriculture, Computer Science, Data Science, Veterinary Science, Health Sciences or
- b. any branch of Engineering
- c. any relevant Social Science subjects and Management Studies
- d. The candidate should have secured at least 50% in the aggregate at undergraduate level and 45% for SC /ST / OBC candidates.
- e. If the candidate has a degree in any other subject than the ones mentioned above he/she should have a working experience of minimum of three years in the area of conservation field to be eligible for the Master's program. A work experience certificate from the relevant organization duly signed and stamped by the Head of the Institution must be submitted.

DURATION OF THE COURSE

This program consists of a minimum of 104 credits that may be completed in two years consisting of four semesters. The medium of instruction and examination will be only English.

RULES AND REGULATIONS

1. **Commencement and Conclusion:** The dates for the commencement and conclusion of each semester shall be determined by the University authorities. The terms can be kept only by duly admitted students. Each semester is of 14 weeks duration. Students must check the academic calendar for exact dates of commencement and conclusion.

Credits: The entire Course is of 104 credits and will be executed in four semesters. Semester I and II consist of 29 and 25 credits respectively while Semester III and Semester IV consist of 26 and 24 credits respectively.

The student will undertake guided research in the third semester (dissertation) program (four months field/lab work and two months for data analysis and writing). In the fourth semester the student will have a mandatory internship (maximum six months and minimum five months) along with two electives.

One credit for the theory course is equivalent to 15 hours of interaction of student with facilitator, while one credit for the practical course is equivalent to 30 hours of practical work or 30 hours of field work.

2. The curriculum comprises of Core (Hard and Soft) and Value Added Courses. All Core courses are compulsory while the Value Added Courses are elective.
3. The Core courses are aimed at providing fundamental knowledge and skills relevant to the discipline while the Value Added Courses intend to develop relevant skills.

4. The respective elective course will be implemented only if atleast seven students enroll in the course.
5. Some of the core courses are common in the three Master's programmes: M.Sc. Environment Science and Technology, M.Sc. Geoinformatics, M.Sc. Wildlife Conservation Action.
6. The teaching and evaluation for these courses will be combined for both disciplines.
7. All hard core courses will be evaluated by the University Examination.
8. One extra credit will be awarded to the student if there is any significant outcome of their dissertation study. The research outcome in terms of publication in indexed national / international journal; filing of patent will be considered for the award of credits.
9. The number of students for each elective should not be less than five.
10. **Dissertation:** The student will undertake a dissertation in semester III spanning six months (four months for field work and two months for analysis and writing) for which 24 credits have been allotted. The topic for the research must be finalized by the send of Semester II after thorough literature review.
11. **Field Visits:** The field / academic Institute visits will be organized for demonstration of advance experimental techniques wherever necessary along with the courses. Attendance for these are mandatory and will form part of assessment as indicated in the syllabus.
12. **Internship:** The student must complete an internship of maximum six months duration (minimum five months duration) in semester IV which will entail 10 credits. It is mandatory for students to attend the mid internship assessment. Formats of submission of internship report are attached in the relevant section of this document for reference. Students should submit their reports in these formats only.
13. **Attendance:** A student must attend every lecture, tutorial, and practical class. However, to account for late admission, sickness, or other such contingencies, the attendance requirement will be a minimum of 75% of the classes actually held. A student must have minimum 75% attendance in theory and 100% attendance in the practical courses to fulfill the term. A student who does not have the required attendance (less than 75%) will not be allowed to appear for the Continuous Assessment.

A student with less than 75% attendance in a course during the semester, in lectures, tutorials, and practicals taken together (as applicable), will be debarred from taking the final test/examination in the course and will be awarded an Ab. grade.

If a student remains absent for more than 50 percent of the term due to illness as reported by a licensed medical practitioner, the student will have to repeat the term. Application for medical leave should be supported with test reports, hospitalization reports, prescriptions and certificate from a registered practitioner). The registration number of the medical practitioner should explicitly appear on the medical certificate. These will be reviewed by the management and it management retains the right to grant/ refuse the medical leave.

In order to maintain the attendance record of a particular course, course coordinators will record attendance in every scheduled lecture, tutorial, and practical class.

14. Leave Rules

Students may be granted leave only in exceptional cases on approval of the Head of the Department/ Director. However, the period of leave would count as absence for the attendance requirements for a course.

A student must inform in writing/through an e-mail to the Course coordinator with a copy to the administration office immediately of any instance of continuous absence from classes.

15. Maximum duration of the course

The student must complete all four semesters in a maximum of four years, failing which he/she will have to re-register for the course.

RULES FOR EXAMINATION

A. Nature of Examination

- i. Examination for the theory and practical courses will be conducted at the end of each respective semester or as continuous assessment as indicated in the syllabus.
- ii. Each course will have 40% marks for internal assessment and 60% marks for semester end examination.
- iii. The Internal Assessment (IA) will be conducted by the Institute and the end-of-the-term University Examination (UE) will be conducted by the University. The UE will be based on the entire syllabus. The internal assessment will be conducted throughout the semester in the form of tests/tutorials/seminars/oral presentations/assignments/debates, etc. as indicated in the syllabus.
- iv. Internal assessment for the practical course is through continuous assessment. Each practical is evaluated for fifteen marks. Of this, performance in the class is assessed for five marks and timely journal submission (within a week of the practical being conducted) as per instructions given by the concerned teacher is assessed for ten marks. The aggregate of the practical assessment will be averaged to 40 marks. Practical's missed by the student, need to be completed by the student themselves before appearing for the final examination.
- v. The general courses will be evaluated by the instructor on the basis of continuous assessment as indicated in the syllabus.

B. Ethical standards during the Examination

- i. The University maintains high ethical standards during examinations and there is a zero-tolerance policy in place regarding cheating and use of any unfair means in the examinations. The entire institution is under camera surveillance including classrooms and laboratories. Anyone found to be using unfair means will face a Disciplinary

Committee immediately. Punishments for use of unfair means includes expulsion from the University.

- ii. The students shall occupy the seats allotted to them by the concerned Invigilator.
- iii. The student must be present inside the hall ten minutes before the commencement of the exam. Students coming late will be debarred from attending the examinations.
- iv. Students are not permitted to leave the examination hall during the examination period. However, in a very exceptional case, if the faculty invigilator allows such leave; a candidate not returning within 5 minutes shall be liable to cancellation of her/his paper.
- v. During the Continuous and University examinations, students are permitted to carry a transparent writing support pad, and a transparent pouch for pens, pencils, eraser. Calculator is permitted if needed. All books and notes, electronic gadgets including cell-phones, i-pads, i-pods, tablets, laptop, etc. must be deposited outside the classroom. Pockets must be empty during the exam.
- vi. Every candidate is expected to observe silence, decorum and abide by the instructions given by the faculty on invigilation during the examination.
- vii. Talking or discussing among themselves or sharing answers/hints in any form shall be punishable and will lead to disciplinary action.
- viii. Mobile phones are not allowed in the examination hall. Students have to switch off the mobile and submit it to the invigilator or put in the bags. Mobile phones should not be available with students or on their respective desk.
- ix. Internet access is not allowed during examination time.
- x. In addition to above, the students must adhere to any additional instructions from the supervisors from time to time.

STANDARD OF PASSING

A . Grading System

- i. A 10 point absolute grading system will be adapted for grading each head of passing. The details are given in the table below:

Table 1: The grading system under CBCS

Range of Marks (Out of 100)	Grade	Grade Point
$80 \leq \text{Marks} \leq 100$	O	10
$70 \leq \text{Marks} < 80$	A+	9
$60 \leq \text{Marks} < 70$	A	8
$55 \leq \text{Marks} < 60$	B+	7

$50 \leq \text{Marks} < 55$	B	6
$40 \leq \text{Marks} < 50$	C	5
Marks < 40	D	0

- ii. The grade point average (GPA) for a course shall be calculated by first finding the total marks out of 100 for the course. The corresponding GP (as per Table 2) shall be the GPA for the course.
- iii. Two kinds of performance indicators, namely the Semester grade Point Average (SGPA) and the Cumulative Grade Point Average (CGPA) shall be computed at the end of each term. The SGPA measures the cumulative performance of a learner in all the courses in a particular semester, while the CGPA measures the cumulative performance in all the courses up to and including the current semester. The CGPA of a student when he/she completes the programme is his/her final result.
- iv. The SGPA is calculated by the
$$\text{SGPA} = \frac{\sum C_k \times \text{GPA}_k}{\sum C_k}$$
 formula, where C_k is the credit value assigned to a course and GPA_k is the GPA obtained by the student in the course. In the above, the sum is taken over all the courses that the student has undertaken for the study during the semester, including those in which he/she might have failed or those for which he/she remained absent. The SGPA shall be calculated up to two decimal place accuracy.
- v. The CGPA is calculated by the
$$\text{CGPA} = \frac{\sum C_k \times \text{GPA}_k}{\sum C_k}$$
 formula, where C_k is the credit value assigned to a course and GPA_k is the GPA obtained by the student in the course. In the above, the sum is taken over all the courses that the student has undertaken for the study from the time of his/her enrolment and also during the semester for which CGPA is calculated, including those in which he/she might have failed or those for which he/she remained absent. The CGPA shall be calculated up to two decimal place accuracy.
- vi. The CGPA, calculated after the minimum credits specified for the program are 'earned' and will be the final result. Grace marks of 1, 2 or 3 may be awarded to a candidate at UE as per the rules of the University.

B. Standards of Passing and ATKT Rules

1. For all courses, both UE and IE constitute separate heads-of-passing (HoP). In order to pass in such courses and to 'earn' the assigned credits

- i. The learner must obtain a minimum grade point of 5.0 (40% marks) at UE and also a minimum grade point of 5.0 (40% marks) at IA;

OR

- ii. If he / she fails in IA, the learner passes in the course provided he / she obtains a minimum of 25% in IA and GPA for the course is atleast 6.0 (50% in aggregate). The GPA for a course will be calculated only if the learner passes at the UE. The following examples illustrate this rule for passing in a course under.
2. A student who fails at UE in a course has to reappear only at UE as a backlog candidate and clear the HoP. Similarly, A student who fails in a course at IA has to reappear only at IA as a backlog candidate and clear the HoP.
 3. A candidate shall be permitted to proceed further from the First Semester upto the Fourth Semester irrespective of his/her failure in any of the above semester examinations subject to the conditions that the candidates should register for all the backlog courses of the earlier semesters alongwith current (subsequent) semester courses.

Table 2: Illustration of Passing Rule specified

Case No.	UE Marks Out of 60	IA Marks Out of 40	Total Marks Out of 100	GP of UE	GP of IA	GPA	Remarks
1	24	16	40	5.0	5.0	5.0	Pass
2	40	10	50	7.0	0	6.0	Pass
3	40	06	46	7.0	0	5.0	Fails at IA
4	20	40	--	0	10.0	0	Fails at UE
5	34	12	46	7.0	0	5.0	Fails at IA
6	20	15	--	0	0	0	Fails at both UE & IA

C. Award of Honours

A student who has completed the minimum credits specified for the program shall be declared to have passed in the programme. The final result will be in terms of letter grade only and is based on the CGPA of all courses studied and passed. The criteria for the award of honors are given below.

Table 3: Criteria for the award of honours at the end of the program

Range of CGPA	Final Grade	Performance Descriptor	Equivalent Range of Marks (%)

$9.50 \leq \text{CGPA} \leq 10.00$	O	Outstanding	$80 \leq \text{Marks} \leq 100$
$9.00 \leq \text{CGPA} \leq 9.49$	A+	Excellent	$70 \leq \text{Marks} < 80$
$8.00 \leq \text{CGPA} \leq 8.99$	A	Very Good	$60 \leq \text{Marks} < 70$
$7.00 \leq \text{CGPA} \leq 7.99$	B+	Good	$55 \leq \text{Marks} < 60$
$6.00 \leq \text{CGPA} \leq 6.99$	B	Average	$50 \leq \text{Marks} < 55$
$5.00 \leq \text{CGPA} \leq 5.99$	C	Satisfactory	$40 \leq \text{Marks} < 50$
CGPA Below 5.00	F	Fail	Marks Below 40

PATTERN FOR ASSESSMENT

A. Pattern of Evaluation for Internal Assessment of Theory Courses

The weightage for Internal Assessment is 40%. Students of IA of every theory course will be assessed for a total of 40 marks for a 3 credit course for 20 marks for a 2 credit course which will be cumulative marks obtained in two/three separate assessments as specified in the individual course.

In case of hard core courses, the pattern will be as below:

- Two internal written examinations for 20 marks each for 3 credit courses. Average of the two tests will be considered.
- Two assignments of ten marks each as given by the concerned teachers. A total of the two assignments will be considered.

In case of soft core (electives), the pattern will be as below:

- One written examinations for 60 marks each for 3 credit courses.
- Three assignments of a total of 40 marks (10 + 10 + 20) given by the concerned teachers. A total of the three assignments will be considered.

B. Pattern of Evaluation for Internal Assessment of Practical Courses

The Internal Assessment for every practical course will be of 40 marks for 2 credits. The students for IA will be assessed on the basis of:

- Performance for every practical: 5 marks each for every practical
- Assignment: Timely submission of assignment with accuracy: 10 marks. The marks obtained in all the practical's will be added and averaged to out of 40.

C. Pattern of Evaluation of General Courses

- i. The Internal Assessment of General Courses for 2 credits will be done through two assignments, each of 25 marks.
- ii. For those with 3 credits along with continuous assessment as indicated in B (a and b) above, an end term examination of 60 marks will be conducted internally.

D. Pattern of question paper at the University Examination

University examination of 3 credit theory course will be of 60 marks.

The question paper will comprise of 6 questions. Any four questions may be answered from Q1 to Q5, while Q6 is compulsory. Q1 to Q5 will have two sub questions of 6 marks each. Q6 will comprise of three short notes of 4 marks each. The pattern of the question paper is given below:

Pattern of question paper for 3 credit course of University Theory Examination of M.Sc. Wildlife Conservation Action 2019 CBCS Course

Total marks: 60

Time: 3 Hours

Question paper pattern for all courses.

Q6 is mandatory and students will answer any four of the remaining five questions.

Q.1	a		(06)
	b		(06)
Q.2	a		(06)
	b		(06)
Q.3	a		(06)
	b		(06)
Q.4	a		(06)
	b		(06)

Q.5	a		(06)
	b		(06)
Q.6.		Write short notes on any three of the following	(12)
	a		
	b		
	c		
	d		

Pattern of question paper of University Practical Examination of M.Sc. Environment Science and Technology 2019 CBCS course

Total marks: 60 for 2 credit courses Time: 3 Hours

Q.1	Major Practical	(25)
Q.2.	Minor exercise	(15)
Q.3.	Minor exercise	(10)
Q.4.	Viva	(10)

IMPORTANT INSTRUCTIONS FOR STUDENTS

- Read carefully the entire Syllabus, making sure that all aspects of the course are clear to you, ie. Structure of the program, electives, details of assignments, internal and external examinations systems, marking systems, grading, attendance requirements as well as rules and regulations.
- Course coordinators are liable to change from those mentioned. Students will be informed about the change if any before the commencement of the semester.
- Familiarize yourself with the library and online resources for maximizing your learning experience. Be a self motivated learner.
- Faculty are always willing to accommodate interested and exceptional students in their on going research. If you are interested in volunteering your time on any of the projects to gain valuable work experience, do get in touch with them.
- Make sure that all assignments are submitted on time. Late submission of assignments may result in loss of a certain percentage of marks or rejection of your assignment.
- Every practical journal must be completed in the stipulated time.

Academic Integrity

Bharati Vidyapeeth University is committed to maintaining academic quality, excellence, and honesty. All faculty and students are expected to share the commitment to academic integrity, an essential component of a quality academic experience.

Students are expected to read and follow all policies, procedures, and program information guidelines contained in publications; pursue their learning goals with honesty and integrity; demonstrate that they are progressing satisfactorily and in a timely fashion by meeting course deadlines and following outlined procedures; observe a code of mutual respect in dealing with mentors, staff, and other students; behave in a manner consistent with the standards and codes of the profession in which they are practicing; keep official records updated regarding changes in name, address, telephone number, or e-mail address.

Payment of fees

Fees for the first term must be paid at the time of admission. Fees for the second term and fourth must be paid before 30 September of the same year. Fees for the third semester must be paid before 30 May. Students must meet financial obligations in a timely manner. The admission process for the term is not complete without payment of fees. If a student fails to pay the fees, the name of the concerned student will not reflect in the list of admitted students, affecting the attendance. Such a student will not be permitted to attend either the continuous / internal / external examination.

Academic Dishonesty

All students are expected to approach their education with academic integrity. Academic dishonesty undermines this objective. Academic dishonesty can take the following forms:

- Cheating

- Gaining or providing unauthorized access to examinations or using unauthorized materials during exam administration
- Submitting credentials that are false or altered in any way
- Plagiarizing (including copying and pasting from the Internet without using quotation marks and without acknowledging sources)
- Forgery, fabricating information or citations, or falsifying documents
- Submitting the work of another person in whole or in part as your own (including work obtained through document sharing sites, tutoring schools, term paper companies, or other sources)
- Tampering with the academic work of other students

Plagiarism

Plagiarism, is using the work and ideas of others without proper citation. This is strictly prohibited in all assignments and dissertation. Students should check their assignments through online antiplagiarism softwares (Eg. Grammarly, etc) before submission. Students are liable to lose marks or may find that their work is not assessed when they submit plagiarized content.

Plagiarism defeats the purpose of education. If you plagiarize, you are not educating yourself, and you are wasting your time on courses meant to improve your skills.

SEMESTER WISE COURSE INFORMATION

Semester I

Course Number	Course Title	Credit Value	Hours per week	Weightage UE	Weightage IA	EoTM
EST 101	Ecosystem Studies	3	3	60	40	University
CA 101	Sustainability Of Socio-Ecological Systems	3	3	60	40	University
CA 102	Wildlife Law And Trade Control	3	3	60	40	University
CA 103	Conservation Problems And Practices	3	3	60	40	University
GEO 102	Fundamentals Of Geoinformatics	3	3	60	40	University
EST 111	Field Techniques I	2	3	60	40	University
GEO 112	Techniques In Geographical Information Systems	2	3	60	40	University
CA 104	Research Methodology	2	2		100	Continuous
CA 111	Field Taxonomy I	2	60 hours cumulative		100	Continuous
	General Courses					
EST 104	Statistical Methods	3	3		100	Continuous
EST 105	Introduction To Data Analysis	3	3		100	Continuous
	Total	29	32			

From the core courses:

Course Nos EST 101, CA 101, CA 102, CA 103, GEO 102, CA 104 are theory courses

Course Nos EST 111, GEO 112, CA 111 are practical courses

Total Credits offered in Semester I : 29

Semester II

Course Number	Course Title	Credit Value	Hours per week	Weightage UE	Weightage IA	EoTM
EST 201	Biodiversity Assessment And Conservation	3	3	60	40	University
CA 201	Wildlife Health, Rescue And Rehabilitation	3	3	60	40	University
CA 202	Behavioural Ecology	3	3	60	40	University
CA 211	Advanced Statistics	2	3		100	Continuous
CA 212	Field Techniques II	2	3	60	40	University
CA 213	Field Taxonomy II	2				
CA 214	Field Work	2	60 (cumulative)		100	Continuous
	Electives (any two)					
EST 206	Natural Resource Management	3	3		100	Continuous
EST 401	Ecorestoration	3	3		100	Continuous
CA 203	Urban Biodiversity	3	3		100	Continuous
	General Courses					
GEN 201	General English	2	2		100	Continuous
GEN 202	Technical Writing	2	2		100	Continuous
	Total	25	26			

From the core courses:

Course Nos EST 201, CA 201, CA 202 are theory courses

Course Nos CA 211, CA 212, CA 213, CA 214 are practical courses

Total Credits offered in Semester II: 25

Semester III

Course Number	Course Title	Credit Value	Hours per week	Weightage UE	Weightage IA	EoTM
	Core Courses					
CA 311	Dissertation	24	40	60	40	University
	General Courses					
GEN 301	Project Management	2	2		100	Continuous
	Total	26	42			

Total Credits offered in Semester III : 26

Semester IV

Course Number	Course Title	Credit Value	Hours per week	Weightage UE	Weightage IA	EoTM
	Core Courses					
CA 411	Internship	10	40	60	40	University
	Electives (any three)					
CA 401	Conservation Leadership	3	3		100	Continuous
CA 402	Conservation Communication, Education And Public Awareness	3	3		100	Continuous
CA 403	Conservation Management	3	3		100	Continuous
EST 208	Climate Change Science And Strategies	3	3		100	Continuous
	General Credit Course					
GEN 401	Entrepreneurship Development	2	2		100	Continuous
GEN 402	Soft Skills	2	2		100	Continuous
	Total	24	54			

Total Credits offered in Semester IV : 24

SEMESTER I

COURSE NO: EST 101

Course Title: Ecosystem Studies

Number of Credits: 3

No. of Lectures-Tutorial: 36-07-02

Course Coordinator/Instructor: Dr. Sougata Sadhukhan

Course Outline

Ecosystems provide a vast range of services, from food and medicines to a stable climate, clean water and storm protection. This course provides an introduction to the functioning of ecosystems underlying these services, in particular looking at how ecosystems are structured and how they function. The course has a practical ethos and involves fieldwork and analysis of real data. The course looks at the dynamic nature of ecosystems, which often behave as complex systems. The course provides students with the core ecosystem knowledge needed for management.

Learning Outcomes

Student will develop:

- An understanding of the fundamental principles of ecosystem ecology including how ecosystem structure relates to function and the dynamics of ecosystems.
- Appreciation of the diversity of ecosystem functions across time, space and biomes.
- Appreciation of how ecosystems respond to global change drivers including climate change, land use change and biodiversity loss.
- An understanding of ecosystem services, principles of ecosystem valuation and its importance

Pre-requisite

None

Evaluation Procedure: 60/40: University/Internal Assessment

Assignment	2	20%	Internal Assessment
Minor Test	1	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1.	Natural Resources , Biogeography and evolution • Air , water, soil as resources	02	

	• Patterns of species distribution – evolutionary relicts, climatic relicts, endemic organisms, environmental gradients, interaction of factors, species interactions • Natural selection, Darwin's theory • Plate tectonics and evolution of biodiversity • Species diversity in the tropics		
2.	Ecological Concepts and Ecosystem • Evolution of natural environment: Biotic and abiotic factors • Ecosystem productivity • Food chains and food webs and trophic levels • Energy flows– pyramid of number, pyramid of energy and pyramid of biomass • Patterns and types of bio-geochemical cycles – oxygen, nitrogen, carbon, sulphur and phosphorus • Water cycle • Principles of limiting factors- Liebig's law of Minimum, Shelford's law of tolerance, Combining concepts of limiting factors, limiting factors in ecosystem context • Ecological indicators, Ecotones and concept of edge effect, successional patterns (grasslands to old growth) and response of wildlife	04	
3.	Biodiversity • Definition: species richness, species diversity, biological diversity • Levels of biodiversity: genes to landscapes • Values of biodiversity – direct and indirect • Biogeographic zones of India • Biodiversity conservation- in situ and ex situ	02	
	Assignment 1 Discussion and presentation of selected research paper in groups of 2/3 students.		3
4.	Ecosystems • Forests – Biogeography of forests in India, vegetation structure and functions, food chain and food webs, plant-animal interaction, productivity and nutrient cycling, biological diversity of tropical forests, limiting factors, gap theory, threats and conservation. • Grasslands – Biogeography of grasslands in India,	08	

	structure and function, food chains and food webs, animal population dynamics, limiting factors, threats and conservation • Deserts – Biogeography of deserts in India, structure and function, limiting factors, environmental factors and plant-animal distributions, threats and conservation • Mountains – Tropical mountains, structure and function, plant and animal ecophysiology, threats and conservation • Mangroves – structure and function, ecological adaptations of mangroves, plant and animal diversity and interactions, mangrove productivity, food chains and food webs, threats and conservation • Marine ecosystems – structure and function, plant and animal diversity with reference to India, food chains and food webs, threats and conservation • Coral reefs – Distribution, structure and function, coral reef biology, coral reef communities, coral reef biodiversity, threats and conservation • Wetlands/Rivers - Biogeography, structure and function, stratification, food chains and food webs, catchment area concept, threats and conservation.		
5.	Taxonomy • Classification of living organisms (kingdoms) Introduction to Protista, Plant and Animal Overview of Protista (Classification of microorganisms, ecology, uses with examples) • Overview of Plant Kingdom: Diversification and evolution of plant groups; Cryptogams: Characteristics of Algae, Bryophytes, Pteridophytes • Characteristics of Fungi and Lichens (distinguishing characters with examples, place in evolution, ecological importance, uses) • Phanerogams: Gymnosperms and Angiosperms, (distinguishing characters with examples, place in evolution, ecological importance, uses) Systematics and Phylogeny	10	

	• Purpose of taxonomy, Concepts of Taxonomic characters, types of classification systems (artificial, phylogenetic, natural with examples) , basics of nomenclature (binomial classification) Introduction to APG III • Study of identification and classification characters / Morphological features of selected angiosperm families: Angiosperms- Polypatales - Malvaceae, Leguminosae Gamopatales - Asteraceae, Lamiaceae / Bignoniaceae, Monocotyledons-(Liliaceae/Amaranthaceae); Use of flora for identification of angiosperms Animal taxonomy • Invertebrates – Protozoa, Porifera, Cnidaria, Platyhelminthes, Nemertean, Nematoda, Mollusca, Annelida, Arthropoda, Echinodermata- Distinguishing characters of each phyla with examples • Vertebrates - key characters of each class -fishes, amphibians, reptiles, birds and mammals. • Classification of mammals upto order level with key characters of each order and examples		
	Assignment 2 Critical review of a research paper by individual students.		5
6.	Ecosystem services and ecosystem dynamics Ecosystem services • Ecosystem functioning and ecosystem services provided by different ecosystems at present – provisioning services, regulating services, habitat or supporting services, cultural services • Species population and ecosystem services-the connections • Millennium Ecosystem Assessment, TEEB with case studies Ecosystem dynamics • Definition of ecosystem dynamics and its relevance • Changes in ecosystems over different time scales, drivers of ecosystem dynamics (natural and human induced), patterns and elements of ecosystem	04	

	dynamics with examples		
7.	Valuation of Ecosystem Services • Overview of economic valuation of ecosystems • Key issues in valuation of economics of ecosystems- identifying key stakeholders, key development goals, assessing the status and trends of key ecosystems, engaging stakeholders • Payments for ecosystem services • Case studies	06	
	Minor test 1		1
	Total	36	09

Suggested Readings

1. Alfred J. R.B, A.K.Das and A.K.Sanyal, Ecosystems of India, ZSI, 2001.
2. Banarjee A., 2010, Footprints in the forest, Winrock International India.
3. Botkin Daniel. B and Edward. A. Keller, Environment Science – Earth as a living Planet, John Wiley and Sons, 2005.
4. Carabias Julia and Kishore Rao, Capacity Needs to Manage Protected Areas, The Nature Conservancy, 2003.
5. Champion S., Seth S, (2005). Revised survey of forest types of India. Nataraj Publishers, New Delhi.
6. Clark T., Reading R., Clarke A., 1994. Endangered Species Recovery: Finding the Lessons, Improving the Process, Island Press.
7. Cleveland H., Larry R., Susan K., Allen L., David E., 2009, Animal diversity, McGraw Hill.
8. Dinerstein E. 2013. The Kingdom of Rarities. Island Press.
9. Enger, E.D., Ross, F.C., Bailey, D.B., 2003. Concepts in biology. McGraw-Hill Science / Engineering/Math.
10. Estuaries of India, ENVIS, 2002.
11. Gopal, R., 2011. Fundamentals of Wildlife Management. Natraj Publishers, New Delhi.
12. Grimmett R., Inskipp C. and Inskipp T. (2001) *Pocket Guide to the Birds of the Indian Subcontinent*, Oxford University Press, Oxford.
13. Groom M.J., Meffe G.K. and Carroll C.R. (2006) *Principles of Conservation Biology* (3rd edition), Sinauer Associates, Sunderland
14. Hunter Malcom. Jr, Maintaining Biodiversity in Forest Ecosystems, Cambridge University Press, 1999.
15. J. B. Lal, 1992, Forest ecology, Natraj publishers.
16. Kamaljit S. B., et. Al., 2011, Conservation Biology, Universities Press.

17. Keddy Paul. A, Wetland Ecology – Principles and Conservation, Cambridge University Press, 2000.
18. Mangroves of India, ENVIS, 2002.
19. Menon, V., 2014. Indian mammals: a field guide. Hachette India.
20. Michael S., Robert P., 2014, Early years in modern conservation biology, Island press.
21. Miller, G., Spoolman, S., 2007. Environmental Science: Problems, Connections and Solutions. Cengage Learning.
22. Nebel Bernard. J. and Richard. T. Wright, Environment Science, Pearson Custom Publishing, 8th Edition, 2003.
23. Owen Oliver. S, Daniel. D. Chiras and John. P. Reganold, Natural Resource Conservation, 7th Edition, 1998.
24. Parenti L., 2009, Comparative biogeography, Rawat Publishers.
25. Parenti L., Ebach M., 2009. Comparative Biogeography: Discovering and Classifying Biogeographical Patterns of a Dynamic Earth. University of California Press.
26. Peter R., George J., Jonathan L., Susan S., 2005, Biology, Tata McGraw Hill.
27. Primack R.B. (2006) *Essentials of Conservation Biology* (4th ed.), Sinauer Associates, Sunderland.
28. Puri, G.S., Gupta, R.K., Meher-Homji, V.M., Puri, S., others, 1989. Forest ecology. Volume 2. Plant form, diversity, communities and succession. Oxford & IBH Publishing Co. Pvt. Ltd.
29. Puri, G.S., Meher-Homji, V.M., Gupta, R.K., Puri, S., others, 1983. Forest ecology. Volume I. Phytogeography and forest conservation. Forest ecology. Volume I. Phytogeography and forest conservation.
30. Raphael M., Molina R. 2013. Conservation of Rare or Little-Known Species: Biological, Social, and Economic Considerations. Island Press.
31. Sahara V.B. (2001) *Wildlife in India*, Natraj Publishers, Dehra Dun.
32. Sawarkar, V.B., 2005. A guide to planning wildlife management in protected areas & managed landscapes. Natraj Publishers.
33. Sharma, B.D., Karthikeyan, S., Singh, N.P., Flora of Maharashtra State. Botanical Survey of India.
34. Sloomweg R., Rajvanshi A., Mathur V., Kolhoff A., 2009. Biodiversity in Environmental Assessment: Enhancing Ecosystem Services for Human Well-Being. Cambridge University Press.
35. Sustainable management of wetland, biodiversity and beyond. Jyoti Parikh & Hemant Date.
36. Sutherland, William J. 2006. Ecological Census Techniques: A Handbook. Cambridge University Press.
37. Townsend Colin. R, John. L. Harper and Michael Begon, Essentials of Ecology, Blackwell Science, 2000.
38. Vandana S., 2012, Biopiracy – the Plunder of nature and knowledge, Natraj Publishers.
39. Venkataraman K., 2012. Fauna of Maharashtra Part 1: Vertebrates Zoological Survey of India

Journals (to be accessed through JGATE)

1. Ecology
2. Conservation Biology

COURSE NO: CA 101

Course Title: Sustainability of Socio-Ecological Systems

Number of Credits: 3

No. of Lectures-Tutorial: 36-06

Course Coordinator: Dr. Kranti Yardi

Course Outline

This course focuses on the human dimension of environmental change, analyzing how social and ecological processes are intertwined. The emphasis is on the significance and function of ecosystems, how humans have affected these systems over time, and what are the opportunities of and barriers to making positive changes. The course will introduce conceptual frameworks and methodologies to explore natural and human systems together – a task that remains critical to addressing today’s environmental challenges. Dynamical systems’ thinking is introduced as a means of comprehending the behaviour of these complex situations. Students will analyze integrative frameworks from both the social and natural sciences and apply them to the study of complex social-ecological systems. The goal of the course is to enable students, through the presentation of case studies, to explore how interdisciplinary research contributes to a deeper understanding of environmental problems. Students will learn how to apply social-ecological frameworks to contemporary societal problems and learn the benefits and challenges of interdisciplinary research.

Learning Outcomes

Students will:

- Apply a social science approach to investigate large scale drivers of place-based environmental problems
- Synthesize the local and global factors that contribute to environmental and social problems
- Identify and explain the social and ecological components embedded in contemporary environmental problems; based on this understanding, apply an interdisciplinary analysis of the problem and potential solutions
- Explain the interrelationships of social and ecological factors that contribute to environmental problems and their solutions
- Demonstrate proficiency in both written and oral communication through an oral presentation and written report that critically analyzes an environmental problem through the various lenses discussed in class
- Identify and apply theories integrating natural and social sciences that can contribute to robust interdisciplinary research and scholarship

Pre-requisite

None

Evaluation Procedure: 60/40: University/Internal Assessment

Assignment	2	20%	Internal Assessment
Minor Test	1	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Introduction Basic concepts of sustainable development - Understanding 'sustainability' and 'development'; different world views; the economic growth/GDP perspective. - Linkages between economic growth and quality of life; Causes and effects of unsustainable development consumerism, globalization, urbanization, ecosystem degradation, war, terrorism, disasters, inequity - Pillars of sustainable development-economic, social, environmental, political (governance) - Sustainability as a process for sustaining socio-ecological change	6	
2.	Evolution and human society - Evolution of the ecosystem and growth of human society in different landscapes; hunters and gatherers, pastoralism, agricultural development, urbanization (from prehistory to present) - Human population history; Exponential population growth; positive and negative feedback	04	
2	Perceptions towards nature - Common perceptions of nature; traditional ecological knowledge - Attitudes of religions towards nature - Coevolution and coadaptation of human social systems and ecosystems – coadaptation in	04	

	traditional social systems and modern systems		
	Socio ecological systems Challenges and approaches; Systems theory and resilience thinking; governance and management of socio ecological systems; resilience reflections and applications	08	
	Assignment 1 Discussion and presentation of selected research paper in groups of three students.		3
3	Control, Conflict and Development - Early environment and community debate (forest and community) - Ecological change, development and social tension, human-wildlife interactions - Critical review of community based practices in India using case studies	10	
	Assignment 2 Critical review of research paper (individual assignment) OR as given by the faculty		03
5	Community Resource Management in practice - Joint Forest Management: Principles, problems, advantages using case studies - Ecodevelopment: Success and the way forward - Case studies of national and international practices in community resource management: Critical Analysis	10	
	Minor test 1		1
	Total	36	9

Assignments

In the assignments the students will carry out a review of community-nature interactions that are related to the subject or topics students have worked on during the field trips or any current issue.

Suggested Readings

1. Bernis, C. and M. Sandin. 1987. *Prospecting Human Ecology*. Madrid: Universidad Autonoma de Madrid.
2. Borden, R.J. 1984. *Directory of Human Ecologists*. College Park, MD: Society for Human Ecology.
3. Borden, R.J., J. Jacobs and G.L. Young (eds.). 1985. *Human Ecology: A Gathering of Perspectives*. College Park, MD: Society for Human Ecology.
4. Borden, R.J., J. Jacobs and G.L. Young (eds.). 1988. *Human Ecology: Research and Applications*. College Park, MD: Society for Human Ecology.
5. Borden, R.J. and J. Jacobs. 1989. *International Directory of Human Ecologists*. Bar Harbor, ME: Society for Human Ecology.
6. Cohen, J. 1995. *How Many People Can the Earth Support?* New York: Norton and Co.
7. Eisenberg, E. 1998. *The Ecology of Eden*. New York: Knopf.
8. Grossman, E. 2006. *High Tech Trash: Digital Devices, Hidden Toxics and Human Health*. Washington, D.C.: Island Press.
9. Huib, E. (ed.). 1994. *Pathways to Human Ecology: From Observations to Commitment*. Bern, Switzerland: P. Lang.
10. McDonnell, M.J. and S.T. Pickett. 1993. *Humans as Components of Ecosystems: The Ecology of Subtle Human Effects and Populated Areas*. New York: Springer-Verlag.
11. Miller, J.R., R.M. Lerner, L.B. Schiamberg and P.M. Anderson. 2003. *Encyclopedia of Human Ecology*. Santa Barbara, CA: ABC-CLIO.
12. Nathawat, G.S., Z. Daysh and G.J. Unnithan (eds.). 1985. *Human Ecology: An Indian Perspective*. Jaipur, India: Indian Human Ecology Council.
13. Ostrom, E., T. Dietz, N. Dolsak, P.C. Stern, S. Stonich, and E.U. Weber(eds.). 2002. *The Drama of the Commons*. Washington D.C.: National Academy Press.
14. Pratt, J., G.L. Young and J. Jacobs. 1990. *Human Ecology: Steps to the Future*. Sonoma, CA: Society for Human Ecology.
15. Sargent, F. (ed.). 1974. *Human Ecology*. New York: American Elsevier.
16. Siniarska, A. and F. Dickinson. 1996. *Annotated Bibliography in Human Ecology*. Delhi, India: Kamla-Raj Enterprises.
17. Sontag, M.S., S.D. Wright, G.L. Young and M. Grace. 1991. *Human Ecology: Strategies for the Future*. Ft. Collins, CO: Society for Human Ecology.
18. Suzuki, T. and R. Otsuka. 1987. *Human Ecology of Health and Survival in Asia and the South Pacific*. Tokyo, Japan: University of Tokyo Press.
19. Theodorson, G.A. 1961. *Studies in Human Ecology*. Evanston, IL: Row, Peterson and Co.
20. Wang, R. 1990. *Human Ecology in China*. Beijing, China: China Science and Technology Press.

21. Wright, S.D., R. Borden, M. Bubolz, L. Hens, J. Taylor and T. Webler. 1995. *Human Ecology: Progress Through Integrative Perspectives*. Fort Collins, CO: Society for Human Ecology.
22. Young, G.L. (ed.). 1989. *Origins of Human Ecology*. Stroudsburg, PA: Hutchinson Ross.

COURSE NO: CA 102

Course Title: Wildlife law and trade control

Number of Credits: 3

No. of Lectures-Tutorial: 36-06

Course Coordinator: Adv. Gouri Joshi and Mr. Jose Louis

Course Outline

The course provides an introduction to the wildlife trade scenario in the country/world and the legal instruments available for control of wildlife trade in India. An overview of the international agreements along with in-depth knowledge of anti-poaching plans, wildlife crime investigations are included.

Learning Outcomes

- Demonstrate a good understanding of wildlife trade and contributory factors.
- Develop a deep insight into various legal provisions for control of wildlife trade.
- Demonstrate an understanding of role of forest personnel and communities in prevention of wildlife crime
- Develop skills for conducting a wildlife crime scene search and identifying wildlife parts and products

Pre-requisite

None

Evaluation Procedure : Evaluation Procedure: 60/40: University Exam / Internal Assessment

Assignment	2	20%	Internal Assessment
Minor Test	1	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

Unit	Topic	Time (Hours)	
		L	T
1	Overview of wildlife crime in India • Defining wildlife and wildlife crime • Difference between subsistence and sport hunting and commercial poaching and trade • Important species in the illegal wildlife trade-tiger, leopard, lesser cats, canids, otter, civets, martens,	04	

	rhino, elephant,, musk deer, Tibetan antelope, whale shark, reptiles and amphibia • Global wildlife trade scenario • Methods of poaching-trapping, poisoning, shooting, electrocution, netting and snaring, destruction of sites, marine poaching, plant collection		
2	The Indian Wildlife Protection Act (1972) • Understanding various definitions under the WPA • Interpretation of sections under the WPA with detailed examples • Use of case scenarios to understanding applications of sections of WPA	12	
3	Forest Acts • The Indian Forest Act 1927 • The Forest (Conservation) Act 1980	6	
4	Other Legal Instruments • Coastal Zone Regulations • Biodiversity Act	6	
	Assignment 1: As given by faculty		03
5	Identification of wildlife parts and products Identification of parts, products and fakes	4	
6	Preparing an antipoaching plan for the PA Understanding the ecosystem, conservation history of the area, boundaries of the area , major wildlife species, sensitive area and threats	04	
7	Conducting a criminal investigation • Overview of a criminal investigation • Maintaining of an informer network, intelligence gathering and intelligence analysis • Conducting a sting operation	04	

	• Conducting a search • Interrogation techniques • Steps for investigating a crime scene • Collecting evidence from crime site • Disposal of confiscated specimens		
	Assignment 2: As given by faculty		03
8	Legal Control at International Level • CITIES • TRAFFIC • Convention on Biological Diversity • Ramsar Convention • Convention on Migratory Species	05	
	Minor Test 2		2
	Total	36	09

Assignments

In the assignments the students will carry out a review of legal instruments for wildlife conservation or any issue related to wildlife crime or any current issue.

Suggested Readings

1. Mohanty S. K., Environment and Pollution Law Manual, Universal Law Publishing Vompany Ltd., 3rd edition, 2002.
2. Environment and Pollution Laws, Law Publishers, 2000.
3. Leelakrishnan P, Environmental Law in India, Butterworths, 2000.
4. Singh Kuldeep, Environmental Jurisprudence, Modern Law House, 2nd edition 2002.
5. Choudhuri S.K, Environmental Legislations in India, Oxford and IBH Publishing 1996.
6. Pollution Control Acts, Rules and Notifications, Pollution Control Law Series – Volume – I, Central Pollution Control Board, 1992.
7. Conserving Life – Implications of Biodiversity conservations for India, Kalpavriksh, 1994.
8. Convention of Biological Diversity, World Wide Fund for Nature India 1992.

9. Singh Kuldeep, Handbook of Environment, Forest and Wildlife Protection Laws in India Natraj Publishers, 1998.
10. The Environment (Protection) Act and Rules 1986, Law Publishers.
11. Traffic Bulletin, Traffic International.
12. Vanguri Kishore, Environmental Laws in India – A guide, C.P.R. Environmental Education Centre, Madras, 1994.
13. The Water (Prevention and Control of Pollution) Act, 1974 and Rules 1975, Akalank Publications, 1999.
14. The Air (Prevention and Control of Pollution) Act, 1981 Akalank Publication 1999.
15. The Indian Forest Act, 1927 along with Forest (Conservation) Act 1980, Indira Gandhi National Forest Academy, Natraj Publishers 2002.
16. The Wildlife (Protection) Act 1972, Natraj Publishers, 1994.
17. Understanding Biodiversity Law Module, Center of Environmental Education Research and Advocacy (CEERA)
18. Trivedy R.K., Handbook of Environmental Law, Acts, Guidelines, Compliances and Standards, Volume Environment Media, 1996.
19. Nair Manju, The Montreal Protocol – in the Indian Context, Centre for Environmental Law, WWF India, 1996.
20. Environmental Legislation in India – A guide for Industry and Business, Environment Management Division, Confederation of Indian Industry, 1999.

COURSE NO: CA 103

Course Title: Conservation Problems and Practices

Number of Credits: 3

No. of Lectures-Tutorial: 36-06

Course Coordinator: Dr. Shamita Kumar and Dr. Kranti Yardi

Course Outline

The course provides an introduction to various conservation problems in India with a focus on their genesis and drivers using an interdisciplinary approach. It also builds awareness about the various conservation practices across the country.

Learning Outcomes

- Demonstrate a good understanding of conservation problems and their drivers.
- Demonstrate an understanding of the blending of science, social science and technology along with the role of communities, forest personnel and communities in conservation.
- Develop skills for analyzing conservation problems through a problem based learning approach.

Pre-requisite

None

Evaluation Procedure : Evaluation Procedure: 60/40: University Exam / Internal Assessment

Assignment	2	20%	Internal Assessment
Minor Test	1	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

Unit	Topic	Time (Hours)	
		L	T
1	Human-wildlife interactions and conservation practices Genesis of the conflicts; impacts on human-wildlife conflict on natural systems; impacts of human wildlife conflicts on human lives and livelihoods (using case study approach); Bearing the costs of human wildlife conflict: the challenges of compensation schemes; Increasing the value of wildlife through non-consumptive use (wildlife tourism, access	15	

	and benefit sharing; Zoning (with case studies) Transformation of conflicts		
2	Poverty, overpopulation and conservation practices Livelihoods, poverty and overpopulation: the casual links; threats to livelihoods from development and conservation Integrated conservation and development projects; conceptual tools for addressing conservation and poverty with case studies; Economic instruments;	07	
3	Loss of traditional knowledge and conservation practices Defining traditional knowledge; types of traditional knowledge; causes for decline; conservation practices with case studies	07	
	Assignment 1: Critical review of research paper in group of three students		03
4	Urbanization and conservation practices Urbanization in India; effects on conservation; new emerging practices for conservation	07	
5	Consumerism, lack of awareness and conservation practices Trends of consumerism and its effect on biodiversity and natural resources; causes and conservation practices	07	
	Assignment 2: Critical analysis of a conservation problem in group of three students		03
	Minor Test 1		
	Total	36	06

1. Madden, F., and B. McQuinn. 2014. Conservation's blind spot: the case for conflict transformation in wildlife conservation. *Biological Conservation* **178**:97-106
2. Bennett, N.J., Roth, R., 2015. The conservation social sciences: What? How? and Why? Canadian Wildlife Federation and Institute for Resources, Environment and Sustainability, University of British Columbia: Vancouver, BC, Canada.

3. Boitani, L., Linnell, J.D., 2015. Bringing large mammals back: large carnivores in Europe, in: *Rewilding European Landscapes*. Springer, Cham, pp. 67–84.
4. Decker, D.J., Lauber, T.B., Siemer, W.F., 2002. Human-wildlife conflict management: A practitioner's guide. Northeast Wildlife Damage Management Research and Outreach Cooperative.
5. Dickman, A.J., 2010. Complexities of conflict: the importance of considering social factors for effectively resolving human–wildlife conflict. *Animal conservation* 13, 458–466.
6. Ghosal, S., Athreya, V.R., Linnell, J.D., Vedeld, P. al O., 2013. An ontological crisis? A review of large felid conservation in India. *Biodiversity and conservation* 22, 2665–2681.
7. Ghosal, S., Skogen, K., Krishnan, S., 2015. Locating human-wildlife interactions: landscape constructions and responses to large carnivore conservation in India and Norway. *Conservation and Society* 13, 265–274.
8. Madden, F., McQuinn, B., 2014. Conservation's blind spot: the case for conflict transformation in wildlife conservation. *Biological Conservation* 178, 97–106.
9. Sillero-Zubiri, C., Sukumar, R., Treves, A., 2007. Living with wildlife: the roots of conflict and the solutions. *Key topics in conservation biology* 266–272.
10. Thomassen, J., Linnell, J.D., Skogen, K., 2011. Wildlife-Human Interactions: From Conflict to Coexistence in Sustainable Landscapes: Final report from a joint Indo-Norwegian project 2007-2011. NINA rapport.
11. Human-wildlife conflicts in a changing world. CONSERVATION BIOLOGY SERIES- CAMBRIDGE- 9, 388.
12. Menon, V, and Chaudhary, RG (2017). Conflict to Co-Existence: A dozen cost effective human interventions for co-existence with wildlife. Wildlife Trust of India, Noida - 201301, National Capital Region, India.

Websites

<http://www.hwctf.org/>

http://wiienviis.nic.in/Database/Human_Wildlife_Conflict_8248.aspx

COURSE NO: GEO 102

Course Title: Fundamentals of Geoinformatics

Number of Credits: 3

No. of Lectures-Tutorial: 36-06

Course Coordinator/Instructor: Dr. Shamita Kumar

Course Outline

The course provides a firm understanding of the conceptual and technical issues of geospatial technologies and an overview of applications in various aspects of wildlife, natural resource management, environment management, etc. It introduces the students to the fundamentals of geographic information systems, navigation systems, data models, data sources, cartography as well as multi-criteria analysis.

Learning Outcomes

Students will:

- Demonstrate a good understanding of the basics of geospatial technologies
- Demonstrate an understanding of building geo-databases.
- Develop abilities to think about and implement geographic data management and analysis for research and a variety of planning and management applications.

Pre-requisite

None

Evaluation Procedure : Evaluation Procedure: 60/40: University Exam / Internal Assessment

Assignment	2	20%	Internal Assessment
Minor Test	1	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Introduction to geoinformatics • Introduction to the concept of geoinformatics and its applications	03	
2	Geographic data and data measurement • Data types and scales of data measurement, sampling methods Map basics • History of cartography, basic characteristics of maps,	05	

	categories of maps, map scale • Typography and lettering the map, elements of generalization-classification, simplification and exaggeration, symbolization-point, line, area, volume • Nature of geographic phenomena and measurement of geographical variables Basic geographic concepts Basic geodesy: Spherical, ellipsoidal and geoidal earth, geographical co-ordinates, Co-ordinate systems: Plane co-ordinate system, Geographic co-ordinate system • Map projections: Scale factor and transformation, distortions resulting from map transformations, properties of map projections, classification of map projections, aspects of map projections, some commonly used projections, selection of a particular projection, geo-referencing, relationship between co-ordinate systems and map projections • Geodetic datum-concept and types		
3	Data Models, data structures and data input • GIS data models: Raster data models-nature, characteristics of raster data, principles of raster data compression • GIS data models: Vector and raster data models-nature, characteristics • Concept of topology, topological relationships between spatial objects • Data input (raster and vector), metadata, data sources for GIS, input of methods of data input, digitization, error identification, types and sources of errors, correction, data editing, topology building.	06	
	Assignment 1 Discussion and presentation of selected research paper in groups of 2/3 students.		3
4	Global Navigation Satellite Systems (GNSS) • Introduction, GNSS segments, GNSS satellite generations, current GNSS satellite constellation working principle • GNSS working principle, GNSS signal structure, types of GNSS receivers, pseudorange measurements, carrier	05	

	phase measurements, cycle slips • GNSS errors and biases • Methods of GNSS observations • GNSS applications		
4.	Database Management • Introduction to database and database management systems, importance of databases in GIS • Database structures • Database data models: Hierarchical model, network model, relational database model, object oriented data model • Database creation, linking spatial and attribute data, GIS database applications	04	
	Assignment 2 Critical review of research paper /making a video poster		03
5.	Data analysis • Measurements • Queries • Buffering and neighbourhood functions • Map overlay • Spatial analysis • Multicriteria analysis • Network Analysis	07	
6.	Application of Geoinformatics • Applications in forestry and wildlife management • Applications in mining • Applications in urban planning • Applications in disaster management • Applications in health studies • Business applications	03	
7.	GIS project design and management • Identify the problem and its geospatial component • Data and data sources; GIS operations, spatial analysis.	03	
	Minor test 1		1

	Total	36	06

Suggested Readings

1. Burrough P. A., R. A MacDonneli, Principles of Geographical Information Systems, Oxford University Press, 2000.
2. Lo. C. P., A.W. Yeung, Concepts and Techniques of Geographical Information Systems, Prentice- Hall of India Pr. Ltd., 2002.
3. Heywood I., S. Cornelius, S. Carrer, An Introduction to Geographical Information Systems, Pearson Education Pvt. Ltd, 2002.
4. Kang-stung-Chang, Introduction to Geographical Information System, Tata McGraw Hill Pub. Comp, 2002.
5. Demers M.N, Fundamentals of Geographic Information Systems, John Wiley & Sons, 2000.
6. Roy P.S., Dwivedi R.S., Vijayan D., 2010 Remote Sensing Applications National Remote Sensing Centre, India
7. Reddy, M.A., 2008. Textbook of remote sensing and geographical information systems. BS publications.
8. El-Rabbany, A., 2002. Introduction to GPS: the global positioning system. Artech House.
9. Arthur Robinson, H., 1958. Elements of cartography, John Wiley and Sons Inc.

Websites (as mentioned from time to time in class)

Journals

1. International Journal of Geoinformatics
2. International Journal of Remote Sensing
3. ISPRS Journal of Photogrammetry and Remote Sensing
4. Journal of Indian Society of Remote Sensing

COURSE NO: EST 111

Course Title: Field techniques I

Number of Credits: 2

Course Coordinator/Instructor: Dr. Sougata Sadhukhan

Course Outline

The course provides hand on expertise in identifying flora and fauna as well as in depth understanding of ecosystem structure and function through a combination of field visits and lab work.

Learning Outcomes

Students will:

- Develop skills in identifying birds, mammals and major plant species
- Develop an ability to analyze structure of ecosystems.
- Acquire competence in design and implementation of sampling techniques.

Pre-requisite

None

Evaluation Procedure: 60/40: University Exam / Internal Assessment

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed Journal submitted timely (within 7 days): 5 marks	Internal Assessment
Major exam	60%		University Assessment

Details of course content

1. Identification of terrestrial birds
2. Identification of wetland birds
3. Vegetation analysis using quadrats and analysis in excel
4. Vegetation analysis using line transects and analysis in excel
5. Vegetation analysis by using belt transect and analysis in excel
6. Calculation of plant diversity index
7. Study of planktons.

8. Converting study area into grids and mapping transects
9. Field work in forest ecosystem (Mulshi) (assessment for forest structure, measurement of GBH, canopy estimation, vegetation analysis) (This will be completed over two classroom sessions and one field session)
- 10.. Field work in grassland ecosystem (Rehekhuri) (grassland vegetation analysis, animal census techniques by using indirect signs). (This will be completed over two classroom sessions and one field session)
11. Field work in wetland ecosystem (Pashan) (Vegetation mapping, wetland bird analysis)

References

1. Vivek M., 2014, Indian Mammals – a field guide, Hachette book publishing India, Pvt. Ltd.
2. Brandis D., 2009, Indian Trees, Natraj Publishers.
3. Grewal B., 2017, A naturalists guide to the mammals of India, Prakash Books.
4. Sachdera P., 2017, A naturalists guide to the trees and shrubs of India, Prakash Books.
5. Grewal B., 2016, A Pictorial field guide to birds of India, Om book international.
6. Grimmett R., 1998, Birds of Indian Subcontinent, Oxford University Press.
7. Yiqi, Luo, Desharnais, Robert, 2015, Population Dynamics and Laboratory Ecology, Elsevier.
8. Rieger, John, Stanley, Traynor, Raymond, 2014, Plant Material, Washington, DC, Island Press/Center for Resource Economics

COURSE NO: GEO 112

Course Title: Techniques in Geographical Information Systems

Number of Credits: 2

Course Coordinator/Instructor: Dr. Madhurima Dey

Course Outline

The course provides hand on expertise with use of open source as well as commercial GIS software through a series of well designed practical's related to cartography, building geo databases, querying data, use of GPS and multicriteria analysis.

Learning Outcomes

- Proficiency in use of open source and commercial software for basic GIS operations.
- Ability to use location based devices for data collection.
- Ability to build basic geo databases.
- Competence in querying and making GIS analysis.

Pre-requisite

None

Evaluation Procedure : Evaluation Procedure: 60/40: University Exam / Internal Assessment

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed Journal submitted timely and in digital format: 5 marks	Internal Assessment
Major exam	20%		University Assessment

Details of course content

1. Introduction to ArcGIS tools
2. Introduction to QGIS (Assignment-self study with discussion)
3. Digital cartography and Story Maps
4. Defining co-ordinate systems and projecting data sets
5. Map registration
6. On screen digitization (Assignment using QGIS)
7. Error identification, rectification
8. Working with tables (Assignment using QGIS)

9. Using the analysis tools/ data query in ArcGIS (Assignment using QGIS)
10. Use of Mobile Navigation System and input of location data (Design of Survey Form)
11. Introduction to Google Earth
12. Performing multicriteria analysis

COURSE NO: CA 104

Course Title: Research Methodology

Number of Credits: 2

No. of Lectures-Assignments: 30

Course Coordinator: Mr. Venkatraman G

Course Outline

The course will provide students with a critical understanding of the research process and familiarize students with the main approaches, methods and techniques of qualitative and quantitative research. The course will enable students to undertake their own independent research and apply appropriate research methodologies in order to plan, conduct and evaluate basic research as part of their degree and provide a solid foundation for further advanced research.

Learning Outcomes

- Ability to identify various sources of information and write up a literature review
- Planning and conducting basic qualitative and quantitative research
- Ability to write an introduction and literature review

Evaluation Procedure: Continuous

Assignments	1. Write an introduction chapter (2500 words) 2. Write a literature review (2500 words)

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	A
1.	Research Design: Overview • Understanding research • The qualitative/quantitative divide • Overview of different research traditions – action research, case studies, documentary analysis, ethnographic research, experiments, grounded theory, surveys	02	
2.	Planning the research • Selecting a topic • Topic to research question – problem definition,	02	

	research question, hypothesis, research objectives • Research question to research design –developing the design • Data gathering – primary and secondary		
3.	Literature Review • Introduction to literature review • Methodology of literature review • Literature sources – books and journals, electronic databases, government and industry, internet; searching on keywords • Information management – keeping records of searches • Writing a literature review • Referencing – systems, referencing websites, citations, use of software	06	
4.	Developing the methodology Types of research design structure: Experimental design structure, quasi experimental design, observational research Sampling: Sampling strategies, Probability sampling (simple, systematic, cluster stratified); Non-probability sampling (convenience sampling, quota sampling, targeted sampling, chain referral); sample size in qualitative and quantitative research	04	
5.	Qualitative Research • Collecting secondary data - journals, existing documents and records, etc.; • Collecting primary data through: Participant observation; Qualitative interviews (informal, unstructured, semi-structured, focus), interview techniques, sources of inaccuracy and dealing with them, recording data, triangulation; Questionnaires-drafting questions, building a coding list, field piloting; Documenting local environmental knowledge and	06	

	change; PRA techniques; Participatory mapping		
6.	Preparing for fieldwork Paperwork, permissions, equipment, travel; Role of the researchers; Ethical Considerations - Ethics committee, ethical guidelines – voluntary participation, informed consent, confidentiality and anonymity, plagiarism, academic fraud and misinterpreting results, conflict of interests, observation, permissions, video/audio taping	04	
7.	Processing and analysis of qualitative data Analysis during data collection- annotations, memos, coding; Quantitative Analysis: Descriptive statistics – tools and software, types of data, visualizing data (graphs), cluster analysis, measuring the spread Quantitative Analysis: Inferential statistics – significance levels and hypothesis testing, probability distributions, comparing single variable in two or more samples, relationship between variables	06	
	Assignment 1: Writing an introduction		
	Assignment 2: Writing a literature review		
	Total	30	

Assignments

The separate assignments will result in a single document – the research proposal of the student.

Suggested Readings

1. Becker, H. S. Writing for Social Scientists: How to Start and Finish Your Thesis, Book, or Article. University of Chicago Press, 2007.
2. Creswell, J. W., and V. L. P. Clark. Designing and Conducting Mixed Methods Research. Wiley Online Library, 2007.
3. Denzin, N. K., and Y. S. Lincoln. The Sage Handbook of Qualitative Research. Sage Publications, Incorporated, 2005.

4. The SAGE Handbook of Qualitative Research (3 Rd. Thousand Oaks, CA: Sage, 2005.
5. Hart, C. Doing a Literature Review: Releasing the Social Science Research Imagination. Sage Publications Limited, 1999.
6. Malmfors, B., P. Garnsworthy, and M. Grossman. Writing and Presenting Scientific Papers. Nottingham University Press UK, 2004.
7. Morrison, M. L., B. Marcot, and W. Mannan. Wildlife-habitat Relationships: Concepts and Applications. Island Press, 2006.
8. O'Connell, A. F., J. D. Nichols, and K. U. Karanth. Camera Traps in Animal Ecology: Methods and Analyses. Springer, 2010.
9. O'Leary, Z. The Essential Guide to Doing Research. Sage Publications Limited, 2004.
10. The Essential Guide to Doing Your Research Project. Sage Publications Limited, 2009.
11. Peat, J. et al. Scientific Writing: Easy When You Know How. BMJ books, 2007.
12. Ridley, D. The Literature Review: a Step-by-step Guide for Students. Sage Publications Limited, 2012.
13. Silverman, D. Doing Qualitative Research. Sage Publications Limited, 2009.
- 14.** Torraco, R. J. "Writing Integrative Literature Reviews: Guidelines and Examples." Human Resource Development Review 4.3 (2005): 3

COURSE NO: CA 111

Course Title: Field Taxonomy

Number of Credits: 2

Course Coordinator/Instructor: Dr. Sougata Sadhukhan with experts

Course Outline

The course provides hand on expertise in identifying flora and fauna as well as in depth understanding of habitats and niches of different taxa. The course will provide a field exposure and various observational methods for different taxa through a combination of classroom sessions and field visits.

Learning Outcomes

Students will:

- Develop skills in identifying various flora and fauna.
- Develop an ability to analyze various habitats and microhabitat requirements of species.
- Acquire competence in design and implementation of sampling techniques for various flora and fauna.

Pre-requisite

None

Evaluation Procedure : Continuous assessment

Continuous assessment during field work and post field work submissions	100 %	6 assignments to be submitted digitally 1 end course written exam	Internal Assessment

Details of course content and allotted time

Unit	Topic	Time (Hours)	
T	P	Lectures	Practical
1	Identification and field taxonomy of plants (herbs). • Broad classification of plants • Endemic plants (herbs) • Plant animal interactions with examples • Rare and threatened plants (herbs) in Western Ghats • Sampling and monitoring techniques for rare	4	

	endangered plants (herbs)			
	Field work at Kass Plateau			8
	Assignment 1			
2	Identification of Fishes • Freshwater fishes • Characteristics of different fish fauna, endemic and rare fish species with examples • Key morphological characters • Field observations methods • Indirect methods • Sampling techniques	4		
	Field visit to Mulshi			8
	Assignment 2			
3.	Taxonomy of amphibians • Classification of amphibians • Morphological characters • Field observations- direct observations • Indirect methods • Capture techniques • Marking individuals	4		
	Field work at Mulshi			8
	Assignment 3			
4.	Study of bats • Classification of Chiropterans (bats) • Mega and Microchiropteran species • Identification criteria • Sampling techniques Echolocation studies	3		
	Field work on campus			5
	Assignment 5			

5	Study of Birds • Divide in groups of three (7 groups) • Allocate different areas of campus • Observations twice a month (early morning / evening) • Identifying roosts and doing population counts at roosts	2		
	Field work on campus (2 months)			15
	Assignment 6			

COURSE NO: EST 104

Course Title: Basic Statistical Methods

Number of Credits: 3

No. of Lectures-Tutorial-Practical: 13-3-22

Course Coordinator/Instructor: Dr. Sougata Sadhukhan

Course Outline

The course has been designed to help biologists/environmental scientists answer questions of applications of statistics in their field of work. The course focuses on techniques for generating informative data, extraction information from data and to analyze data to get meaningful interpretations.

Learning Outcomes

After the course the student will be able to:

- Apply the appropriate technique for extraction of information from data
- Analyze data using appropriate statistical techniques and software

Pre-requisite

Students are encouraged to join and complete the free online course offered by Harvard University at :<https://www.coursera.org/learn/basic-statistics#syllabus> (starts Sep 15. Enrollement is free. If you want a certificate, there is a small fee).

Evaluation Procedure : Continous assessment

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed home assignment submitted timely: 10 marks	Practicals must be in the prescribed format	Internal Assessment
Major exam	60%	Theory cum practical examination		Internal Assessment

Details of course content and allotted time

Unit	Topic	Time (Hours)		
		Lectures	T	P
1	Basic concepts in biostatistics	01		

	• Terms and Terminologies • Sampling Vs Population; Types of sampling; Variables and derived variables • Concept of Frequency and Distribution • Data in Ecology and Environment Sciences and its types • Organization of data • Representation of data – tabular and graphic			
2	Basic elements and tools of statistical analysis • Measures of central tendency – arithmetic mean, geometric mean, harmonic mean, mode, median • Measures of dispersion – Standard deviation, Coefficient of variation, coefficient of correlation • Graphical representation of data	01		
3.	Practical 1 A: Graphical representation of data and calculation of different types of mean based on different types of data Practical 1 B: Calculation of mode and median based on different types of data by different methods.			02
4.	Practical 2: Calculation of standard deviation, coefficient of variation and coefficient of correlation of different data types by different methods.			02
5.	Concepts of probability • Basic laws – Examples from Ecology – Discrete probability distribution – expectation and variance	1.5		
6.	Distribution • Binomial distribution • Normal distribution	1.5		
7.	Practical 3: To calculate simple probability and solve examples based on binomial and normal probability distribution			02
8.	Categorical Variable Test Simple Proportion Test, Chi-Square Test Single Numerical variable Test			2

	Simple t-test, Wilcoxon Test for one Sample			
9.	Practical 4: Solve example based on Categorical or Single Numerical Variable			2
10.	Test of Dependable or Independent Variable - Paired Test: t-test, Z-test, Wilcoxon Test - Unpaired Test: t-test, Z-test and Mann-Whitney U test	2		
11.	Practical 5: Calculation of Paired test			2
12.	Practical 6: Calculation of Unpaired Test			2
13.	Hypothesis and comparison of means - Hypothesis & testing of hypothesis - Comparison of means ANOVA - One sample; Two samples	03		
14.	Practical 7: Solve examples based on one-way ANOVA			02
15.	Practical 8: Solve examples base on two-way ANOVA			02
16.	Regression analysis - Correlation and Regression - Regression coefficient - Standard errors and significance tests	03		
17.	Practical 9: Calculation of Simple Regression and Regression Coefficient			02
18.	Practical 10: Calculation Standard error and significance test			02
	Final Assessment		3	
	Total	13	3	22

Suggested Readings

1. Clark, J. S. Models for Ecological Data: An Introduction. Princeton University Press Princeton, New Jersey, USA, 2007.
2. Legendre, P., and L. Legendre. Numerical Ecology. Vol. 20. Elsevier, 2012.
3. Ott, L., and M. Longnecker. An Introduction to Statistical Methods and Data Analysis. Duxbury press, 2010.
4. Sokal, R.R. and Rohlf, F.J. 1995. Biometry: the principles and practice of statistics in biological research. 3rd edition. New York.
5. Zar J.H. 1999. Biostatistical Analysis. Prentice Hall, New Jersey, 663 pp.

COURSE NO: EST 105

Course Title: Introduction to Data Analysis

Number of Credits: 3

No. of Lectures-Tutorial-Practical: 12-3-24

Course Coordinator/Instructor: Mr. Anand Shinde

Course Outline

The course will introduce basic data analysis fundamentals in excel, visualizing data in excel, math and statistics in excel

Learning Outcomes

At the end of the course the student will:

- Have an insight into the various features for analysis available in Microsoft Excel
- Develop the ability to prepare charts, tables, and professional reports that involve complex data.
- Develop the ability to analyze and summarize data.

Pre-requisite

Students are strongly encouraged to complete the following free online course:

<https://www.edx.org/course/introduction-to-data-analysis-using-excel-2>

Evaluation Procedure : Continuous

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed home assignment submitted timely: 5 marks	Practicals must be in the prescribed assignment format	Internal Assessment
Major exam	60%	Theory cum practical examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	T	P
1	Practical 1: Introduction to Data Analysis, Overview of Database, Structure for Storing,	1		2

	Cleaning and Normalizing Data			
2	Practical 2: Introduction to Excel - Overview of Worksheet and Workbook; Tabs and Ribbons; Creating worksheets; Copying and moving worksheets Basic text and cell formatting; Editing: Cut; copy; paste; paste special; Freeze panes Entering numbers and Formatting numbers: Currency format; formatting dates; Custom and Special formats; Autocompletion of series; sort and filter	1		2
3	Practical 3: Working with External Data, importing Data from other sources, Importing Data from an Access Database, Text File, CSV files, Inserting a Hyperlink, Working with Existing Data Connections	1		2
4.	Practical 4: Introduction to formulas , Understanding cell references, creating and modifying formulas with cell references, reading a formula	1		2
5	Practical 5: Logic functions: Building standalone logical IF functions, and make them more complex by nesting AND and OR within them.	1		2
6	Practical 6: Text Functions, Date Functions and Time Functions <i>Text Functions:</i> Learn to break apart text with the LEFT, RIGHT, MID, FIND and SEARCH functions, and to combine text with the & character. <i>Understanding Dates:</i> Understand how dates work in Excel using the TODAY, YEAR, MONTH, DAY and DATE functions. <i>Understanding Time:</i> Understand how time works in Excel, and how to change from whole	1		2

	numbers into time increments and back again.			
7	Practical 7:Data Management Basics Sorting and filtering data in a data list, using the database functions in excel, querying external databases (one to one, one to many relations), combining queries, use of power query editor			
8	Practical 8: Web and text data analysis Retrieving data from the web, retrieving data from text files			
9	Practical 9: Using the 3D Map feature in excel	1		2
10	Practical 10: Creating a pivot table, formatting a pivot table, sorting and filtering pivot table data, modifying a pivot table, creating pivot chart	1		2
11	Practical 11: Develop a automation module of worksheet using Macro	1		2
12	Practical 12: Problem analysis in excel (using all of the above to analyze a given dataset).	1		2
	Major Test 1		3	
	Total	12	3	24

Suggested Readings

1. Banfield, C., Walkenbach, J., 2010. Microsoft Excel 2010 for Dummies. New York: Wiley Publishing.
2. Harvey, G., 2010. Excel 2010 Workbook for Dummies. John Wiley & Sons.
3. Jackson, M., Staunton, M., 2006. Advanced modelling in finance using Excel and VBA. John Wiley & Sons.
4. Schmuller, J., 2013. Statistical analysis with Excel for dummies. John Wiley & sons.

SEMESTER II

COURSE NO: EST 201

Course Title: Biodiversity Assessment and Conservation

Number of Credits: 3

No. of Lectures-Assignments-Examination: 36-6

Course Coordinator: Dr. Sougata Sadhukhan

Course Outline

The course focuses on the essential concepts and skills related to biodiversity conservation and assessment. This includes understanding threats to biodiversity, assessing biodiversity at various levels, concepts of landscape ecology and habitat management. It elucidates the perspectives of science and management of biodiversity in the context of current and future strategies needed for biodiversity conservation.

Learning Outcomes

Students will :

- Develop a deep understanding of the threats to biodiversity
- Develop skills of assessing biodiversity with different methodologies
- Develop a comprehensive understanding of issues in planning conservation areas and managing habitats.
- Acquire the ability to construct a conservation action plan for a species or site

Pre-requisite

EST 101

Evaluation Procedure : Evaluation Procedure: 60/40: University Exam / Internal Assessment

Assignment	2	20%	Internal Assessment
Minor Test	1	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	A	T/E
1	Overview of biodiversity • Status of biodiversity • Biodiversity at regional and landscape levels • Biodiversity at ecosystem, community and population levels	04		
2	Threats to biodiversity			

	• Loss of biodiversity – past rates of extinction, human caused extinctions, extinction rates on islands, island biogeography and extinction rates, case studies • Vulnerability to extinction – Endemic species, case studies • Habitat destruction, fragmentation and degradation • Exotic species introductions and disease • Problems of small populations – loss of genetic variability, demographic variation, environmental variations	05		
3	Assessment of biodiversity • Types of sampling – Qualitative and quantitative assessment techniques for mammals, birds, butterflies, plants. • Indices associated with species diversity, species similarity, temporal and spatial rate of change in species population • Alpha, Beta and Gamma diversity • Statistical approach to assessment of biodiversity • Software for biodiversity assessment	09		
	Assignment 1: Discussion and presentation of selected research paper in groups of 2/3 students OR any assignment as given by the faculty		03	
4	Planning Conservation Areas • Criteria for conservation – Conservation status, generalists and specialists; population size, sex and age classes, species restricted in distribution, isolated populations, habitat specialists and habitat obligates, species under illegal trade; key ecological functions of species; utility of the species • Approaches to conservation – species approach (featured species), management indicator species, species guild approach, flagship species approach, keystone species, ecosystem approach • Tools used for conservation – Population assessments, Gap analysis, habitat evaluation, GIS • Design criteria – habitat constituents, reserve design, reserve shape and size, population size, need for	10		

	buffers, wildlife corridors, landscape connectivity, administrative, political and economic considerations			
	Assignment 2: Discussion and presentation of selected research paper in groups of 2/3 students OR any assignment as given by the faculty		03	
5	Habitat Management • <i>Insitu</i> management – categories of biotic factors and their pressures- livestock grazing, fire wood collection, non wood forest produce collection, fires, encroachments, mining and quarrying, weeds and weed infestations (Invasive species), large scale monocultures, soil erosion, timber smuggling, poaching, development activities that are insensitive to ecological integrity, vandalism, unregulated tourism; • Eco-restoration- habitat restoration techniques and monitoring • Wildlife management plans.	08		
	Minor test 1			01
	Total	36	06	01

Suggested Readings

1. Alexander, M. Management Planning for Nature Conservation: a Theoretical Basis & Practical Guide. Springer, 2008.
2. Groves, C. Drafting a Conservation Blueprint: a Practitioner's Guide to Planning for Biodiversity. Island Press, 2003.
3. Margules, C., S. Sarkar, and C. R. Margules. Systematic Conservation Planning. Cambridge University Press, 2007.
4. McNeely, J. A. Expanding Partnerships in Conservation. Island press, 1995.
5. Postel, S. et al. Nature's Services: Societal Dependence on Natural Ecosystems. Island Press, 1997.
6. Smith, D. S., and P. C. Hellmund. Ecology of Greenways: Design and Function of Linear Conservation Areas. University of Minnesota Press, 1993.
7. Sutherland, W. J. Conservation Science and Action. Blackwell Science Ltd, 1998.
8. Sutherland, W. J., and D. A. Hill. Managing Habitats for Conservation. Cambridge University Press, 1995.

9. Sutherland, W. J., I. Newton, and R. E. Green. Bird Ecology and Conservation: a Handbook of Techniques. Oxford University Press, USA, 2004.
10. Kamaljit S. B., et. Al., 2011, Conservation Biology, Universities Press

COURSE NO: CA 201

Course Title: Wildlife Health, Rescue and Rehabilitation

Number of Credits: 3

No. of Lectures-Tutorial: 36-06

Course Coordinator: Dr. Kazveen Umrigar

Course Outline

The course provides in depth understanding of the various issues involved in wildlife health, capturing and handling wild animals, wildlife forensics and conservation breeding along with wildlife rehabilitation.

Learning Outcomes

At the end of the course, students will:

- Demonstrate a basic knowledge of complexities involved in animal welfare, wild animal health, conservation breeding, rehabilitation of wild animals
- Resolve applied ecological problems using basic biological information

Pre-requisite

EST 101, EST 201

Evaluation Procedure : Evaluation Procedure: 60/40: University Exam / Internal Assessment

Assignment	2	20%	Internal Assessment
Minor Test	1	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Wildlife Health • Introduction to disease and epizootiology • Determinants of disease and disease transmission, disease and population dynamics • Review of major viral, bacterial, protozoan, fungal and parasitic diseases of Indian wild mammals, birds, amphibians and reptiles. • Noninfectious diseases – nutritional diseases,	14	

	poisoning, stress, shock, capture, myopathy, physical trauma - Emerging and reemerging diseases, zoonosis - Assessment of condition, health and nutritional status in free ranging populations, disease control operations.		
2	Capture and handling of wild animals - Capture and handling of wild animals –purpose, restraint techniques, different capture methods and animal barriers - Drug immobilization – drug delivery equipment and accessories - Immobilization drugs – action, dosage, response and side effects, safety measures, complications - Handling and transport of wild animals, designing sledge, crate and holding enclosures	8	
	Assignment 1 Discussion and presentation of selected research paper in groups of two students.		03
3	Conservation genetics and wildlife forensics - Introduction of bio-molecules – DNA, RNA and Proteins; Central dogma of molecular biology - Replication, Transcription and Translation; Medelian genetics – Mendel’s laws; Genetic Code –characteristics and feature of genetic code; Molecular markers ; PCR, DNA - Sequencing, Genotyping; Allelic variation; Interpretation of genetic data - Applications of genetics for wildlife conservation - Loss of genetic diversity - Resolving taxonomic uncertainties Wildlife forensics – Overview, various forensic protocols for species identification, molecular markers used in wildlife forensics; Wildlife forensics based on DNA	08	

4	Conservation Breeding • Captive breeding and propagation; Founder population, rehabilitation, education, utilization, gene banks • Ex-situ and in-situ linkages • Conservation breeding management plans • Role of scientific institutions and NGOs in conservation breeding programs • Principles of conservation breeding – understanding biological requirements of species, design of facilities, food, hygiene, disease control, breeding • Propagation of threatened plants ; Case studies • Case studies on conservation breeding program of endangered wild animals	10	
5	Wildlife Utilization • Non-consumptive and consumptive utilization, their economic benefit • Game ranching and controlled off-take from wild population, rationale, management design, harvesting by management or hunting licenses, marketing procedures • Use of wildlife products – skins, meat, musk, etc- • Wildlife tourism – objectives, planning and economics	04	
	Assignment 2 As given by faculty		03
6	Wildlife rehabilitation • Approaches to establish new populations -Wildlife introduction, reintroduction and rehabilitation programs • Considerations for successful programs - social behavior of released animals, selection of animals, enabling field conditions, monitoring of released	06	

	animals		
	• Case studies		
	Minor Test 2		1
	Total	36	09

Assignments

In the assignments the students will carry out a review of issues involved in wildlife capture and rehabilitation or present a poster synthesizing any aspect of the course demonstrating an ability to use varied literature sources and present a coherent story of applied or theoretical interest.

Suggested Readings

1. Atkinson, C. T., N. J. Thomas, and D. B. Hunter. Parasitic Diseases of Wild Birds. Wiley Online Library, 2008.
2. Avise, J. C. "The History, Purview, and Future of Conservation Genetics." Conservation biology: evolution in action. Oxford University Press, New York (2008): 5–15. Print.
3. Avise, J. C., and J. L. Hamrick. Conservation Genetics. Springer, 1996.
4. Frankham, R., J. D. Ballou, and D. A. Briscoe. A Primer of Conservation Genetics. Cambridge University Press, 2004.
5. Introduction to Conservation Genetics. Cambridge University Press, 2002.
6. Grenfell, B. T., and A. P. Dobson. Ecology of Infectious Diseases in Natural Populations. Vol. 7. Cambridge University Press, 1995.
7. Hoff, G. L., and J. W. Davis. Noninfectious Diseases of Wildlife. Iowa State University Press, 2121 South State Avenue, 1982.
8. Hudson, P. J. et al. Ecology of Wildlife Diseases. Oxford University Press, 2002.
9. Loeschcke, V., and J. Tomiuk. Conservation Genetics. Vol. 68. Birkhäuser, 1994.
10. Nielsen, L., and R. D. Brown. "Translocation of Wild Animals." Translocation of wild animals. (1988)
11. Nunn, C. L., and S. Altizer. Infectious Diseases in Primates: Behavior, Ecology and Evolution. Oxford University Press, 2006.

COURSE NO: CA 202

Course Title: Behavioural Ecology

Number of Credits: 3

No. of Lectures-Assignments: 36-06

Course Coordinator: Dr. Meena Venkatraman

Course Outline

The course helps the students to understand how behavioural patterns have evolved and its connection to ecology. The subject develops an understanding regarding the importance of the physical and social environments and how animal behavior changes and evolves based on the variations observed in them. The course will work towards building a consolidated understanding on the subject so that they are able to gauge the importance of understanding various aspects of animal behaviour in devising management and conservation strategies.

Learning Outcomes

- Demonstrate a good understanding of behavioural ecology, including knowledge of the Factors influencing the behavior.
- How social processes and systems change the behavior and how it affects the conservation of species.
- Understand both opportunities and barriers to making positive changes in wildlife habitat which will help in creating positive action towards wildlife conservation.

Pre-requisite

None

Evaluation Procedure

Assignment	2	20%	Internal Assessment
Minor Test	1	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
	Introduction to Behavioural Ecology • Approaches to Study Animal Behavioural ecology (theoretical, conceptual and empirical) • Foundations of Behavioural ecology	2	
1	Natural selection, Sexual selection and Mating Systems • Natural selection • Artificial selection	6	

	• Behavioural genetics and variation in behaviour • Adaptation • Proximate and Ultimate Causation • Neurological underpinnings and proximate causation • Environment and variation in sex ratios • Sexual selection and mate choice • Mating Systems • Mate choice and inter-male competition Phenotypic plasticity: Behavioural adaptations to sudden environmental changes		
2	Learning • Learning as a proximate factor • Mechanism of animal learning • Why and what do animals learn • Social learning and cultural transmission • Genes and cultural transmission • Learning and mate choice • Learning and foraging	4	
3.	Habitat Selection and Foraging • Habitat Choice and ideal free distribution • Ideal free distribution and foraging success • Territoriality • Migration • Optimal foraging theory • Nutrient constraints and risk sensitive foraging • Foraging and animal grouping	6	
4	Predator-Prey Relationships • Antipredator strategies – behavioural tradeoffs • Alarm signals • Inter-population variation in antipredator strategies • Individual and social learning and Antipredator behaviour	6	
	Assignment		4

5	Cooperation • Cooperative behaviours • Reciprocity, byproduct mutualism and group selection • Coalitions • Mutualism and different species	5	
6.	Kinship • Kinship theory • Kinship and animal behaviour • Intra-family conflicts • Kin-recognition	5	
7.	Aggression and Play • The Hawk and Dove game • War of Attrition • Winner and Loser effects • Bystanders • Defining play • Types and function of play • Phylogenetic approach to play	8	
	Assignment 2		4
8.	Animal Communication • Honesty • Situations of Communication – Foraging, Mating, aggression, predation, play • Songs	3	
9.	Animal Personalities • Coping Styles • Boldness and Shyness • Case Studies and applications of personality research	2	

10.	Methods of studying animal behavior • Observational approach • Experimental approach • Comparative approach • Sampling methods of observational study of behaviour	4	
	Minor test 1		
	Total	50	06

Assignments

In the assignments the students will carry out a critical review of behavioral ecology research of their choice and submit the same.

Suggested Readings

- An introduction to behavior Ecology by Nicholas B. Davis ,John R .Krebs and Stuan A. west. 4th edition-2012- Wiley Blackwell publication
- Foraging : Behaviour and Ecology, By David W. Stephens and Joel S. Brown, Ronald C .Ydenberg.
- Principles of Animal Behaviour by Lee Alan Dugatkin, 2004 – W.W.Norton and Company
- Animal Behaviour: Mechanisms, Ecology and Evolution by John Alcock, 1979
- Animal Behaviour: An evolutionary approach by John Alcock, 2009, 9th Edition, Sinauer publications.

COURSE NO: CA 211

Course Title: Advanced Statistics

Number of Credits: 2

No. of Lectures-Practical: 29-25

Course Coordinator/Instructor: Dr. Shamita Kumar

Course Outline

The course will introduce data analysis using R. The students will be introduced to the R language fundamentals and basic syntax along with data analysis in R

Learning Outcomes

At the end of the course the student will:

- Have an insight into the various features for analysis available in R
- Develop the ability to prepare charts, tables, and professional reports that involve complex data.
- Develop the ability to analyze and summarize data using R

Pre-requisite

Students are strongly encouraged to complete the following free online course:

<https://www.edx.org/professional-certificate/microsoft-excel-fundamentals>

Evaluation Procedure : Continuous

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed home assignment submitted in digital format: 5 marks	Practicals must be in the prescribed format and be submitted digitally.	Internal Assessment
Major exam	60%	Theory cum practical examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	T	P
1	Practical 1: Introduction to Basics R and R Studio; Basic data types in R and assign	1		2

	variables.			
2	Practical 2: Data wrangling Working with tables: Filtering observations, arranging observations and adding/changing columns.	1		2
3	Practical 3: Data Visualisation 1 Data visualization using the ggplot2 package, using the dplyr and ggplot2 packages for creating graphs	1		2
4	Practical 4: Grouping and Summarising Using the group by and summarize verbs, visualizing summarized data	1		2
5	Practical 5: Data visualisation Create line plots, bar plots, histograms, and boxplots using different methods of data manipulation and preparation.	1		2
6	Practical 6: Exploring your data in tidyverse Using readR and exploring data	1		2
7	Practical 7: Taming the data Basics of data taming: taming the variable types, names, and values.	1		2
8	Practical 8: Tidying the data Tidying data and combining multiple tidying functions together in a chain using the pipe operator.	1		2
9	Practical 9: Transforming the data Taming specific types of variables such as dates, strings, and factors.	1		2
10.	Practical 10: Case Study			

	Use all the tools learnt above to solve a problem.			
	Major Test		3	
	Total	12		30

1. Chang, W., 2018. R graphics cookbook: practical recipes for visualizing data. O'Reilly Media.
2. Grolemund, G., Wickham, H., 2018. R for data science.
3. Hadley, W., Garrett, G.R., 2017. R for data science: Import, tidy, transform, visualize, and model data. O'Reilly Media.
4. Villanueva, R.A.M., Chen, Z.J., 2019. ggplot2: Elegant graphics for data analysis. Taylor & Francis.
5. Wickham, H., 2016. ggplot2: elegant graphics for data analysis. springer.
6. Wickham, H., Averick, M., Bryan, J., Chang, W., McGowan, L.D., François, R., Grolemund, G., Hayes, A., Henry, L., Hester, J., 2019. Welcome to the Tidyverse. Journal of Open Source Software 4, 1686.
7. Wickham, H., Grolemund, G., 2016a. R for Data Science: Import. Tidy, Transform, Visualize, and Model Data.
8. Wickham, H., Grolemund, G., 2016b. R for data science: import, tidy, transform, visualize, and model data. O'Reilly Media, Inc.

COURSE NO: CA 212

Course Title: Field Techniques II

Number of Credits: 2

Course Coordinator: Dr. Sougata Sadhukhan

Course Outline

The course provides hand on expertise with using various quantification techniques and tools for wildlife assessment including use of advanced equipment's like camera traps, bat detectors, mobile mappers, etc.

Learning Outcomes

Students will develop:

- Proficiency in using quantitative assessment techniques
- Ability to use mobile mappers, camera traps and other equipment for data collection.

Evaluation Procedure: 60/40: University Exam / Internal Assessment

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed assignment submitted timely : 5 marks	Internal Assessment
Major exam	60%		University Assessment

Details of course content

1. Estimating bird density by distance sampling –line transect/ point count methods
2. Use of DISTANCE software to analyse ecological data.
3. Occupancy Modeling
4. Conducting Participatory Rural Appraisal using household surveys (structured interview technique) and analyzing data (quantitative methods) (use two sessions if needed)
5. Conducting informal interviews and Analysing interview data (qualitative methods) (use two sessions if needed)
6. Conducting Participatory Rural Appraisal using participatory mapping/ matrix scoring/ seasonality calendar (in groups)
7. Scat Analysis
8. Animal call analysis
9. Use of camera traps and data analysis

COURSE NO: CA 213

Course Title: Field Taxonomy II

Number of Credits: 2

Number of hours: 60

Course Coordinator/Instructor: Dr. Sougata Sadhukhan with expert inputs

Course Outline

The course provides hand on expertise in identifying flora and fauna as well as in depth understanding of habitats and niches of different taxa. The course will provide a field exposure and various observational methods for different taxa through a combination of classroom sessions and field visits.

Learning Outcomes

Students will:

- Develop skills in identifying various flora and fauna.
- Develop an ability to analyze various habitats and microhabitat requirements of different taxa.
- Acquire competence in design and implementation of sampling techniques for various flora and fauna of different ecosystems.

Pre-requisite

- None

Evaluation Procedure : Continuous assessment

Assignments	100 %	• 6 Assignments • Final Exam	Internal Assessment

Details of course content and allotted time

Unit	Topic	Time (Hours)		
		Lect ures	T	P
1	Taxonomy of snakes • Broad classification of snakes • Morphological characters and taxonomy of snakes • Indirect methods of collecting data	3		
	Field visit to BNHS museum			4
	Assignment 1			4

2	Taxonomy of mammals • Classification of mammals • Morphological characters • Distribution of species • Rare and endangered species	2		
	Field visit to BNHS museum			4
	Assignment 2			4
3	Wetland and migratory aquatic birds • Wetlands and migratory bird sites • Ramsar Convention • Bird flyways • Monitoring bird diversity on wetlands • Methods of data collection	3		
	Visit to Bhigwan wetland			6
	Assignment 3			4
4	Study of flowering trees • Common evergreen, deciduous, thorn forest tree species • Tree sps regeneration and availability of saplings • Shrubs and climbers	2		
	Field visit to Valvan			6
	Assignment 4			4
5	Identification of butterflies and insects and other invertebrates • Commonly seen invertebrates • Butterflies and their common groups • Use of various sampling methods for study • Invertebrates as indicators with examples • Field methods	4		
	Field work at Valvan			6
	Assignment 5			4

6.	Study of mangroves and marine fauna • Common mangrove tree species • Mangroves at Sewri and about birds • Flamingoes at Sewri • Sampling methods of marine fauna	2		
	Visit to Sewri and walk on the coast			6
	Assignment 6			4
7.	Study of Birds • Divide in groups of three (7 groups) • Keeping notes of visits	2		
	Field work at Pachagaon Parvati			8
	Assignment 7			5

COURSE NO: CA 214

Course Title: Field Work

Number of Credits: 2

Number of hours: 60

Course Coordinator: Dr. Shamita Kumar / Dr. Sougata Sadhukhan

Course Outline

The course provides field experience in analyzing conservation problems around Protected areas through a combination of natural science and social science research techniques.

Learning Outcomes

Students will develop:

- Proficiency in use of field methods
- Ability to analyse conservation problems.
- Competency in interpretation and presentation of results.

Pre-requisite

None

Evaluation Procedure: Continuous

Continuous assessment	100 %	Participation and submission of field work report	Internal Assessment

Details of course content

The field work to a National Park will be done through a twelve day block course that will involve pre field work sessions and post field work sessions. The fieldwork will focus on use of field techniques, bird identification as well as surveys to analyse resource use, tourism related problems, conservation problems, etc.

COURSE NO: EST 206

Course Title: Natural Resource Management

Number of Credits: 3

No. of Lectures-Tutorial: 36-06

Course Coordinator: Dr. Kranti Yardi

Course Outline

The course is intended to impart knowledge and skills considered crucial for natural resource managers to manage effectively in the dynamic and intricate environment. It enhances the students' understanding at diverse levels by maintaining the equilibrium between the occupation obligations and enduring growth requirements. The fundamental thrust of the course is to assist the students to obtain theoretical and logical abilities in relation to the field situations, necessary for managing natural resources efficiently.

Learning Outcomes

The student will be able to:

- Contribute in managing the resource in a comprehensive way as professionals working in this sector
- Balance the needs of people and the economy with protecting the ability of ecosystems to support soil, water, forests, wildlife, fish, recreation, and other resources

Evaluation Procedure: Continuous

Assignments	40 % (3)	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment • Completed home assignment submitted timely and excellent written presentation	Assignments must be in the prescribed format. One journal may contain assignments of different elective courses separated by a separator. Index must reflect all the assignments duly signed by the concerned teacher. Marks for every assignment must reflect on the assignment itself.	Internal Assessment
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	A	T/E
1.	Natural Resources – overview - Natural Resources –global, national (role of environment ministry and congruent ministries, local (Panchayati raj) - Land, water, air ,biodiversity, energy resources , Common property resources - Natural resource governance and policy – policy building, legislation, administrative action, judiciary - Role of NGOs and academics	05		
2.	Theoretical aspects of Natural Resource Management - Livelihoods and Natural Resources - Global natural resource issues (water conflicts, interstate conflicts) International collaboration to address complex natural resource issues - Natural Resource Economics - Society, Ethics and Participatory Development - Conflicts management - land, biodiversity, water	03		
	Assignment 1: Discussion and presentation of selected research paper in groups of two/three students OR as given by faculty		03	
3.	Integrated watershed management - Definition of watershed - Watershed development strategy - Socio-economic and natural resource information through PRA's - Land surveys through land class determination for area, slope, depth of soil, texture, erodibility; soil and water testing - Engineering surveys – topographical surveys, drainage line survey, contour survey - Ecological assessment of the area – A statement of significance; site description-significant habitat types, native species of wild plants and animals of conservation importance, significant corridors, biotic	10		

	pressures and threats, significant ecological services. People and their relationship with natural areas (valid and invalid stakes). • Microplanning – microplanning process, difficulties faced during microplanning, advantages of microplanning • Principles of soil and water conservation			
	Assignment 2: Ecological assessment of a given area using GIS compatible technique		03	
	Assignment 3: Collection of data using GIS compatible participatory rural appraisal technique		03	
4	Analytical aspects of Natural Resource Management • Remote sensing and GIS application in NRM • Statistical analysis in NRM • Vegetation inventory and rapid assessment • Financial analysis and project management in NRM • Environmental Impact Assessment (EIA) and Auditing	05		
5	Managerial aspects of Natural Resource Management The role of communication in natural resource management; Facilitating discussions with multiple stakeholders, multiple perspectives; Conflict management; Policy negotiation; Collaborative planning for • Wildlife conservation and management • Wetland management • Watershed management • Urban forestry • Biodiversity and landscape • Climate change and carbon trading • Agro-ecosystems and Agro forestry • Environmental modeling • Eco-tourism and other environmental services • Bio-resources – Access and benefit sharing	11		
	Final Assessment			03
	Total	36	9	03

Suggested Readings

1. Francois Ramade 1984. Ecology of Natural Resources. John Wiley & Sons Ltd.
2. Harris, J.M. 2006. Environmental and Natural Resource Economics: A Contemporary Approach, 2nd edition. Houghton Mifflin.
3. Coastal Ecology & Management, Mann, K.H. 2000. Ecology of Coastal Waters with Implications for Management (2nd Edition). Chap. 2-5, pp.18-78 & Chap. 16, pp.280-303.
4. Global Change and Natural Resource Management, Vitousek, P.M. 1994. Beyond global warming: Ecology and global change. Ecology 75, 1861-1876.
5. Agarwal, K.C., 2001. Environmental Biology, Nidhi Publication Ltd. Bikaner.
6. Cunningham, W.P. Cooper, T.H. Gorhani, E & Hepworth, M.T. 2001, Environmental Encyclopedia, Jaico Publishing House.
7. Heywood, V.H. & Watson, R.T. 1995. Global Biodiversity Assessment. Cambridge Univ. Press.
8. Miller T.G.Jr. Environmental Science, Wadsworth Publishing Co. (TB)
9. Townsend C., Harper J, and Michael Begon. Essentials of Ecology, Blackwell Science.
10. Barber, E. 1989. Economics: Natural Resources Scarcity and Development. Earthscan.
11. Kamaljit S. B., et. Al., 2011, Conservation Biology, Universities Press.

COURSE NO: EST 401

Course Title: Eco-restoration

Number of Credits: 3

No. of Lectures-Tutorial/Assignment: 36-06

Course Coordinator: Dr. Sougata Sadhukhan with inputs from Dr. Rahul Mungikar

Course Outline

The course will introducing learners to the principles, concepts, methodologies and key challenges in the field of ER. The course will give an understanding of key topics including identifying degradation, its causes and ecological impacts and restoration methodologies and their application. It will make students familiar with the restoration methods of different fragile ecosystems such as wetlands as well as develop an understanding of restoring degraded waste land in urban landscape. principles and concepts of ER, including international standards and protocols. The course includes two local field trips.

Learning Outcomes

The student will develop:

- Analyze causes of degradation
- A deep understanding of eco-restoration including different approaches applicable for the restoration practices of different landscapes.
- Ability to design and implement an ecorestoration program for a specific ecosystem

Pre-requisite

None

Evaluation Procedure : Continuous

Assignments	40 % (3)	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment • Completed home assignment submitted timely and excellent written presentation	Assignments must be in the prescribed in format digitally.	Internal Assessment
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T/A
1	Introduction to ecological restoration (ER) - Definition(s) of ER, Difference between ER and other rehabilitation approaches; Aim of restoration - Importance of ER in the contemporary conservation context - Policies and programs for restoration of ecosystems in India	02	
2.	Concept of Degradation - Causes of land degradation; Macro-level indicators of degradation; Methods of identifying factors causing degradation; Assessing level of degradation severity; Presentation of degradation profile from a real-life project - Ecological Succession: Principles and types of ecological succession	02	
3.	Assignment 1: Participants' group work on analyzing degradation profiles in diverse ecosystems e.g. lakes, dry deciduous forests, grasslands, etc. and present results.		02
4.	Key concepts in ecological restoration - Ecosystem approach; Species Approach; Landscape Approach - Restoration of populations and communities; Minimum viable populations; metapopulation theory and its implications for restoration; - Application of community ecological theory to restoration - Principle of least possible intervention; Principle of assisted regeneration; Understanding biodiversity in the ecological restoration context	04	
5.	Understanding soil for restoration - Introduction to soil science; Role of soil in ecosystem functioning and resilience; - Soil types and characteristics: Physical, chemical, biological, etc., Biotic interface with the soil: role of soil microbes, fungi, insects and plants in maintaining soil health - Restoring degraded soil: Types of soil degradation with causes; Physical indicators of degraded soil; Methods of assessing soil health using tests; Soil restoration techniques - Relationship between soil and hydrology	06	

	• Soil water conservation practices and measures		
6.	Assignment 2: Analysis of a restoration site (Pashan Lake)		03
7.	Restoring sites with degraded vegetation • Characteristics of sites with degraded vegetation; • Factors causing vegetation degradation; • Restoration principles; Restoration methods: spontaneous regeneration, assisted natural regeneration techniques, active intervention techniques; Collection or raising of plant material • Importance of plant material in restoration; • Basics of seed science; Seed collection techniques; • Raising plants in nurseries: nursery establishment and development ; Techniques of nursery operations in semi-arid areas; Seedling production; Nursery Level Operations Planting methods • Revegetation and regeneration; Natural regeneration-important principles; planting techniques; Selection of tree and shrub species • Post planting activities; Stepwise establishment and management techniques of plantations • Types of plantation: Windbreaks and shelterbelts; Forest and grassland plantation; Sand dune plantation; River side plantation	08	
	Field Visit to a Nursery		02
8	Role of fauna in restoration Role of fauna in restoration: soil enrichment, pollination, seed dispersal, nutrient recycling, biological control, etc.; Leveraging on fauna for accelerating restoration progression.	02	
9	Human Dimension of Ecological Restoration • Role of people in ecological restoration; Developing a volunteer base; Collaboration and public participation in a restoration project; Grazing and fire management • Eco-cultural restoration; • Role of education and awareness in restoration	04	
11.	Planning and project design Key steps in designing a restoration project; Deciding desired	06	

	outcomes; Deciding project scale ; Estimating resource requirements; Cost considerations and using low-cost ; restoration options; Funding avenues for ER; ROAM Method (WRI) Project implementation Activity planning and scheduling; Managing uncertainties and risks; Project monitoring Survey and documentation techniques; Use of satellite imaging and similar techniques Project management case studies Forest restoration; Restoration of mined out areas; Lake restoration; Grassland restoration		
12	Assignment 3: Restoration Project Design The report should include details on: Site selection criteria, Site description and problem identification; Developing restoration goals (using reference conditions/sites, consultation, etc.); Formulate a plan for achieving restoration goals (activities, interventions, etc.); Budget and Timeline; Monitoring plan		04
	Final assessment exam		
	Total	36	09

Suggested Readings

1. Hammitt, W.E. & Cole D.N. 1998. Wildland Recreation: Ecology and Management, 2nd Ed. New York: John Wiley & Sons. 361 pp. (ISBN: 0-471- 19461).
2. Liddle M. 1997. Recreation Ecology: The Ecological Impact of Outdoor Recreation and Ecotourism. New York: Chapman & Hall. 639 pp.
3. Higgs, E. 1997. What is Good Ecological Restoration? Conservation Biology, pp. 338-348.
4. Egan, B. 1998. Ecological Restoration for British Columbia. British Columbia Environmental Report, pp. 7-9.
5. B.K. Tiwari, Surendra Singh 1995. Eco restoration of degraded hills.
6. Robert U Ayres, Paul M Weaver. Eco restructuring: Implications for sustainable development. IN-05457.

COURSE NO: CA 203

Course Title: Urban Biodiversity Conservation

Number of Credits: 3

No. of Lectures-Tutorial: 36-09

Course Coordinator: Dr. Shamita Kumar

Pre-requisite

None

Evaluation Procedure : Continuous

Continuous assessment during assignments	40 %	Marking pattern for every assignment: • Evidence of clear line of thinking, written up well • Excellent presentation	Internal Assessment
Major exam	60%		University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Fundamentals of Urban Biodiversity Introduction, biodiversity in urban areas, typologies of urban biodiversity, biodiversity of urban industrial areas, urbanization of terrestrial ecosystems, cultural aspects of urban biodiversity, social aspects of urban biodiversity, urban patterns and biodiversity, history and development of urban biodiversity.	10	
2	Social integration and programmes to enhance urban biodiversity Use of urban green spaces- natural, man made and accessible, attracting interest in biodiversity, services provided by green spaces; Values of urban biodiversity	8	
3	Impacts on urban biodiversity Constraints of urbanization on biodiversity- vegetation, flora and fauna, role of non native species, avian diversity, encroachments., climate change and its impacts, environmental	6	

COURSE NO: GEN 201

Course Title: General English

Number of Credits: 2

No. of Lectures-Tutorial: 24-8

Course Coordinator:

Learning Outcomes

The student should be able to:

- Construct sentences with correct grammar
- Write simple reports correctly

Evaluation Procedure: Continuous

Assignment	1	100%	Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Basic language skills: grammar and usage The ability to fill in blanks, correct errors, choose correct forms out of alternative choices, join clauses, rewrite sentences as directed, replace indicated sections with single words/opposites/synonyms, etc. Skills such as punctuation of passages, changing between direct and indirect speech, expanding points into complete sentences.	08	
	Comprehension This implies (a) an understanding of the passage in question and (b) a grasp of general language skills and issues with reference to words and usage within the passage and (c) the power of short independent composition based on themes and issues raised in the passage.	08	
	Composition: Paragraph-writing Formal training in composition and précis/summary writing through instruction, discussion and written work. Letter writing, Basic report writing	08	
	Assignment		4
	Total	24	8

COURSE NO: GEN 202

Course Title: Technical Writing

Number of Credits: 2

No. of Lectures-Tutorial: 24-06

Course Coordinator: Mr. Venkatnarayan Ganpati

Course Outline

The course provides an outline of how to develop communication skills with an emphasis on scientific writing, proposal preparation and scientific but attractive way of presentation of research findings along with proper means of audio-visual documentation. The course prepares students to think, read and write scientific papers; conceptualize, frame and prepare complete project proposals and also will help them to realize the basics of audio-visual communication systems.

Learning Outcomes

The student will be able to:

- Think, read and prepare scientific manuscripts
- Conceptualize, frame and prepare project proposals
- Prepare oral presentations and posters
- Document, edit and publish findings in field and related topics

Pre-requisite

None

Evaluation Procedure

Assignment	1	50%	Internal Assessment
Assignment	2	50%	Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Technical writing Outlining content • Organizing content: Checklist for components of journal articles and research papers • Difference between Abstract and Executive Summary • Writing an Introduction and Conclusion • Using logic to present content: the building blocks of analytical writing	8	

	• Using graphics to represent data: making data more readable and using graphics to present analysis • Using keywords to enhance search: Effective use of keywords to enhance online reach of your articles Using language effectively • Using effective words and editing content: Using a tool kit for writing; what to avoid when writing • Creating flow of information: understanding the difference between listing or cataloguing details and analyzing and interpreting them for your reader Submitting papers • Understanding submission guidelines • Using appropriate resources • Handling manuscript rejections		
	Assignment 1		
2	Preparing project proposals • Mapping the donor needs to organisational needs • Structuring content • Specifying deliverables and timelines • Asking for commitment • Checklist for a complete proposal	6	
3	Oral and Poster Presentations • Designing the presentation and flow of content • Communicating with the audience: verbal and non-verbal soft skills • Using visuals effectively: basics of using graphics, illustrations and copyright issues	4	
	Assignment 2		
4	Visual Documentation • Methods	6	

SEMESTER III

COURSE NO: CA 311

Course Title: Dissertation

Number of Credits: 24

Evaluation Procedure : Evaluation Procedure: 60/40: University Exam / Internal Assessment

Assessment 1	Internal	10%	<i>Presentation on introducing the topic and its feasibility (literature review to justify the gap)</i>
Assessment 2	Internal	15%	<i>Detailed literature review, methodology with data collection protocols</i>
Mid term Assessment	Internal	15%	<i>Mid-course review. Presentation of results and preliminary analysis</i>
Major Exam	External	60%	University Assessment

Guidelines for dissertation

Topic: Candidates will write a dissertation on issues related to environmental/geospatial issues under the guidance of their respective guides. Each student will work independently on the topic. The dissertation must consist of review of literature and produce a deep insight of the subject on the basis of personal research.

Initiation of work: Dissertation work will be initiated during the second semester during the course of the paper on Research Methodology. During the Research Methodology course in Semester II, students will be allotted guides (from within the faculty associated with the Institute) based on their area of interest. As part of their assignments in the Research Methodology course students will write their introduction and literature review. **Guides will be from empaneled faculty only.**

Evaluation of thesis: The thesis will be evaluated in **two phases** over two semesters (third and fourth). **For the first phase** (in the third semester), 12 credits are allotted. The schedule for evaluation (internal and external) is given in the table above. **The guidelines given below only pertain to the first phase.**

Guidelines for the first assessment (first): The first presentation should cover gap analysis (supported with literature review), justification for the study, aim, objective and proposed methodology. A document covering the above points should be submitted.

Guidelines for the second assessment (second): For every presentation students will prepare a power point presentation highlighting the objectives, research question, methodology and key findings and defend the same. The presentation must not be texty. It should be aesthetically appealing and contain relevant graphs and analysis. Wordy presentations are likely to get marked down. Students should be smartly dressed and speak in a clear voice. Do ensure that your presentations are loaded as per the given deadlines.

Submission for Mid term assessment: For the University presentation the student is expected to submit one **spiral bound copy** of the thesis consisting of introduction, literature review, aims and objectives, methodology, data and preliminary analysis along with a content page and interim certificate signed by the guide. (See attached certificate format below.

The dissertation should be typed on A4 size bond paper with 1.5 line spacing. Illustrations and photographs should be of high quality. Font to be used is Times New Roman or Arial with the text not less than in 12 pt. Referencing must be done in Zotero or any other referencing software strictly in standard referencing style (Vancouver). The report should be flawless without any spelling mistakes and grammatical errors etc. If the dissertation contains such mistakes, the student will have to resubmit their dissertation after the necessary corrections.

The student will be permitted to appear for the second phase of the thesis ONLY if he/she has cleared the first phase.

FORMAT OF INTERIM CERTIFICATE

This is to state that Mr./Ms. _____ has worked under me for his dissertation from _____ till date. During this period he/ she has completed the following tasks.

- 1.
- 2.
- 3.
- 4.
- 5.
- 6.
- 7.

I have verified the authenticity of the data that he is using for his/her presentation.

Name of guide

Signature of guide

FINAL SUBMISSION

The dissertation will have to be submitted as per the dates indicated in Academic Calendar for appraisal and acceptance by the University. The students should submit their dissertation in the following format.

Thesis Organisation

Cover Page

Inner Cover Page

Certificate duly signed by guide and head of institution

Acknowledgements

Abbreviations

Contents

Chapter 1 – Introduction

A background with historical information and a review of existing material or data on the subject.

Chapter 2- Aims and Objectives

This chapter must contain the overall study design and aims and objectives of the study.

Chapter 3 – Literature Review

Detailed review of all existing literature related to the topic justifying the topic with a comprehensive bibliography generated using Zotero.

Chapter 3 –Methodology

Description of the issues, environmental setting and methodology adopted for the study etc.

Chapter 3 – Results

Presentation of results.

Chapter 4 – Discussion

Discussion on the data and results obtained and presentation of method suggested to solve the problem.

Chapter 5 – Summary and Conclusions

A summary of the dissertation and important conclusions drawn at the end of the investigation and a list of references cited in the text.

Chapter 6 - Bibliography

The dissertation should be typed on A4 size bond paper with 1.5 line spacing. Illustrations and photographs should be of high quality. Font to be used is Times New Roman or Arial with the text not less than in 12 pt. Referencing must be done in Zotero or any other referencing software in standard referencing style (Vancouver) for both intext citing and bibliography. The report should be flawless without any spelling mistakes and grammatical errors etc. If the dissertation contains such mistakes, the student will have to resubmit their dissertation after

the necessary corrections. The dissertation should be bound in hard black mounted cover. **Dissertations with spiral binding and paper cover will not be accepted. The front matter should be embossed and not on a sticker.**

The students are expected to prepare 3 copies (4 in case of a co-guide). If the guide gives a written consent that he/she does not need a hard copy a soft copy may be provided. The soft copy must contain a sticker with the cover page information. **The thesis will only be accepted after the relevant data used has been submitted to the faculty nominated and verified by them. It is mandatory that all data collected be submitted to the Institute for verification.**

Students must submit the plagiarism report before submission. Students making special efforts to present their papers at conferences or publishing it will receive marks as below:

1.	Poster presented at a National level UGC recognized conference	5 marks
3.	Paper presented at a national level conference	10 marks
4.	Paper published in a SCOPUS/ WEB of SCIENCE indexed journal ONLY	25 marks

Guidelines for final presentation: The final presentation must consist of gap analysis (inbrief), aim, objectives, research question, methodology and key findings and action plan (if any) and defend the same.

The presentation must not be texty. It should be aesthetically appealing and contain relevant graphs and analysis. Wordy presentations are likely to get marked down. Students should be smartly dressed and speak in a clear voice. Do ensure that your presentations are loaded as per the given deadlines.

Guidelines for poster (to be submitted digitally)

For the final presentation students will prepare a poster as per the guidelines given below.

Poster size: 2ft (W) x 3ft (H)

Content: Aim, Objective, Method (in brief in a flow chart), findings (key graphs to be included), publications (if any), conclusion, suggestion

Name of the student and guide as well as institutional affiliation should be included.

FORMAT OF FINAL CERTIFICATE (Times New Roman 12 pt; Line spacing 1.5)

CERTIFICATE (14 pt)

This is to certify that **NAME OF STUDENT**, final year student at the Bharati Vidyapeeth (Deemed to be University) Institute of Environment Education and Research, Pune has successfully completed the dissertation titled, '**Topic**' under the guidance of **Guide name**, in partial fulfilment of the Master Degree in Environment Science And Technology during the academic year **2019-20**.

The work has been completed to our satisfaction and standards. The said dissertation has not been submitted for any other degree or diploma and any such material which has been obtained from other sources has been duly acknowledged in the dissertation.

Guide name and designation

**Prof. Dr. Erach Bharucha
Director
Bharati Vidyapeeth (Deemed to
be University) Institute of
Environment Education and
Research, Pune Satara Road,
Pune 43**

COURSE NO: GEN 301

Course Title: Project Management

Number of Credits: 2

No. of Lectures-Tutorial: 18-12

Course Coordinator: Mr. Parag Khatavkar/ Dr. Girish Jathar

Course Outline

The course provides an overview of techniques of project management with an emphasis on project management, organizational structures, teams, functions, planning, scheduling, cost controls, trade-offs, risk management and other related topics. The course prepares students to conceptualize, implement, monitor and evaluate the project.

Learning Outcomes

The student will:

- Construct, organize and explain project management.
- Devise, plan and compile work breakdown structures (WBS) and understand life cycle phases as quantitative tools in project management.
- Design, generate and explain scheduling techniques.

Evaluation Procedure: Continuous

Assignment	1	100%	Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	A
1	Introduction to project management • Definition and attributes of project and project management • Strategy in project management – establishing objectives, scoping the boundaries, priority setting, strategic development • Understanding project management and resistance to change • Project management life cycle • Critical success factors in project management • Best practices in project management • Project monitoring	06	
2.	Project management methodologies	06	

	• Modeling the project system – WBS, responsibility, communication plan • Estimations in projects – basic, time, cost, resources, techniques, guidelines • Developing project plans – Gantt charts, evaluating and constructing networks • Overcoming development and implementation barriers • Critical components of project management • Implementing a methodology • Strategic planning for project management		
3.	Issues in project management • Management Styles • Project Management Skills • Involvement of senior managers and stakeholders • Identification of projects • Project management information systems • Risk management • Change management • Role of culture in project management	06	
	Assignment		15
	Total	18	20

Assignments

In the assignment the students will be expected to design WBS, review of best practices in project management, role of change management, etc.

Suggested Readings

1. Baker, B. N., D. C. Murphy, and D. Fisher. "Factors Affecting Project Success." Project Management Handbook, Second Edition (2008): 902–919.
2. Dyball, R., and M. Keen. Social Learning in Environmental Management: Towards a Sustainable Future. Routledge, 2012.
3. Kerzner, H. Advanced Project Management: Best Practices on Implementation. Wiley, 2003.
4. Project Management: a Systems Approach to Planning, Scheduling, and Controlling. Wiley, 2009.
5. Strategic Planning for Project Management Using a Project Management Maturity Model. Wiley, 2002.

SEMESTER IV

COURSE NO: CA 411

Course Title: Internship

Number of Credits: 10

Course Coordinator: Dr. Sougata Sadhukhan

Course Outline

The internship of six month (minimum 5 months) duration to be completed in the fourth semester is an opportunity for students to develop research skills and/or gain professional expertise as well as academic knowledge. Students must plan for the internship towards the end of the second semester itself. While the Institute will facilitate the placement for internships, students are encouraged to find placements for internships and make initial contact with prospective organization as this builds skills of communication.

Learning Outcomes

Students will learn to:

- Plan, execute and present findings of tasks completed in the six month period.
- Write concisely and effectively in order to communicate concepts and ideas in a logical and coherent manner.
- Produce effective data presentations and use them to enhance the communication of quantitative information.
- Work effectively in a team.

Pre-requisites

The student must apply for the internship/scan internship opportunities atleast six to eight months in advance. Requisite correspondence with the concerned organization is the responsibility of the student. The Institute will support with a letter of intent. Throughout the internship, the student must maintain a work log that includes dates, time spent on site, and a summary of the work performed and its relevance. An updated copy of the log must be turned into the supervisor (at the place of work) and the faculty supervisor in the form of monthly reports. The student must meet with the supervisor (at the place of work) on a regular schedule (determined by the supervisors at their discretion). The supervisor must be willing to submit a written evaluation of the student at the conclusion of the internship.

Evaluation: Continous

Midterm report submitted with signature of the supervisor and a letter of appointment	Three month from time of commencement of internship	20%	Details of tasks assigned, tasks completed till date
End project report submitted with a report by the supervisor	Within seven days of completion of the internship	40%	

Presentation on internship	As per University schedule	40%	Detailed presentation of tasks completed with concrete outcomes and learnings.

Format of Internship Report

- Cover page with title, your name and name of company
- Certificate from the employer on employer letterhead stating tasks completed and level of achievement (see certificate format below).
- (on a new page)

Name of the student

Place of internship

Supervisor

Duration of internship (Date of commencement of internship – date of completion)

1.0 Introduction

Para about the organization

Para about your work in general

2.0 Objectives

3.0 Tasks done with methodology and date

4.0 Outputs

4.1

4.2

-
-
-

5.0 Learnings (to be added only for final report, not interim report) This is an important section for you to reflect on your learnings.

- Work experience
- Academic and scientific and experience
- Social and cultural experience

Kindly add photographs of yourself at your workplace/ field. Videos maybe taken

The internship report should be typed on A4 size bond paper with 1.5 line spacing. Illustrations and photographs should be of high quality. Font to be used is Times New Roman or Arial with the text not less than in 12 pt. Referencing must be done in Zotero or any other referencing software in standard referencing style (Vancouver) for both intext citing and bibliography. The report should be flawless without any spelling mistakes and grammatical errors etc. If the report contains such mistakes, the student will have to resubmit their dissertation after the necessary corrections. The students are expected to prepare 3 copies (Spiral Bound/ Wiro Bound). Two copies of the report with original certificates in both must be submitted. Good photos of the student in the place of internship (in action) must also be included in the report apart from other relevant photos.

CERTIFICATE

This is to certify that _____, a student of the Masters in Geoinformatics (M.Sc.) at the Institute of Environment Education and Research, Bharati Vidyapeeth Deemed University, Pune has successfully completed his/her internship in partial fulfillment for the course at _____ under the mentorship of _____ from _____ to _____.

He/She has completed the following tasks... /was involved in (as per suitability to be filled in by the candidate and supervisor)

____ XXXXXX

(Name and designation of mentor/ supervisor with seal on the University/Company letterhead)

COURSE NO: CA 401

Course Title: Conservation Leadership

Number of Credits: 3

No. of Lectures-Tutorial: 36-06

Course Coordinator: Dr. Shamita Kumar with external inputs

Course Description

The course focuses on understanding seminal and contemporary leadership theories and principles, their impact on practice, and managing change. The course will include lectures, group activities, case studies, role plays and take-home assignments. The students will also be expected to use online resources besides printed material. There will be opportunities to present views, learn through various activities, and work on group projects. The activities, projects, and assignments are designed to help students gain knowledge and understanding of key leadership and management models and principles, and help them to connect to theory to practice.

Course Outcomes

- At the end of the course the student will:
- Reflect on their personalities and assess their potential to be a leader in the field of conservation
- Understand how attitudes, values, beliefs and leadership styles impact conservation effectiveness
- Understand tools for effective and efficient decision-making processes, and how to influence decision-making for a positive conservation outcome

Pre-requisite

None

Evaluation Procedure : Continuous

Continuous assessment during assignments	40 %	Two assignments	Internal Assessment
Major exam	60%	Final Examination	Institute Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Introduction to Leadership, Project Planning - Defining Leadership: Distinguishing Leadership and Management; Leadership Fundamentals: Individual Factors and Situational factor; Approaches to defining leaders and leadership: Trait, Behavioural Approach, Skills approach; Role of motivation <i>Task: Analysing your personality traits</i> - System Leadership Approach	03	
2	Project Planning and Management Need for planning; Components of project planning; Knowing where you fit in; Actor/partner identification and analysis; the problem tree; the objective tree; Logical Framework Analysis; Fundraising principles: Understanding types of donors; key donor criteria; production of a funding proposal; budgets and time plans; submission; donor relations; fundraising basics Project Implementation: Managing the money and managing human resources; Managing health and safety; Monitoring, evaluation and reporting	09	
	Assignment 2		5
3	Working with people The importance of important people skills in conservation; people skills in action (case studies); Resolving conflicts and defusing contentious situations – communication techniques; Persuading People – needs of people and techniques of influencing; Developing your image	06	
4	Case Studies on Conservation Leadership Case studies from various conservation practioners	06	
	Major Exam		5
	Total	27	09

Reference Books and papers

1. Black, S.A., Groombridge, J.J., Jones, C.G., 2011. Leadership and conservation effectiveness: finding a better way to lead. *Conservation Letters* 4, 329–339.
2. Bruyere, B.L., 2015. Giving direction and clarity to conservation leadership. *Conservation Letters* 8, 378–382.
3. Rastogi, A., Badola, R., Hussain, S.A., Hickey, G.M., 2010. Assessing the utility of stakeholder analysis to Protected Areas management: The case of Corbett National Park, India. *Biological Conservation* 143, 2956–2964.
4. Straka, T.M., Bal, P., Corrigan, C., Di Fonzo, M.M., Butt, N., 2018. Conservation leadership must account for cultural differences. *Journal for Nature Conservation* 43, 111–116.

COURSE NO: CA 402

Course Title: Conservation Communication, Education and Public Awareness

Number of Credits: 3

No. of Lectures-Tutorial: 36-06

Course Coordinator: Dr. Shamita Kumar with external inputs

Pre-requisite

None

Evaluation Procedure : Continuous

Continuous assessment during assignments	40 %	Marking pattern for every assignment: • Evidence of clear line of thinking, written up well • Excellent presentation	Internal Assessment
Major exam	60%		University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Conservation Education Need, scope, objectives, approaches for conservation education, curricula and conservation education, history of conservation education, formal and non-formal conservation education programs, Government and NGO initiatives curricula	03	
	Assignment 1: Discussion and presentation of a research paper in teams		3
2	Techniques for conservation education- principles and implementation Non formal techniques in environment education - Games, puppetry, poster making, exhibit development, and nature trails, nature camps, field visits; Social media; internet communication; leadership programs; Case Studies	09	

	Assignment 2: Design of conservation communication tool (games, activities) for school students		06
3	Designing Training programmes: Principles, design, planning, implementation, evaluation and monitoring .	03	
	Assignment 3: Making a ten minute film based on the thesis		3
4	Designing a wildlife communication program Concept, principles, case study analysis, best practices; Campaigns, action projects, community activities; Developing material- activity sheets, booklets, educational material Interpretations and nature education centers- planning and budgeting; Designing campaigns	12	
	Total	27	06

Reference Books

1. Holliman, R., Whitelegg, L., Scanlon, E., Smidt, S., Thomas, J., 2009. Investigating science communication in the information age: Implications for public engagement and popular media. Oxford University Press.
2. Jacobson, S.K., 2009. Communication skills for conservation professionals. Island Press.
3. Jensen, E., Holliman, R., 2009. Investigating science communication to inform science outreach and public engagement. Oxford University Press.
4. Jurin, R.R., Roush, D., Danter, K.J., 2010. Environmental Communication.: Skills and Principles for Natural Resource Managers, Scientists, and Engineers. Springer.
5. Kouper, I., 2010. Science blogs and public engagement with science: Practices, challenges, and opportunities. Journal of science communication 9, A02.
6. López-Goñi, I., Sánchez-Angulo, M., 2018. Social networks as a tool for science communication and public engagement: focus on Twitter. FEMS Microbiology letters 365, fnx246.
7. Nisbet, M.C., 2009. Framing science: A new paradigm in public engagement. Understanding science: New agendas in science communication 40, 67.
8. Stilgoe, J., Lock, S.J., Wilsdon, J., 2014. Why should we promote public engagement with science? Public understanding of science 23, 4–15.
9. Varner, J., 2014. Scientific outreach: toward effective public engagement with biological science. BioScience 64, 333–340.

COURSE NO: CA 403

Course Title: Conservation Management

Number of Credits: 3

No. of Lectures-Tutorial: 36-09

Course Coordinator: Dr. Sougata Sadhukhan. Lectures will be conducted by experts from WTI, Forest Department and other organizations.

Pre-requisite

None

Evaluation Procedure : Continuous

Continuous assessment during assignments	40 %	Marking pattern for every assignment: - Evidence of clear line of thinking, written up well - Excellent presentation	Internal Assessment
Major exam	60%		University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1.	Management Plans for Protected Areas Functions of management plan for Protected Areas in India, with goals and objectives; Hierarchies in management planning; Components of a management plan for Protected Areas; Constraints in planning	03	
2.	Habitat Management for wildlife - Silviculture and Habitat Management: Basics of even-aged and uneven-aged silvicultural systems and how silviculture can be used to achieve desired future conditions. - Disturbance Ecology and Habitat Dynamics: Characteristics of disturbances in forest systems as a basis for understanding how silvicultural systems may be adapted to achieve habitat goals. - Managing fire: Implications of wild fire, housing	09	

	developments and other contemporary disturbances and pressures on habitat structure and composition for various wildlife species • Landscape Ecology and Management: Placing habitat management into the larger spatial scale and understanding implications for animal movement and gene flow. • Biodiversity Conservation over Complex Landscapes: How to approach management of multiples species of mixed ownership regions. • Management Effectiveness Evaluation measures for monitoring Protected Areas in India.		
	Assignment 1		3
3.	Conservation Management: (through case studies) Coral Reef management (A case study) Grassland habitat management (A case study) Mangrove habitat management (A case study) The case studies will cover the problems, assessment techniques and strategies used.	09	
	Assignment 2		3
4.	Ecotourism: Definition and historical background; conventional mass tourism, nature tourism and ecotourism; government policies Impacts of tourism: Environmental impacts, social impacts, economic impacts Challenges in setting up ecotourism: cultural settings as a barrier, lack of skills, capacity building, market challenges, community involvement in ecotourism Ecotourism and social justice: Community conservation projects, Ecolodges	09	
	Assignment 3		3
	Total	30	06

Assignment 1: Make a management plan

Your management plan should include:

Species background: What plant and animal species goals are intended for this stand? Are individual species or groups of species to be managed? What are their habitat needs? Over what spatial scale (e.g., nest sites, foraging patches, or home ranges) must they be met? How do these goals complement those for adjacent stands?

Current stand condition: What are the habitat conditions in the stand now for the species that you intend to manage? What factors are limiting habitat suitability for the species? What is the tree and shrub species composition? Site index? Stocking? Existing or possible future regeneration?

Desired future condition: What are the habitat conditions that you would like to produce? Be specific and describe the plant species composition, size classes, basal area, and any predictions of future stand development that you can develop. Stand-growth models are particularly useful for understanding if your desired future condition can be met.

Management actions to achieve the desired future condition: What will you do to the stand now and over time to achieve your desired future conditions? How long do you think it will take to achieve them? How long will they last? How much will it cost?

Monitoring plans: What will you measure and how often will you measure to determine if your management plan was implemented correctly and if the actions were successful? How will you decide if you need to change your management plans?

Budget: What will implementation and monitoring of the plan cost? Regardless of the landowner, cost becomes a factor when implementing a prescription to achieve a goal. There must not be a net loss to most landowners, and there must be maximum profit for some landowners. Understanding the products that can be derived from implementing the prescription, both economic and ecological, can help the manager decide if the trade-offs are acceptable.

Schedule: When will each step of the plan be completed? Of course, the monitoring of stand development may lead to changes in the schedule, but there should be a plan for when actions will occur.

References: Scientific references should be used to support assumptions used in the development of the prescription. Because new information is always becoming available to guide management, it is important to understand why decisions were made at this point in time.

Assignment 2: Preparation of an Ecotourism Plan

Assume any area and prepare an ecotourism plan. The plan must contain the following:

Introduction: Containing background and objectives of the ecotourism venture plan

Description of the proposed ecotourism venture: (day trips, 2 day stay/ 3 day stay. (Specify)

Proposed activities: Provide description of activities mentioned above)

Impact on the Environment (Environment history of the area, land management strategies currently implemented, campsite design, infrastructures, resources, possible negative and positive impacts)

Cultural considerations: History and culture, traditional cultural activities and art, possible negative and positive impacts and management strategies)

Economic and Social Issues: Community support, impact on community, employment and training, possible negative and positive impacts and management strategies)

Health, safety and security of visitors and staff

Quality Assurance certifications

Reference Books and Research Papers

1. Ballantyne, R., Packer, J., 2013. International handbook on ecotourism.
2. Bulbeck, C., 2012. Facing the wild: Ecotourism, conservation and animal encounters. Earthscan.
3. Chauhan, N.P.S., Singh, R., 1990. Crop damage by overabundant populations of nilgai and blackbuck in Haryana (India) and its management.
4. DasGupta, R., Shaw, R., 2017. Participatory Mangrove management in a changing climate. Springer.
5. DasGupta, R., Shaw, R., 2013a. Changing perspectives of mangrove management in India—an analytical overview. Ocean & coastal management 80, 107–118.
6. DasGupta, R., Shaw, R., 2013b. Changing perspectives of mangrove management in India—an analytical overview. Ocean & coastal management 80, 107–118.
7. Datta, D., Chattopadhyay, R.N., Guha, P., 2012. Community based mangrove management: A review on status and sustainability. Journal of environmental management 107, 84–95.
8. Datta, D., Guha, P., Chattopadhyay, R.N., 2010. Application of criteria and indicators in community based sustainable mangrove management in the Sunderbans, India. Ocean & Coastal Management 53, 468–477.
9. Fox, J.L., Sinha, S.P., Chundawat, R.S., 1992. Activity patterns and habitat use of ibex in the Himalaya Mountains of India. Journal of Mammalogy 73, 527–534.
10. Gergel, S.E., Turner, M.G., 2017. Learning landscape ecology: a practical guide to concepts and techniques. Springer.
11. Gopal, R., 1992. Rajesh Gopal's fundamentals of wildlife management.
12. Hosetti, B.B., 2005. Concepts in Wildlife Management. Daya Books.

13. Pickett, S.T., White, P.S., 2013. The ecology of natural disturbance and patch dynamics. Elsevier.
14. Ramakrishnan, U., Coss, R.G., Pelkey, N.W., 1999. Tiger decline caused by the reduction of large ungulate prey: evidence from a study of leopard diets in southern India. *Biological conservation* 89, 113–120.
15. Sathyakumar, S., 2001. Status and management of Asiatic black bear and Himalayan brown bear in India. *Ursus* 21–29.
16. Sawarkar, V.B., 2005. A guide to planning wildlife management in protected areas & managed landscapes. Natraj Publishers.
17. Schaller, G.B., 2009. The Deer and the Tiger: Study of Wild Life in India. University of Chicago Press.
18. Suman, D.O., 2019a. Mangrove management: challenges and guidelines, in: *Coastal Wetlands*. Elsevier, pp. 1055–1079.
19. Suman, D.O., 2019b. Mangrove management: challenges and guidelines, in: *Coastal Wetlands*. Elsevier, pp. 1055–1079.
20. Wearing, S., Schweinsberg, S., 2018. Ecotourism: Transitioning to the 22nd century. Routledge.

COURSE NO: EST 208

Course Title: Climate Change Science And Strategies

Number of Credits:34

No. of Lectures-Tutorial: 36-09

Course Coordinator:

Course Outline

Global climate change is a planetary scale phenomenon that impacts upon all socioeconomic and natural systems. Despite the growing consensus about the fundamentals of climate warming, scientific understanding of the complex interactions of ocean, land, clouds, and atmosphere remains highly uncertain, particularly with respect to environmental, social, and economic disruptions affecting human societies. This course will provide students with the scientific literacy to understand the issue itself and consider existing solutions such as the Kyoto Protocol, voluntary measures, etc. The guiding principle will be to promote the understanding needed to evaluate, develop, and propose emerging and creative solutions at individual, campus, and local levels. This course will examine the dilemmas faced in climate science, politics, economics, management, and ethics – all with an eye to the implications for global and regional sustainability.

Learning Outcomes

The student will be able to:

- Think intelligently about the issue and to understand what processes are currently underway and what more can be undertaken.
- Understand the precarious feedbacks from the climate system that could create dramatic impacts.
- Understand, plan and propose creative solutions at temporal, spatial, political, scientific, and social scale.

Evaluation Procedure: 0.6/0.4 University

Assignments	40 % (3)	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment • Completed home assignment submitted timely and	Assignments must be in the prescribed format. One journal may contain assignments of different elective courses separated by a separator. Index must reflect all	Internal Assessment

		excellent written presentation	the assignments duly signed by the concerned teacher. Marks for every assignment must reflect on the assignment itself.	
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	A	T/E
1	Climate science and impacts • Introduction: overview of the topic • Climate change: cause and effect • Climate disruption • Impact analysis: freshwater sources and oceans • Impact analysis: food and forests • Economic impacts of climate change	10		
	Assignment 1: Discussion and presentation of selected research paper in groups of three students.		05	
2	Policies and market issues • International treaties • Carbon trade and taxation • Strategies for low cost carbon abatement • Climate policy: global scenario • Climate policy: Indian scenario • Green business initiatives	10		
	Assignment 2: Discussion and presentation of selected research paper in groups of three students.		05	
3	Climate solutions • Energy solutions: past and present • Transportation • Building and habitation • Industry and waste management • Land use, agriculture and forestry	15		

	• Adaptation and tropical forest sequestration • Geo-engineering of earth's atmosphere • Smart Cities			
	Assignment 3 : Discussion and presentation of selected research paper in groups of three students.		10	
4	Future direction • Mobilizing the world to action • Trends and futures of food scarcity solutions • Trends and futures of green and clean energy supply and consumption • The negotiating challenges ahead	10		
	Final Assessment			03
	Total	36	09	03

Assignments

In the assignments the students will be expected to express their view on promise and limitations of sustainability ideas and practices for dealing with climate threats. They will also be expected to understand and illustrate the nature of climate controversies and the positions of various stakeholders. The assignments will also help to create an interdisciplinary understanding of climate interactions with human and natural systems.

Suggested Readings

1. Stephen Schneider, Armin Rosencranz, Michael Mastrandrea, eds., 2010. Climate change science and policy. Island Press.
2. Bert Metz, 2010. Controlling climate change, Cambridge University Press.
3. Lester Brown, 2009. Plan b 4.0: mobilizing to save civilization. W.W. Norton.
4. Kerry Emanuel, 2007. What We Know About Climate Change. Boston: Boston Review/MIT Press
5. Tim Flannery, 2006. The Weather Makers. New York: Atlantic Monthly Press
6. Bill McKibben, 2010. Earth. NY: Times Books,
7. David Blockstein and Leo Weigman 2010. The Climate Solution Consensus NCSE/Island Press.
8. Monty Hempel, 1996. Environmental Governance: The Global Challenge. Washington, DC: Island Press.
9. Arnold J. Bloom, 2009. Global climate change: convergence of disciplines. Sinauer Associates.

COURSE NO. GEN 401

Course Title: Entrepreneurship Development

Number of Credits: 2

No. of Lectures-Tutorial-Practical: 15-15

Course Coordinator:

Course Description

This course is designed to help students evaluate the business skills and commitment necessary to successfully operate an entrepreneurial venture and review the challenges and rewards of entrepreneurship. Students will learn about themselves, their decisions, and their goals to determine how entrepreneurship can play a role in their lives. Students will also be introduced to entrepreneurship from an economic perspective and the concepts of environmentally sustainable practices and social entrepreneurship.

Learning Outcomes

On completion of this course, the student will:

- Develop an understanding of personal attributes and skills that characterize the 'successful' entrepreneur.
- Be able to assess and compare their personal characteristics and interests to that of the 'successful' entrepreneur.
- Be able to identify and assess sources of support for small businesses and entrepreneurs. Be able to research and explain issues relevant to entrepreneurs such as 'green' business practices, environmental sustainability.
- Be able to identify the financial, marketing, legal, human resource, operations, and general management skills that are necessary to successfully launch and operate a successful new venture.

Evaluation Procedure: Continuous

Assignment	1	100 %	Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	• Entrepreneurship-Enterprise: Conceptual issues. Entrepreneurship vs. Management. Roles and functions in relation to the enterprise and in	05	

	relation to the economy. Small business as seedbed of Entrepreneurship.		
2	• Opportunity scouting and idea generation: role of creativity and innovation and business research. Sources of business ideas. • Entrepreneur opportunities in contemporary business environment, for example opportunities in net-workmarketing, franchising, business process outsourcing in the early 21 century. • The process of setting up a small business: Preliminary screening and aspects of the detailed study of the feasibility of the business idea and financing/non-financing support agencies to familiarize themselves with the policies/programs and procedures and the available schemes. • Preparation of Project Report and Report on Experiential Learning of successful and unsuccessful entrepreneurs.	05	
	Assignment 1		08
3.	• Issues in small business marketing. The concept and application of product life cycle, advertising and publicity, sales and distribution management. • The idea of consortium marketing, competitive bidding/tender marketing, negotiating with principal customers. • The contemporary perspectives on Infrastructure development, Product and Procurement Reservation, Marketing Assistance, Subsidies and other Fiscal and Monetary Incentives. National state level and grass-root level financial and non-financial institutions in support of small business development.	05	
	Assignment 1		07
	Total	15	15

COURSE NO: GEN 402

Course Title: Soft Skills

Number of Credits: 2

No. of Lectures: 30

Course Coordinator: External Consultants

Evaluation Procedure : Continuous

Assignment	1	50%	Internal Assessment
Assignment	2	50%	Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Introduction to Personality a) Basic of Personality b) Human growth and Behavior c) Theories in Personality d) Motivation Communication skills and Personality Development a) Intra personal communication and Body Language b) Inter personal Communication and Relationships c) Leadership Skills d) Team Building and public speaking	07	
	Assignment 1		4
2	Techniques in Personality development I a) Self confidence b) Mnemonics c) Goal setting d) Time Management and effective planning	07	
3.	Techniques in Personality Development II a) Stress Management b) Meditation and concentration techniques c) Self hypnotism d) Self-acceptance	08	
	Assignment 2		4
	Total	22	8

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BHARATI VIDYAPEETH
(DEEMED TO BE UNIVERSITY)
INSTITUTE OF ENVIRONMENT EDUCATION AND RESEARCH, PUNE

Faculty of Interdisciplinary Studies

Syllabus

M.Sc. (Geoinformatics)

Semester I, II, III, IV

effective from 2019-20



BHARATI VIDYAPEETH (DEEMED TO BE) UNIVERSITY, PUNE

Syllabus for
MASTER OF SCIENCE
M.Sc. in GEOINFORMATICS
Under
FACULTY OF INTERDISCIPLINARY STUDIES

Course Structure and Detailed Syllabus
Semester I, II, III and IV
(UNDER CHOICE BASED CREDIT SYSTEM)
Effective from the Academic Year 2019-2020

This document provides details of the rules and regulations, examination pattern and course details. Students are advised to read it carefully and refer to it from time to time during the course of their study at the Institute of Environment Education and Research, Bharati Vidyapeeth (Deemed to be) University, Pune.

The Bharati Vidyapeeth (Deemed to be) University is a multidisciplinary, multicampus University having 32 institutions imparting quality education in various disciplines. All programs of the University are approved by the University Grants Commission (UGC) and the respective statutory councils. The University has been re-accredited for the third time with an 'A+' grade by the National Assessment and Accreditation Council (NAAC) in 2017. The UGC has accorded the 12B status (UGC Act 1956) to the University. The Ministry of Human Resource Development, Government of India has awarded 'A' category to the University in 2012 based on several parameters that include innovative programs, research and infrastructure facilities. The University has maintained its rank in the top hundred universities of India consistently since 2012 and is presently ranked at 76th position by the National Institution Ranking Framework (NIRF) by the UGC for the year 2019.

The University is a member of the Association of Indian Universities (AIU) and also the International Association of Universities.

The Institute of Environment Education and Research of the Bharati Vidyapeeth (Deemed to be) University, is a constituent unit of the University established in 1993. The Institute is approved by the UGC to conduct post graduate courses in Environment Science, Geoinformatics and Wildlife Conservation Action as well as Doctoral programs in Environment Science and Geoinformatics. The Institute has excellent infrastructure and competent faculty who are nationally and internationally known. Through its collaborations with several international universities the Institute offers international student and faculty exchange programs as well as international internships.

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BHARATI VIDYAPEETH (DEEMED TO BE) UNIVERSITY, PUNE

Faculty Of Interdisciplinary Studies

Course Structure of Master of Geoinformatics (Under Credit System) Effective from 2019-2020

INTRODUCTION

Geoinformatics is the technology for decision support for management of resources and facilities. Due to the highly spatial nature of data handled by a GI system, it is able to provide outputs to facilitate visualization of choices made thus enabling quick and accurate decision making. Geoinformatics is an extended branch of information technology and involves the use of remote sensing, digital image processing, GPS technology, programming, etc. to build a geospatial database that can be queried to get the relevant answers. Geoinformatics combines geospatial analysis and modeling, development of geospatial databases, information systems design. Geoinformatics uses geocomputation and geovisualization for analyzing geoinformation. Many fields benefit from geoinformatics, including urban planning, land use management, in-car navigation systems, environmental modeling and analysis, military, transport network, planning and management, agriculture, meteorology and climate change, oceanography, business location planning, telecommunications, crime simulation, aviation and maritime transport.

The importance of the spatial dimension in assessing, monitoring and modeling various issues and problems related to sustainable management of natural resources is recognized all over the world. Geoinformatics becomes very important technology to decision-makers across a wide range of disciplines, industries, commercial sector, environmental agencies, local and national government, research, and academia, national survey and mapping organizations, International organizations, emergency services, public health and epidemiology, crime mapping, transportation and infrastructure, information technology industries, tourist industry, utility companies, market analysis and e-commerce, mineral exploration, etc.

Many government and non-government agencies have started to use spatial data for managing their day to day activities.

OUTCOMES

At the end of the course, each student will have acquired the following attributes;

1. Disciplinary Knowledge and Interdisciplinarity

Demonstrate disciplinary knowledge from geospatial, data sciences, programming fields and their application in solving problems in the ecological, social and economic fields; Apply systems concepts

and methodologies to analyze and understand interactions between social and environmental processes and the role of geospatial technologies in these issues; Demonstrate appropriate and advanced technical skills in investigating, analyzing and synthesizing information, problems, concepts and theories in various domains.

2. Quantitative Competence

Understand essential mathematical and statistical approaches used to analyse spatial data; design database management systems and data collection protocols; Accurately comprehend and draw appropriate inferences from numeric data, statistical analysis and predictive models; Use state-of-the-art software, hardware and analytical techniques to solve a given problem.

3. Critical Thinking

Demonstrate the capability to apply analytic thought to a body of knowledge; analyze and evaluate evidence, arguments, claims and beliefs on the basis of empirical evidence; formulate coherent arguments; critically evaluate practices, policies and theories following the scientific approach to knowledge development.

4. Problem Solving

Identify problems, evaluate problem solving strategies and develop science based solutions using spatial data; understand the role of spatial data in problem solving; Use acquired knowledge, skills and ingenuity to solve complex problems.

5 . Communication

Clearly communicate complex analyses, interpretations and significance effectively in writing and orally to varied audiences ranging from scientific to policy and the general public; be proficient in contemporary communication tools

6. Multicultural competence

Possess knowledge of the values and beliefs of multiple cultures and a global perspective; capability to effectively engage in a multicultural society and interact respectfully with diverse groups.

7. Moral and ethical awareness/reasoning

Identify ethical issues related to one's work; formulate a position/argument about an ethical issue from multiple perspectives and use ethical practices in their life and career; avoid unethical behavior; adopting objective, unbiased and truthful actions in all aspects of work.

5. Collaboration and Team work

Collaborate in teams with peers and mentors and work with others in diverse group settings, developing flexibility and leadership skills

6. Lifelong learning

Ability to acquire knowledge and skills, including 'learning how to learn' for meeting changing demands

of workplace.

SCOPE

A career in geoinformatics will have a tremendous positive impact on the world. Geoinformatics can be applied in every imaginable discipline and highly paid opportunities exist in several sectors. Career opportunities lie in the field of land resource management, integrated emergency management, water management, disaster management, risk assessment, transportation, urban planning, environment, hydrology, forestry, agriculture, military, mining, business, health, defence, space research, geology and several related fields.

India entered the space age in 1972 with the establishment of the Department of Space and is among the top ten countries of the world in this field. In India we have Space Application Centre at Ahmedabad, the National Remote Sensing Agency in Hyderabad that are the hotbed of geoinformatics research. Besides this, every state has a Regional Remote Sensing Centre. Post graduate holders in Geoinformatics can apply for the post of Jr. Scientist, Scientist, Project Coordinator, Project Scientist, Scientific /Technical Assistant, GIS Programmer, Research Scholar, etc. Besides these the rapidly growing GIS industry with ESRI, Rolta, Intergraph, Wipro, TCS, Infosys, TomTom, Genesys and others recruit regularly where post graduates can start work as Project Manager, Sr. System Executive, System Analyst, GIS Engineer, Image Analyst, GIS Programmer etc.

Jobs also exist in allied institutes working in the field of environment, biodiversity conservation, forestry, landscape studies, water management, health, etc. where geoinformatics is an indispensable tool. There is also a huge demand for geo professionals from countries like Malaysia, Australia, Canada, France, Germany, Netherlands, China, etc. This field has tremendous scope for entrepreneurship and with bank loans being easily available, for the enterprising individual the sky is the limit.

ELIGIBILITY FOR ADMISSION TO THE COURSE

- a. The candidate should have obtained the Bachelors degree in any Science subject such as Botany, Zoology, Chemistry, Physics, Statistics, Geography, Geology, Life Sciences, Environment Sciences, Microbiology, Biotechnology, Fisheries, Marine Biology, Horticulture, Agriculture, Computer Science, Data Science, Veterinary Science, Health Sciences or
- b. any branch of Engineering
- c. any relevant Social Science subjects and Management Studies
- d. The candidate should have secured at least 50% in the aggregate at undergraduate level and 45% for SC /ST / OBC candidates.

DURATION OF THE COURSE

The duration of this course is two years consisting of four semesters. The medium of instructions and examination will be only English.

RULES AND REGULATIONS

1. **Commencement and Conclusion:** The University authorities shall determine the dates for the commencement and conclusion of each semester. Only duly admitted students can keep the terms.

Each semester is of 14 weeks duration. Students must check the academic calendar for exact dates of commencement and conclusion.

Credits: The entire Course is of 111 credits and will be executed in 4 semesters. Semester I and II consist of 27 and 30 credits respectively while Semester III and Semester IV consist of 30 and 24 credits respectively. One credit for the theory course is equivalent to 15 hours of interaction of student with facilitator, while one credit for the practical course is equivalent to 30 hours of practical work or 30 hours of field work.

2. The curriculum comprises of Core (Hard and Soft) and Value Added Courses. All Core courses are compulsory while the Value Added Courses are elective.
3. The Core courses are aimed at providing fundamental knowledge and skills relevant to the discipline while the Value Added Courses intend to develop relevant skills.
4. The respective elective course will be implemented only if atleast seven students enroll in the course.
5. Some of the core courses are common in the three Master's programmes: M.Sc. Environment Science and Technology, M.Sc. Geoinformatics, M.Sc. Wildlife Conservation Action.
6. The teaching and evaluation for these courses will be combined for both disciplines.
7. All hard core courses will be evaluated by the University Examination.
8. Four extra credit will be awarded to the student if there is any significant outcome (paper in Scopus or Web Of Science) indexed journals. The research outcome in terms of publication in indexed national / international journal; filing of patent will be considered for the award of credits. The number of students for each elective should not be less than five.
9. **Dissertation:** The student will undertake dissertation in Semester III and continue the same in Semester IV for which 24 credits have been allotted. The topic for the research must be finalized by the end of Semester II after thorough literature review in consultation with your allotted guide.
10. **Field Visits:** The field / industrial / academic Institute visits will be organized for demonstration of advance experimental techniques wherever necessary along with the courses. Attendance for these are mandatory and form part of internal assessment as indicated in the syllabus.
11. **Internship:** The student must complete an internship of maximum six months duration (minimum five months duration) in semester IV which will entail 10 credits. It is mandatory for students to attend the mid internship assessment. Formats of submission of internship report are attached in the relevant section of this document for reference. Students should submit their reports in these formats only.
12. **Attendance:** A student must attend every lecture, tutorial, and practical class. However, to account for late admission, sickness, or other such contingencies, the attendance requirement will be a minimum of 75% of the classes actually held. A student must have minimum 75% attendance in theory and 100% attendance in the practical courses to fulfill the term. A student who does not have the required attendance (less than 75%) will not be allowed to appear for the Continuous Assessment.

A student with less than 75% attendance in a course during the semester, in lectures, tutorials, and practical's taken together (as applicable), will be debarred from taking the final test/examination in the course and will be awarded an Ab. grade.

If a student remains absent for more than 50 percent of the term due to illness as reported by a licensed medical practitioner, the student will have to repeat the term. Application for medical leave should be supported with test reports, hospitalization reports, prescriptions and certificate from a registered practitioner). The registration number of the medical practitioner should explicitly appear on the medical certificate. These will be reviewed by the management and it management retains the right to grant/ refuse the medical leave.

In order to maintain the attendance record of a particular course, course coordinators will record attendance in every scheduled lecture, tutorial, and practical class.

13. Leave Rules

Leave may be granted to students only in exceptional cases on approval of the Head of the Department/ Director. However, the period of leave would count as absence for the attendance requirements for a course.

A student must inform in writing/through an e-mail to the Course Coordinator with a copy to the administration office immediately of any instance of continuous absence from classes.

14. Maximum duration of the course

The student must complete all four semesters in a maximum of four years, failing which he/she will have to re-register for the course.

RULES FOR EXAMINATION

A. Nature of Examination

- i. Examination for the theory and practical courses will be conducted at the end of each respective semester or as continuous assessment as indicated in the syllabus.
- ii. Each course will have 40% marks for internal assessment and 60% marks for semester end examination.
- iii. The Internal Assessment (IA) will be conducted by the Institute and the end-of-the-term University Examination (UE) will be conducted by the University. The UE will be based on the entire syllabus. The internal assessment will be conducted throughout the semester in the form of tests/tutorials/seminars/oral presentations/assignments/debates, etc. as indicated in the syllabus.
- iv. Internal assessment for the practical course is through continuous assessment. Each practical is evaluated for fifteen marks. Of this, performance in the class is assessed for five marks and

timely journal submission (within a week of the practical being conducted) as per instructions given by the concerned teacher is assessed for ten marks. The aggregate of the practical assessment will be averaged to 40 marks. Practical's missed by the student, need to be completed by the student themselves before appearing for the final examination.

- v. The general courses will be evaluated by the instructor on the basis of continuous assessment as indicated in the syllabus.

B. Ethical standards during the Examination

- i. The University maintains high ethical standards during examinations and there is a zero-tolerance policy in place regarding cheating and use of any unfair means in the examinations. The entire institution is under camera surveillance including classrooms and laboratories. Anyone found to be using unfair means will face a Disciplinary Committee immediately. Punishments for use of unfair means includes expulsion from the University.
- ii. The students shall occupy the seats allotted to them by the concerned Invigilator.
- iii. The student must be present inside the hall ten minutes before the commencement of the exam. Students coming late will be debarred from attending the examinations.
- iv. Students are not permitted to leave the examination hall during the examination period. However, in a very exceptional case, if the faculty invigilator allows such leave; a candidate not returning within 5 minutes shall be liable to cancellation of her/his paper.
- v. During the Continuous and University examinations, students are permitted to carry a transparent writing support pad, and a transparent pouch for pens, pencils, eraser. Calculator is permitted if needed. All books and notes, electronic gadgets including cell-phones, i-pads, i-pods, tablets, laptop, etc. must be deposited outside the classroom. Pockets must be empty during the exam.
- vi. Every candidate is expected to observe silence, decorum and abide by the instructions given by the faculty on invigilation during the examination.
- vii. Talking or discussing among themselves or sharing answers/hints in any form shall be punishable and will lead to disciplinary action.
- viii. Mobile phones are not allowed in the examination hall. Students have to switch off the mobile and submit it to the invigilator or put in the bags. Mobile phones should not be available with students or on their respective desk.
- ix. Internet access is not allowed during examination time.
- x. In addition to above, the students must adhere to any additional instructions from the supervisors from time to time.

STANDARD OF PASSING

A . Grading System

- i. A 10 point absolute grading system will be adapted for grading each head of passing. The details are given in the table below:

Table 1: The grading system under CBCS

Range of Marks (Out of 100)	Grade	Grade Point
$80 \leq \text{Marks} \leq 100$	O	10
$70 \leq \text{Marks} < 80$	A+	9
$60 \leq \text{Marks} < 70$	A	8
$55 \leq \text{Marks} < 60$	B+	7
$50 \leq \text{Marks} < 55$	B	6
$40 \leq \text{Marks} < 50$	C	5
Marks < 40	D	0

- ii. The grade point average (GPA) for a course shall be calculated by first finding the total marks out of 100 for the course. The corresponding GP (as per Table 2) shall be the GPA for the course.
- iii. Two kinds of performance indicators, namely the Semester grade Point Average (SGPA) and the Cumulative Grade Point Average (CGPA) shall be computed at the end of each term. The SGPA measures the cumulative performance of a learner in all the courses in a particular semester, while the CGPA measures the cumulative performance in all the courses upto and including the current semester. The CGPA of a student when he/she completes the programme is his/her final result.
- iv. The SGPA is calculated by the $\text{SGPA} = \frac{\sum C_k \times \text{GPA}_k}{\sum C_k}$ formula, where C_k is the
- v. credit value assigned to a course and GPA_k is the GPA obtained by the student in the course. In the above, the sum is taken over all the courses that the student has undertaken for the study during the semester, including those in which he/she might have failed or those for which he/she remained absent. The SGPA shall be calculated upto two decimal place accuracy.
- vi. The CGPA is calculated by the formula, $\text{CGPA} = \frac{\sum C_k \times \text{GPA}_k}{\sum C_k}$ where C_k is the credit value
- vii. assigned to a course and GPA_k is the GPA obtained by the student in the course. In the above, the sum is taken over all the courses that the student has undertaken for the study from the time of his/her enrolment and also during the semester for which CGPA is calculated, including those in which he/she might have failed or those for which he/she remained absent. The CGPA shall be calculated upto two decimal place accuracy.

- viii. The CGPA, calculated after the minimum credits specified for the program are 'earned' and will be the final result. Grace marks of 1, 2 or 3 may be awarded to a candidate at UE as per the rules of the University.

B. Standards of Passing and ATKT Rules

- i. For all courses, both UE and IE constitute separate heads-of-passing (HoP). In order to pass in such courses and to 'earn' the assigned credits
 - o The learner must obtain a minimum grade point of 5.0 (40% marks) at UE and also a minimum grade point of 5.0 (40% marks) at IA;

OR

 - o If he / she fails in IA, the learner passes in the course provided he / she obtains a minimum of 25% in IA and GPA for the course is atleast 6.0 (50% in aggregate). The GPA for a course will be calculated only if the learner passes at the UE. The following examples illustrate this rule for passing in a course under.
- ii. A student who fails at UE in a course has to reappear only at UE as a backlog candidate and clear the HoP. Similarly, A student who fails in a course at IA has to reappear only at IA as a backlog candidate and clear the HoP.
- iii. A candidate shall be permitted to proceed further from the First Semester upto the Fourth Semester irrespective of his/her failure in any of the above semester examinations subject to the conditions that the candidates should register for all the backlog courses of the earlier semesters alongwith current (subsequent) semester courses.

Table 2: Illustration of Passing Rule specified

Case No.	UE Marks Out of 60	IA Marks Out of 40	Total Marks Out of 100	GP of UE	GP of IA	GPA	Remarks
1	24	16	40	5.0	5.0	5.0	Pass
2	40	10	50	7.0	0	6.0	Pass
3	40	06	46	7.0	0	5.0	Fails at IA
4	20	40	--	0	10.0	0	Fails at UE
5	34	12	46	7.0	0	5.0	Fails at IA
6	20	15	--	0	0	0	Fails at both UE & IA

C. Award of Honours

A student who has completed the minimum credits specified for the program shall be declared to have passed in the programme. The final result will be in terms of letter grade only and is based on the CGPA of all courses studied and passed. The criteria for the award of honours are given below.

Table 3: Criteria for the award of honours at the end of the program

Range of CGPA	Final Grade	Performance Descriptor	Equivalent Range of Marks (%)
$9.50 \leq \text{CGPA} \leq 10.00$	O	Outstanding	$80 \leq \text{Marks} \leq 100$
$9.00 \leq \text{CGPA} \leq 9.49$	A+	Excellent	$70 \leq \text{Marks} < 80$
$8.00 \leq \text{CGPA} \leq 8.99$	A	Very Good	$60 \leq \text{Marks} < 70$
$7.00 \leq \text{CGPA} \leq 7.99$	B+	Good	$55 \leq \text{Marks} < 60$
$6.00 \leq \text{CGPA} \leq 6.99$	B	Average	$50 \leq \text{Marks} < 55$
$5.00 \leq \text{CGPA} \leq 5.99$	C	Satisfactory	$40 \leq \text{Marks} < 50$
CGPA Below 5.00	F	Fail	Marks Below 40

PATTERN FOR ASSESSMENT

A. Pattern of Evaluation for Internal Assessment of Theory Courses

The weightage for Internal Assessment is 40%. Students of IA of every theory course will be assessed for a total of 40 marks for a 3 credit course for 20 marks for a 2 credit course which will be cumulative marks obtained in two/three separate assessments as specified in the individual course.

In case of hard core courses, the pattern will be as below:

- Two internal written examinations for 20 marks each for 3 credit courses. Average of the two tests will be considered.
- Two assignments of ten marks each as given by the concerned teachers. A total of the two assignments will be considered.

In case of soft core (electives), the pattern will be as below:

- One written examinations for 60 marks each for 3 credit courses.
- Three assignments of a total of 40 marks (10 + 10 + 20) given by the concerned teachers. A total of the three assignments will be considered.

B. Pattern of Evaluation for Internal Assessment of Practical Courses

The Internal Assessment for every practical course will be of 40 marks for 2 credits. The students for IA will be assessed on the basis of:

- Performance for every practical: 5 marks each for every practical
- Assignment: Timely submission of assignment with accuracy: 10 marks

The marks obtained in all the practical's will be added and averaged to out of 40.

C. Pattern of Evaluation of General Courses

- i. The Internal Assessment of General Courses for 2 credits will be done through two assignments, each of 25 marks.
- ii. For those with 3 credits along with continuous assessment as indicated in B (a and b) above, an end term examination of 60 marks will be conducted internally.

D. Pattern of question paper at the University Examination

University examination of 3 credit theory course will be of 60 marks.

The question paper will comprise of 6 questions. Any four questions may be answered from Q1 to Q5, while Q6 is compulsory. Q1 to Q5 will have two sub questions of 6 marks each. Q6 will comprise of three short notes of 4 marks each. The pattern of the question paper is given below.

Pattern of question paper for 3 credit course of University Theory Examination of M.Sc. Geoinformatics 2019 CBCS Course

Total marks: 60

Time: 3 Hours

Question paper pattern for all courses.

Q6 is mandatory and students will answer any four of the remaining five questions.

Q.1	a		(06)
	b		(06)
Q.2	a		(06)
	b		(06)
Q.3	a		(06)
	b		(06)
Q.4	a		(06)
	b		(06)
Q.5	a		(06)
	b		(06)
Q.6.		Write short notes on any three of the following	(12)
	a		

	b		
	c		
	d		

Pattern of question paper of University Practical Examination of M.Sc. Geoinformatics 2019 CBCS course

Total marks: 60 for 2 credit courses Time: 3 Hours

Q.1	Major Practical	(25)
Q.2.	Minor exercise	(15)
Q.3.	Minor exercise	(10)
Q.4.	Viva	(10)

IMPORTANT INSTRUCTIONS FOR STUDENTS

- Read carefully the entire Syllabus, making sure that all aspects of the course are clear to you, ie. Structure of the program, electives, details of assignments, internal and external examinations systems, marking systems, grading, attendance requirements as well as rules and regulations.
- Course coordinators are liable to change from those mentioned. Students will be informed about the change if any before the commencement of the semester.
- Familiarize yourself with the library and online resources for maximizing your learning experience. Be a self motivated learner.
- Faculty are always willing to accommodate interested and exceptional students in their on going research. If you are interested in volunteering your time on any of the projects to gain valuable work experience, do get in touch with them.
- Make sure that all assignments are submitted on time. Late submission of assignments may result in loss of a certain percentage of marks or rejection of your assignment.
- Every practical journal must be completed in the stipulated time.

Academic Integrity

Bharati Vidyapeeth University is committed to maintaining academic quality, excellence, and honesty. All faculty and students are expected to share the commitment to academic integrity, an essential component of a quality academic experience.

Students are expected to read and follow all policies, procedures, and program information guidelines contained in publications; pursue their learning goals with honesty and integrity; demonstrate that they are progressing satisfactorily and in a timely fashion by meeting course deadlines and following outlined procedures; observe a code of mutual respect in dealing with mentors, staff, and other students; behave in a manner consistent with the standards and codes of the profession in which they are practicing; keep official records updated regarding changes in name, address, telephone number, or e-mail address.

Payment of fees

Fees for the first term must be paid at the time of admission. Fees for the second term and fourth must be paid before 30 October of the same year. Fees for the third semester must be paid before 30 May. Students must meet financial obligations in a timely manner. The admission process for the term is not complete without payment of fees. If a student fails to pay the fees, the name of the concerned student will not reflect in the list of admitted students, affecting the attendance. Such a student will not be permitted to attend either the continuous / internal / external examination.

Academic Dishonesty

All students are expected to approach their education with academic integrity. Academic dishonesty undermines this objective. Academic dishonesty can take the following forms:

- Cheating
- Gaining or providing unauthorized access to examinations or using unauthorized materials during exam administration
- Submitting credentials that are false or altered in any way
- Plagiarizing (including copying and pasting from the Internet without using quotation marks and without acknowledging sources)
- Forgery, fabricating information or citations, or falsifying documents

- Submitting the work of another person in whole or in part as your own (including work obtained through document sharing sites, tutoring schools, term paper companies, or other sources)
- Tampering with the academic work of other students

Plagiarism

Plagiarism, is using the work and ideas of others without proper citation. This is strictly prohibited in all assignments and dissertation. Students should check their assignments through online antiplagiarism softwares (Eg. Grammarly, etc) before submission. Students are liable to lose marks or may find that their work is not assessed when they submit plagiarized content.

Plagiarism defeats the purpose of education. If you plagiarize, you are not educating yourself, and you are wasting your time on courses meant to improve your skills.

SEMESTER WISE COURSE INFORMATION

Semester I

Course Number	Course Title	Credit Value	Hours per week	Weightage UE	Weightage IA	EoTM
	Core Courses					
GEO101	Fundamentals of remote sensing	3	3	60	40	University
GEO 102	Fundamentals of Geoinformatics	3	3	60	40	University
GEO 103	Fundamentals of programming	3	3	60	40	University
EST 101	Ecosystem Studies	3	3	60	40	University
EST 306	Urban Environment Management	3	3	60	40	University
EST 111	Field techniques –I	2	3	60	40	University
GEO 111	Techniques in image interpretation and remote sensing	2	3	60	40	University
GEO 112	Techniques in Geographical Information Systems	2	3	60	40	University
	Pre-requisites					
EST 104	Basic Statistical Methods	3	3		100	Continuous
EST 105	Introduction to Data Analysis	3	3		100	Continuous
	Total	27	30			

From the core courses:

Course Nos GEO 101, GEO 102, Geo 103, EST 101, EST 306 are theory courses

Course Nos EST 111, GEO 111, GEO 112 are practical courses

Total credits offered in Semester I : 27

Semester II

Course Number	Course Title	Credit Value	Hours per week	Weightage UE	Weightage IA	EoTM
	Core Courses					
GEO 201	Geodatabase Management	3	3	60	40	University
GEO 202	Advanced Remote Sensing	3	3	60	40	University
GEO 203	Digital Image Processing	3	3	60	40	University
GEO 204	WebGIS	3	3	60	40	University
GEO 205	Research Methodology	2	2		100	Continuous
GEO 211	Techniques in database management	2	3	60	40	University
EST 212	Techniques in digital image processing	2	3	60	40	University
GEO 213	Programming for GIS-I	2	3	60	40	University
GEO 214	Field Work	2	60 (cumulative)		100	Continuous
	Electives (any two)					
EST 201	Biodiversity assessment and conservation	3	3		100	Continuous
EsT 206	Natural resource management	3	3		100	Continuous
EST 207	Health GIS	3	3		100	Continuous
EST 208	Climate change science and strategies	3	3		100	Continuous
EST 209	Data Analysis with R	3	3		100	Continuous
	General Courses (any					

	one)					
GEN 201	General English	2	2		100	Continuous
GEN 202	Project Management	2	2		100	Continuous
	Total	30	31			

From the core courses:

Course Nos GEO 201, GEO 202, GEO 203, GEO 204, are theory courses

Course Nos GEO 211, GEO 212, Geo 213, GEO 214 are practical courses

Total Credits offered in Semester II : 30

Semester III

Course Number	Course Title	Credit Value	No. of Hours/ week	Weightage UE	Weightage IA	EoTM
	Core Courses					
GEO 301	Spatial analysis and modeling	3	3	60	40	University
GEO 311	Programming for GIS-II	3	3	60	40	University
GEO 312	Dissertation	12	14	60	40	University
GEO 313	Programming for GIS-III	2	3	60	40	University
GEO 314	Techniques in Spatial Statistics, Analysis and Modeling	2	3	60	40	University
	Electives (any two)					
GEO 302	Geospatial Modeling	3	3		100	Continuous
GEO 303	Applications of geospatial technologies	3	3		100	Continuous
GEO 304	Photogrammetry	3	3		100	Continuous
GEO 305	Water management and Geospatial Technologies	3	3		100	Continuous
	General Courses (any one)					
GEN 301	Technical Writing	2	2		100	Continuous
GEN 302	Soft Skills	2	2		100	Continuous
	Total	30	34			

From the core courses:

Course Nos GEO 301 is a theory course.

Course Nos GEO 311, GEO 313, GEO 314 are practical courses

Total Credits offered in Semester III : 30

Semester IV

Course Number	Course Title	Credit Value	Hours per week	Weightage UE	Weightage IA	EoTM
	Core Courses					
GEO 411	Dissertation	12	14	60	40	University
GEO 412	Internship	10	20	60	40	University
	General Courses (any one)					
GEN 401	Entrepreneurship Development	2	2		100	Continuous
	Total	24	36			

Total Credits offered in Semester IV : 24

SEMESTER I

COURSE NO: GEO 101**Course Title:** Fundamentals of remote sensing**Number of Credits:** 03**No. of Lectures-Tutorial:** 36-06**Course Coordinator/ Instructor:** Dr. Aravinth R**Course Outline**

The course deals with the fundamentals of remote sensing, introduction to various satellites and introduces the participant to the basic concepts and the operational skills necessary to acquire remote sensing data and extract geo-information from them.

Learning Outcomes

The student should develop:

- A firm understanding of the various remote sensing systems
- Understand the basic principles of remote sensing.
- Acquire skills to interpret satellite imagery and choose imagery for specific applications.

Pre-requisite

None

Evaluation Procedure : Evaluation Procedure: 60/40: University Exam / Internal Assessment

Assignment	2	20%	Internal Assessment
Minor Test	1	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Introduction Definition and concept of remote sensing Components of remote sensing, natural remote sensing, artificial remote sensing, passive and active remote sensing Platforms of remote sensing-aircraft, satellites Remote sensing data collection: The remote sensing process-statement of the problem, identification of	10	

	in-situ and remote sensing data requirements, remote sensing data acquisition and analysis, reference data Applications of remote sensing in various fields such as forestry, mining, watershed, urban planning, agriculture and advantages and limitations of remote sensing Details of Earth Resource Satellites operating: • LANDSAT Series • SPOT series • IRS series • Meteorological satellites Ocean monitoring satellite		
2	Physics of remote sensing Conduction, convection and radiation Electro radiation models (Wave model of electromagnetic energy, the Particle Model-Radiation from atomic structures) Energy-matter interactions in the atmosphere (Refraction, scattering and absorption, reflectance) Atmospheric windows and types of remote sensing systems Energy matter interactions with the terrain (hemispherical reflectance, absorptance and transmittance, spectral reflectance of vegetation, water body and soil spectral response patterns) Radiant Flux Density (Irradiance and radiance exitance) Energy-matter interactions at the sensor system (target and path radiance) An ideal remote sensing system, characteristics of real remote sensing system	4	
3	Fundamentals of aerial photography Classification of aerial photography on the basis of orientation of camera axis, types of cameras (metric	10	

	and non-metric). Scale of aerial photography, photographic resolution, Stereoscopic photography (flight planning, discrepancies-TIP, TILT, DRIFT, CRAB), parallax, neat model. Geometric characteristics of aerial photographs-terms, symbols and definitions Comparison between aerial photography and topographic map (scale, relief, displacement, tilt, optical distortion, paper and film distortion) Measurement of scale and height on aerial photographs Photorecognition elements Digital elevation model, orthophotos		
	Assignment 1 Discussion and presentation of selected research paper in groups of two students.		4
4	Elements of visual interpretation Factors governing the interpretability, elements of image interpretation with examples Methods of search: Use of collateral information, convergence of evidence, the multi concept	6	
5	Sensors and remote sensing data products Quality of image in optical systems, imaging mode, photographic cameras, television cameras, multi-spectral imaging sensors (optical-mechanical scanners and optical –electronic scanners, modular optoelectronic multispectral/stereo scanner, whisk broom, and push broom scanner, multispectral/hyperspectral scanners) Operating principles of across and along track scanning with examples Geometric characteristics of across track and along	8	

	track scanner imagery Data formats, ground segment organization, data product generation, referencing scheme, data products output medium (photo products and digital products)		
	Assignment 2 Seminar presentation by individual students on predecided topics.		5
6	Thermal Infrared Remote Sensing Thermal infrared radiation properties Thermal infrared atmospheric windows Thermal radiation laws (Stefan-Boltzmann Law, Wien's Displacement Law, Emissivity, Kirchoff's law) Thermal properties of terrain Thermal infrared data collection-types of sensors Thermal infrared environmental considerations Applications of thermal remote sensing	6	
	Minor Test 1		1
	Total	42	18

Suggested Readings

1. Askne Jain, Sensors and Environmental Applications of Remote Sensing, A. A. Balkeme Publishers, 2005.
2. Ramasamy S. M., Remote Sensing in Water Resources, Rawat Publications, 2005.
3. Joseph George, Fundamentals of Remote Sensing, Universities Press (India) Private Limited, 2004.
4. Lillesand T. M., Kiefer R. W, Remote Sensing and Image interpretation, John Wiley & Sons Inc, 2000.
5. Campbell James, Introduction to Remote Sensing, Taylor & Francis London.
6. Agarwal C.S, Textbook on Remote Sensing, Wheeler A. H., 2000

7. Agarwal C.S., Garg, P. K., Remote Sensing, A. H. Wheeler and Co. Ltd., New Delhi, 2000.
8. Jensen, John R., Remote Sensing of the Environment: An Earth Resource Perspective, 2009, Prentice Hall

COURSE NO: GEO 102**Course Title:** Fundamentals of Geoinformatics**Number of Credits:** 36-06**Course Coordinator/Instructor:** Dr. Shamita Kumar**Course Outline**

The course provides a firm understanding of the conceptual and technical issues of geospatial technologies and an overview of applications in various aspects of wildlife, natural resource management, environment management, etc. It introduces the students to the fundamentals of geographic information systems, navigation systems, data models, data sources, cartography as well as multi-criteria analysis.

Learning Outcomes

Students will:

- Demonstrate a good understanding of the basics of geospatial technologies
- Demonstrate an understanding of building geo-databases.
- Develop abilities to think about and implement geographic data management and analysis for research and a variety of planning and management applications.

Pre-requisite

None

Evaluation Procedure : Evaluation Procedure: 60/40: University Exam / Internal Assessment

Assignment	2	20%	Internal Assessment
Minor Test	1	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Introduction to Geoinformatics • Introduction to the concept of geoinformatics and its applications	03	
2	Geographic data and data measurement • Data types and scales of data measurement, sampling methods Map basics • History of cartography, basic characteristics of maps, categories of maps, map scale	06	

	• Typography and lettering the map, elements of generalization-classification, simplification and exaggeration, symbolization-point, line, area, volume • Nature of geographic phenomena and measurement of geographical variables Basic geographic concepts Basic geodesy: Spherical, ellipsoidal and geoidal earth, geographical co-ordinates, Co-ordinate systems: Plane co-ordinate system, Geographic co-ordinate system • Map projections: Scale factor and transformation, distortions resulting from map transformations, properties of map projections, classification of map projections, aspects of map projections, some commonly used projections, selection of a particular projection, geo-referencing, relationship between co-ordinate systems and map projections • Geodetic datum-concept and types		
3	Data Models, data structures and data input • GIS data models: Raster data models-nature, characteristics of raster data, principles of raster data compression • GIS data models: Vector and raster data models-nature, characteristics • Concept of topology, topological relationships between spatial objects • Data input (raster and vector), metadata, data sources for GIS, input of methods of data input, digitization, error identification, types and sources of errors, correction, data editing, topology building.	06	
	Assignment 1 Discussion and presentation of selected research paper in groups of 2/3 students.		3
4	Global Navigation Satellite Systems (GNSS) • Introduction, GNSS segments, GNSS satellite generations, current GNSS satellite constellation working principle • GNSS working principle, GNSS signal structure, types of GNSS receivers, pseudorange measurements, carrier phase measurements, cycle slips • GNSS errors and biases • Methods of GNSS observations • GNSS applications	06	
4.	Database Management		

	• Introduction to database and database management systems, importance of databases in GIS • Database structures • Database data models: Hierarchical model, network model, relational database model, object oriented data model • Database creation, linking spatial and attribute data, GIS database applications	03	
	Assignment 2 Critical review of research paper / Video poster		5
5.	Data analysis • Measurements • Queries • Buffering and neighbourhood functions • Map overlay • Spatial analysis • Multicriteria analysis • Network Analysis	06	
6.	Application of Geoinformatics • Applications in forestry and wildlife management • Applications in mining • Applications in urban planning • Applications in disaster management • Applications in health studies • Business applications	03	
7.	GIS project design and management • Identify the problem and its geospatial component • Data and data sources; GIS operations, spatial analysis.	03	
	Minor test 1		1
	Total	36	09

	- History of cartography, basic characteristics of maps, categories of maps, map scale - Typography and lettering the map, elements of generalization-classification, simplification and exaggeration, symbolization-point, line, area, volume - Nature of geographic phenomena and measurement of geographical variables Basic geographic concepts Basic geodesy: Spherical, ellipsoidal and geoidal earth, geographical co-ordinates, Co-ordinate systems: Plane co-ordinate system, Geographic co-ordinate system - Map projections: Scale factor and transformation, distortions resulting from map transformations, properties of map projections, classification of map projections, aspects of map projections, some commonly used projections, selection of a particular projection, geo-referencing, relationship between co-ordinate systems and map projections - Geodetic datum-concept and types		
3	Data Models, data structures and data input - GIS data models: Raster data models-nature, characteristics of raster data, principles of raster data compression - GIS data models: Vector and raster data models-nature, characteristics - Concept of topology, topological relationships between spatial objects - Data input (raster and vector), metadata, data sources for GIS, input of methods of data input, digitization, error identification, types and sources of errors, correction, data editing, topology building.	06	
	Assignment 1 Discussion and presentation of selected research paper in groups of 2/3 students.		3
4	Global Navigation Satellite Systems (GNSS) Introduction, GNSS segments, GNSS satellite generations, current GNSS satellite constellation	05	

	working principle • GNSS working principle, GNSS signal structure, types of GNSS receivers, pseudorange measurements, carrier phase measurements, cycle slips • GNSS errors and biases • Methods of GNSS observations • GNSS applications		
4.	Database Management • Introduction to database and database management systems, importance of databases in GIS • Database structures • Database data models: Hierarchical model, network model, relational database model, object oriented data model • Database creation, linking spatial and attribute data, GIS database applications	04	
	Assignment 2 Critical review of research paper (individual assignment) OR as given by the faculty		4
5.	Data analysis • Measurements • Queries • Buffering and neighbourhood functions • Map overlay • Spatial analysis • Multicriteria analysis • Network Analysis	07	
6.	Application of Geoinformatics • Applications in forestry and wildlife management • Applications in mining • Applications in urban planning • Applications in disaster management • Applications in health studies • Business applications	03	

7.	GIS project design and management - Identify the problem and its geospatial component - Data and data sources; GIS operations, spatial analysis.	03	
	Minor test 1		1
	Total	36	09

Suggested Readings

1. Burrough P. A., R. A MacDonneli, Principles of Geographical Information Systems, Oxford University Press, 2000.
2. Lo. C. P., A.W. Yeung, Concepts and Techniques of Geographical Information Systems, Prentice- Hall of India Pr. Ltd., 2002.
3. Heywood I., S. Cornelius, S. Carrer, An Introduction to Geographical Information Systems, Pearson Education Pvt. Ltd, 2002.
4. Kang-stung-Chang, Introduction to Geographical Information System, Tata McGraw Hill Pub. Comp, 2002.
5. Demers M.N, Fundamentals of Geographic Information Systems, John Wiley & Sons, 2000.
6. Roy P.S., Dwivedi R.S., Vijayan D., 2010 Remote Sensing Applications National Remote Sensing Centre, India
7. Reddy, M.A., 2008. Textbook of remote sensing and geographical information systems. BS publications.
8. El-Rabbany, A., 2002. Introduction to GPS: the global positioning system. Artech House.
9. Arthur Robinson, H., 1958. Elements of cartography, John Wiley and Sons Inc.

Websites (as mentioned from time to time

in class) Journals

1. International Journal of Geoinformatics
2. International Journal of Remote Sensing
3. ISPRS Journal of Photogrammetry and Remote Sensing
4. Journal of Indian Society of Remote Sensing

COURSE NO: GEO 103**Course Title:** Fundamental of Programming**Number of Credits:** 4**No. of Lectures-Tutorial:** 36-07-02**Course Coordinator/ Instructor:** Mr. Anand Shinde**Course Outline**

The course focuses on the essential concepts and skills related to computer programming. This includes understanding of various programming technique.

Learning Outcomes

- Basic understanding of the concepts of programming structure
- Understanding of correct and efficient ways of solving problems.
- Ability to write and execute programming in C++.

Pre-requisite

Students are encouraged to complete the following free online course: <https://www.edx.org/course/programming-basics-iitbombayx-cs101-1x>

Evaluation Procedure

Assignment	2	20%	Internal Assessment
Minor Test	1	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Introduction to programming Structure of CPU Planning the computer program, Purpose Introduction to programming, Developing a Program, Exceptions and errors Basic features programming Language like Identifier, Keywords, Variable, data types, Operators and Expression.	6	
2	Algorithm	4	

	Key features of an Algorithm, What are variables Different ways of stating Algorithms		
3	Flowcharts Standards for flowcharts Symbols used for flowcharts Guidelines for drawing flowcharts. Advantages and Limitations of using flowcharts Understanding programming using flowcharts	4	
	Assignment 1 Students will be allotted case studies for building algorithms and flowcharts which will be presented in class.		3
4	Introduction to Query language DML DDL DCL	4	
5	Number systems Number Representation Decimal and Binary Numbering System– Number system conversions ASCII & Unicode Compiler and Interpreter, Assembler, Linker and Loader	4	
6	Control Structures Decision control structures Logical operators Conditional operator and relational operators Loop control structures-While, do-while, for loop, Break statement and Continue statement Switch-case control structure. Test Conditions, Conditional execution and selection, Iteration and Repetitive Executions, Nested loops.	3	

7	Arrays Introduction to contiguous data types. One dimensional arrays Multidimensional arrays Array as strings Multidimensional character arrays Operations on strings.	2	
8	Functions Built-in and user-defined Function declaration Definition and function call Parameter passing: call by value, call by reference, recursive functions	3	
9	Searching and Sorting Linear and Binary Search Bubble, Heap and Merge		
	Assignment 2 Hands on exercise on programming concepts and numbering system		3
	Minor test 2		2
10	Introduction to OOP Basic Concepts of OOP Applications of OOP. Introduction to C++ Introduction to C++ Declarations in C++, Creating New data types in C++, function Prototypes, Inline functions, Reference Parameters Dynamic memory allocation, default arguments	5	
11	Class, Objects and Constructors Introduction,	5	

	Comparing class with Structure, Class Scope, Accessing Members of a class, Constructor, Destructor, This pointer Data abstraction and Information hiding Container classes and Iterators		
12	Overloading & Inheritance Operator Overloading, Restrictions, Insertion and stream extraction operators, Introduction to Inheritance, multiple inheritance Protected members Overloading Base class members in a Derived class, Public, Protocols and Private inheritance, Direct base classes and Indirect Base Classes, Using Constructors and Destructors in Derived classes,	5	
	Minor test 1		2
	Total	45	15

Suggested Readings

- Stanley B. Lippman , C++ Primer Fourth Edition, 2007, Pearson Education
- H.M. Harwani, C++ for Beginners , 2009, Sharaff Publication
- Lndrey Ullman, C++ Programming, 2007, Person Education Pvt. Ltd.
- Madhusudan Mothe, C. For Beginners, 2009, B.P.B. Publication Navi Mumbai
- Balguruswami E., Programming in C++, 2010, Tata Mc Graw Hill
- Yeshavant Kanetkar Asang Dani, Let Us C++, 2010, B.P.Bpublication New Delhi
- Robert J Oberg , Introduction to c++ Using Net, 2002, Pearsun Education Singapur Ltd.
- Herbert Schildt, The complete reference C++ 4.0, 2010, Tata Mc Graw Hill
- Herbert Schildt A., Beginness Guide C++ 3.0, Tata Mc Graw Hill
- Tom Archer Andrew, Inside C++ 2 , 2007, A.P. Publishing Pvt. Ltd.
- Rohan White, How computers work, 2002, Techmedia Publication
- Paul Wilton Johncolby, Beginning SQL, 2005, Wiley Publishing Inc. India Pvt Ltd.

COURSE NO: EST 101**Course Title:** Ecosystem Studies**Number of Credits: 3****No. of Lectures-Tutorial: 36-06****Course Coordinator/Instructor:** Dr. Sougata Sadhukhan**Course Outline**

Ecosystems provide a vast range of services, from food and medicines to a stable climate, clean water and storm protection. This course provides an introduction to the functioning of ecosystems underlying these services, in particular looking at how ecosystems are structured and how they function. The course has a practical ethos and involves fieldwork and analysis of real data. The course looks at the dynamic nature of ecosystems, which often behave as complex systems. The course provides students with the core ecosystem knowledge needed for management.

Learning Outcomes

Student will develop:

- An understanding of the fundamental principles of ecosystem ecology including how ecosystem structure relates to function and the dynamics of ecosystems.
- Appreciation of the diversity of ecosystem functions across time, space and biomes.
- Appreciation of how ecosystems respond to global change drivers including climate change, land use change and biodiversity loss.
- An understanding of ecosystem services, principles of ecosystem valuation and its importance

Pre-requisite

None

Evaluation Procedure: 60/40: University/Internal Assessment

Assignment	2	20%	Internal Assessment
Minor Test	2	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1.	Natural Resources , Biogeography and evolution • Air , water, soil as resources	02	

	• Patterns of species distribution – evolutionary relicts, climatic relicts, endemic organisms, environmental gradients, interaction of factors, species interactions • Natural selection, Darwin's theory • Plate tectonics and evolution of biodiversity • Species diversity in the tropics		
2.	Ecological Concepts and Ecosystem • Evolution of natural environment: Biotic and abiotic factors • Ecosystem productivity • Food chains and food webs and trophic levels • Energy flows– pyramid of number, pyramid of energy and pyramid of biomass • Patterns and types of bio-geochemical cycles – oxygen, nitrogen, carbon, sulphur and phosphorus • Water cycle • Principles of limiting factors- Liebig's law of Minimum, Shelford's law of tolerance, Combining concepts of limiting factors, limiting factors in ecosystem context • Ecological indicators, Ecotones and concept of edge effect, successional patterns (grasslands to old growth) and response of wildlife	04	
3.	Biodiversity • Definition: species richness, species diversity, biological diversity • Levels of biodiversity: genes to landscapes • Values of biodiversity – direct and indirect • Biogeographic zones of India • Biodiversity conservation- in situ and ex situ	02	
	Assignment 1 Discussion and presentation of selected research paper in groups of 2/3 students.		3
4.	Ecosystems • Forests – Biogeography of forests in India, vegetation structure and functions, food chain and food webs, plant-animal interaction, productivity and nutrient cycling, biological diversity of tropical forests, limiting factors, gap theory, threats and conservation. • Grasslands – Biogeography of grasslands in India, structure and function, food chains and food webs, animal population dynamics, limiting factors, threats and conservation	08	

	• Deserts – Biogeography of deserts in India, structure and function, limiting factors, environmental factors and plant-animal distributions, threats and conservation • Mountains – Tropical mountains, structure and function, plant and animal ecophysiology, threats and conservation • Mangroves – structure and function, ecological adaptations of mangroves, plant and animal diversity and interactions, mangrove productivity, food chains and food webs, threats and conservation • Marine ecosystems – structure and function, plant and animal diversity with reference to India, food chains and food webs, threats and conservation • Coral reefs – Distribution, structure and function, coral reef biology, coral reef communities, coral reef biodiversity, threats and conservation • Wetlands/Rivers - Biogeography, structure and function, stratification, food chains and food webs, catchment area concept, threats and conservation.		
5.	Taxonomy • Classification of living organisms (kingdoms) Introduction to Protista, Plant and Animal Overview of Protista (Classification of microorganisms, ecology, uses with examples) • Overview of Plant Kingdom: Diversification and evolution of plant groups; Cryptogams: Characteristics of Algae, Bryophytes, Pteridophytes • Characteristics of Fungi and Lichens (distinguishing characters with examples, place in evolution, ecological importance, uses) • Phanerogams: Gymnosperms and Angiosperms, (distinguishing characters with examples, place in evolution, ecological importance, uses) Systematics and Phylogeny • Purpose of taxonomy, Concepts of Taxonomic characters, types of classification systems (artificial, phylogenetic, natural with examples) , basics of nomenclature (binomial classification) Introduction to APG III • Study of identification and classification characters / Morphological features of selected angiosperm families: Angiosperms- Polypataleae - Malvaceae, Leguminosae Gamopataleae - Asteraceae, Lamiaceae / Bignoniaceae, Monocotyledons-(Liliaceae/Amaranthaceae); Use of flora for identification of angiosperms	10	

	Animal taxonomy - Invertebrates – Protozoa, Porifera, Cnidaria, Platyhelminthes, Nemertean, Nematoda, Mollusca, Annelida, Arthropoda, Echinodermata- Distinguishing characters of each phyla with examples - Vertebrates - key characters of each class - fishes, amphibians, reptiles, birds and mammals. - Classification of mammals upto order level with key characters of each order and examples		
	Assignment 2 Critical review of a research paper by individual students.		5
6.	Ecosystem services and ecosystem dynamics Ecosystem services - Ecosystem functioning and ecosystem services provided by different ecosystems at present – provisioning services, regulating services, habitat or supporting services, cultural services - Species population and ecosystem services-the connections - Millennium Ecosystem Assessment, TEEB with case studies Ecosystem dynamics - Definition of ecosystem dynamics and its relevance - Changes in ecosystems over different time scales, drivers of ecosystem dynamics (natural and human induced), patterns and elements of ecosystem dynamics with examples	04	
7.	Valuation of Ecosystem Services - Overview of economic valuation of ecosystems - Key issues in valuation of economics of ecosystems- identifying key stakeholders, key development goals, assessing the status and trends of key ecosystems, engaging stakeholders - Payments for ecosystem services - Case studies	06	
	Minor test 1		1
	Total	36	09

	• Patterns of species distribution – evolutionary relicts, climatic relicts, endemic organisms, environmental gradients, interaction of factors, species interactions • Natural selection, Darwin's theory • Plate tectonics and evolution of biodiversity • Species diversity in the tropics		
2.	Ecological Concepts and Ecosystem • Evolution of natural environment: Biotic and abiotic factors • Ecosystem productivity • Food chains and food webs and trophic levels • Energy flows– pyramid of number, pyramid of energy and pyramid of biomass • Patterns and types of bio-geochemical cycles – oxygen, nitrogen, carbon, sulphur and phosphorus • Water cycle • Principles of limiting factors- Liebig's law of Minimum, Shelford's law of tolerance, Combining concepts of limiting factors, limiting factors in ecosystem context • Ecological indicators, Ecotones and concept of edge effect, successional patterns (grasslands to old growth) and response of wildlife	04	
3.	Biodiversity • Definition: species richness, species diversity, biological diversity • Levels of biodiversity: genes to landscapes • Values of biodiversity – direct and indirect • Biogeographic zones of India • Biodiversity conservation- in situ and ex situ	02	
	Assignment 1 Discussion and presentation of selected research paper in groups of two students.		3
4.	Ecosystems • Forests – Biogeography of forests in India, vegetation structure and functions, food chain and food webs, plant-animal interaction, productivity and nutrient cycling, biological	08	

	diversity of tropical forests, limiting factors, gap theory, threats and conservation. • Grasslands – Biogeography of grasslands in India, structure and function, food chains and food webs, animal population dynamics, limiting factors, threats and conservation • Deserts – Biogeography of deserts in India, structure and function, limiting factors, environmental factors and plant-animal distributions, threats and conservation • Mountains – Tropical mountains, structure and function, plant and animal ecophysiology, threats and conservation • Mangroves – structure and function, ecological adaptations of mangroves, plant and animal diversity and interactions, mangrove productivity, food chains and food webs, threats and conservation • Marine ecosystems – structure and function, plant and animal diversity with reference to India, food chains and food webs, threats and conservation • Coral reefs – Distribution, structure and function, coral reef biology, coral reef communities, coral reef biodiversity, threats and conservation • Wetlands/Rivers - Biogeography, structure and function, stratification, food chains and food webs, catchment area concept, threats and conservation.		
	Minor test 1		1
5.	Taxonomy • Classification of living organisms (kingdoms) Introduction to Protista, Plant and Animal Overview of Protista (Classification of microorganisms, ecology, uses with examples) • Overview of Plant Kingdom: Diversification and evolution of plant groups; Cryptogams: Characteristics of Algae, Bryophytes, Pteridophytes • Characteristics of Fungi and Lichens (distinguishing characters with examples, place in evolution, ecological importance, uses) • Phanerogams: Gymnosperms and Angiosperms,	10	

	(distinguishing characters with examples, place in evolution, ecological importance, uses) Systematics and Phylogeny - Purpose of taxonomy, Concepts of Taxonomic characters, types of classification systems (artificial, phylogenetic, natural with examples) , basics of nomenclature (binomial classification) Introduction to APG III Study of identification and classification characters / Morphological features of selected angiosperm families Angiosperms- Polypatales - Malvaceae, Leguminosae Gamopatales - Asteraceae, Lamiaceae / Bignoniaceae, Monocotyledons-(Liliaceae/Amaranthaceae); Use of flora for identification of angiosperms Animal taxonomy - Invertebrates – Protozoa, Porifera, Cnidaria, Platyhelminthes, Nemertean, Nematoda, Mollusca, Annelida, Arthropoda, Echinodermata-Distinguishing characters of each phyla with examples - Vertebrates - key characters of each class - fishes, amphibians, reptiles, birds and mammals. - Classification of mammals upto order level with key characters of each order and examples		
	Assignment 2 Critical review of a research paper by individual students.		4
6.	Ecosystem services and ecosystem dynamics Ecosystem services - Ecosystem functioning and ecosystem services provided by different ecosystems at present – provisioning services, regulating services, habitat or supporting services, cultural services - Species population and ecosystem services-the connections - Millennium Ecosystem Assessment, TEEB with case studies Ecosystem dynamics - Definition of ecosystem dynamics and its	04	

	relevance Changes in ecosystems over different time scales, drivers of ecosystem dynamics (natural and human induced), patterns and elements of ecosystem dynamics with examples		
7.	Valuation of Ecosystem Services - Overview of economic valuation of ecosystems - Key issues in valuation of economics of ecosystems-identifying key stakeholders, key development goals, assessing the status and trends of key ecosystems, engaging stakeholders - Payments for ecosystem services - Case studies	06	
	Minor test 2		1
	Total	36	09

Suggested Readings

1. Alfred J. R.B, A.K.Das and A.K.Sanyal, Ecosystems of India, ZSI, 2001.
2. Banarjee A., 2010, Footprints in the forest, Winrock International India.
3. Botkin Daniel. B and Edward. A. Keller, Environment Science – Earth as a living Planet, John Wiley and Sons, 2005.
4. Carabias Julia and Kishore Rao, Capacity Needs to Manage Protected Areas, The Nature Conservancy, 2003.
5. Champion S., Seth S, (2005). Revised survey of forest types of India. Nataraj Publishers, New Delhi.
6. Clark T., Reading R., Clarke A., 1994. Endangered Species Recovery: Finding the Lessons, Improving the Process, Island Press.
7. Cleveland H., Larry R., Susan K., Allen L., David E., 2009, Animal diversity, McGraw Hill.
8. Dinerstein E. 2013. The Kingdom of Rarities. Island Press.
9. Enger, E.D., Ross, F.C., Bailey, D.B., 2003. Concepts in biology. McGraw-Hill Science / Engineering/Math.
10. Estuaries of India, ENVIS, 2002.
11. Gopal, R., 2011. Fundamentals of Wildlife Management. Nataraj Publishers, New Delhi.
12. Grimmett R., Inskipp C. and Inskipp T. (2001) *Pocket Guide to the Birds of the Indian Subcontinent*, Oxford University Press, Oxford.
13. Groom M.J., Meffe G.K. and Carroll C.R. (2006) *Principles of Conservation Biology* (3rd edition), Sinauer Associates, Sunderland
14. Hunter Malcom. Jr, Maintaining Biodiversity in Forest Ecosystems, Cambridge University Press, 1999.

15. J. B. Lal, 1992, Forest ecology, Natraj publishers.
16. Kamaljit S. B., et. Al., 2011, Conservation Biology, Universities Press.
17. Keddy Paul. A, Wetland Ecology – Principles and Conservation, Cambridge University Press, 2000.
18. Mangroves of India, ENVIS, 2002.
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21. Miller, G., Spoolman, S., 2007. Environmental Science: Problems, Connections and Solutions. Cengage Learning.
22. Nebel Bernard. J. and Richard. T. Wright, Environment Science, Pearson Custom Publishing, 8th Edition, 2003.
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24. Parenti L., 2009, Comparative biogeography, Rawat Publishers.
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26. Peter R., George J., Jonathan L., Susan S., 2005, Biology, Tata McGraw Hill.
27. Primack R.B. (2006) *Essentials of Conservation Biology* (4th ed.), Sinauer Associates, Sunderland.
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29. Puri, G.S., Meher-Homji, V.M., Gupta, R.K., Puri, S., others, 1983. Forest ecology. Volume I. Phytogeography and forest conservation. Forest ecology. Volume I. Phytogeography and forest conservation.
30. Raphael M., Molina R. 2013. Conservation of Rare or Little-Known Species: Biological, Social, and Economic Considerations. Island Press.
31. Sahara V.B. (2001) *Wildlife in India*, Natraj Publishers, Dehra Dun.
32. Sawarkar, V.B., 2005. A guide to planning wildlife management in protected areas & managed landscapes. Natraj Publishers.
33. Sharma, B.D., Karthikeyan, S., Singh, N.P., Flora of Maharashtra State. Botanical Survey of India.
34. Slootweg R., Rajvanshi A., Mathur V., Kolhoff A., 2009. Biodiversity in Environmental Assessment: Enhancing Ecosystem Services for Human Well-Being. Cambridge University Press.
35. Sustainable management of wetland, biodiversity and beyond. Jyoti Parikh & Hemant Date.
36. Sutherland, William J. 2006. Ecological Census Techniques: A Handbook. Cambridge University Press.
37. Townsend Colin. R, John. L. Harper and Michael Begon, Essentials of Ecology, Blackwell Science, 2000.

38. Vandana S., 2012, Biopiracy – the Plunder of nature and knowledge, Natraj Publishers.
39. Venkataraman K., 2012. Fauna of Maharashtra Part 1: Vertebrates Zoological Survey of India

Journals (to be accessed through JGATE)

1. Ecology
2. Conservation Biology

COURSE NO: EST 306

Course Title: Urban Environment Management

Number of Credits: 3

No. of Lectures-Tutorial: 36-6

Course Coordinator/Instructor: Ms. Samruddhi Pathak

Course outline

With increasing urbanisation all across the world there are rapid changes in quality of life and living space. This course provides an overview of present management of urban areas both nationally as well as internationally with special reference to the environmental aspects. The course will provide a practical insight into the development process of an urban area keeping in mind open spaces, basic needs like water supply and sanitation, protection from disasters, traffic issues and overall governance of a city. Various economic and social policies involved in urban housing and slums and importance of environment laws and management in today's urban areas will be discussed.

Learning Outcomes

At the end of the course students will :

- Develop an understanding of the urban environment.
- Develop an understanding of the process of urban planning and governance in India
- Develop skills of analysis of urban issues especially housing – formal and informal, disasters affecting urban areas, transportation issues, green spaces, open spaces and zoning and bye laws in urban areas
- Develop an insight into the importance of development plans and their processes.

Evaluation Procedure : Continuous

Assignments	40 % (3)	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment • Completed home assignment submitted timely and excellent written presentation	Assignments must be in the prescribed format digitally.	Internal Assessment
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T

1	Urbanization and its impacts • Definition of urban, urbanization and urban growth • Urban concentration and its impacts on natural and urban resources • Causes of degradation • Globalisation and urbanisation • Consumptive changes and its impacts on cities • Core and peripheral area developments Planning development and its impacts Urban climatology • Urban form and energy usage • Climate responsive interventions, Resilient city Ancient and contemporary case-studies	05	
2	Introduction to urban environmental planning • Basic concepts of planning and development planning, development plans, master plans, bye-laws, surveys, landuse etc. levels of planning, participatory planning • Planning as a tool for development and control • Historical planning and environmental concerns from ancient times to contemporary developments • Environmental incorporation through planning principles, infrastructural provisions and utility layouts • Urban public finance • Concept of Smart city	05	
	Assignment 1 Analysis and written presentation (individual) and oral presentation (in groups of three students) of the environmental problems in the urban fringe OR as given by the faculty		4
3	Disasters and urbanization • Impacts of disasters on urban areas • City collapse – trends from ancient to modern times	03	
4	Housing • Brief introduction to various concepts of demand, need, supply, tenures, densities, income groups etc. • Characteristics of urban housing • Urban forms of housing • Indian housing scenario • Housing economics	04	
5	Slums • Introduction • Causes of slums, characteristics of slums	03	

	Impacts of slums on the urban city image, slum improvements and prevention of slums		
	Assignment 2 Analysis and written presentation (individual) and oral presentation (in groups of three students) of the environmental problems in informal housing sector OR as given by the faculty.		5
6	Urban traffic - Concerns - Types of roads - Requirement of good roads - Traffic management - Urban traffic problems - Mass vs individual transportation systems - Impacts of roads and vehicles over environment	03	
7	Urban utility planning - UDPFI guidelines - Water, solid waste, waste water, garbage etc. - Norms and standards, CPHEEO, urban housing and poverty alleviation - Spatial, social, economic and environmental considerations, SLB Open space provisions - Requirement and needs - Hierarchy and importance - Urban social infrastructure planning - Urban environment and environmental status - Public private partnerships - Role of various non-governmental agencies and organizations in environmental upkeep	4	
	Assignment 3 Analysis and written presentation (individual) and oral presentation (in groups of three students) of water management in the urban sector. OR Analysis and written presentation (individual) and oral presentation (in groups of three students) of urban green spaces OR as given by the faculty.		5
9	Planning laws and environment - Historical perspective - Mega projects and developmental control and concerns	6	

	• New town developments Planning agencies • Duties and responsibilities • Environmental agendas • Efforts undertaken for environmental conservation and upgradation • Globalisation and urbanisation • Consumptive changes and its impacts on cities		
	Major Test		2
	Total	36	09

Suggested Readings

1. Bhatt S, Environment Protection and Sustainable Development, A.P.H. Publishing Corporation, 2004.
2. Rangwala, Town planning, Charotar Publishing House, Eighteenth Edition, 2003.
3. Bandyapadhyay A, Town Planning, Books and Allied Ltd, 2002.
4. Koperdekar and Diwan, Urban and Regional Planning – Principles, Practice and Law, Sudhanwa Kopardekar Publishers, 1994
5. Hiraskar G. K, Fundamentals of Town Planning, Dhanpat Rai Publications Ltd, 1997.
6. Khosla P.K, D.K.Uppal, R.K.Sharma, R.K.Kohli, Y.C.Jain, Ecofriendly Trees for Urban Beautification. Indian society of tree scientists, Jolan and National Horticulture Board, Gurgaon, 1996.
7. Cerver Francisco, Urbanismo – Urban Planning, Axis Books
8. Ohri M. L, Water Supply and Sanitary Engineering, India Publishing House, 1995.

COURSE NO: EST 111

Course Title: Field techniques I

Number of Credits: 2

Course Coordinator/Instructor: Dr. Sougata Sadhukhan

Course Outline

The course provides hand on expertise in identifying flora and fauna as well as in depth understanding of ecosystem structure and function through a combination of field visits and lab work.

Learning Outcomes

Students will:

- Develop skills in identifying birds, mammals and major plant species
- Develop an ability to analyze structure of ecosystems.
- Acquire competence in design and implementation of sampling techniques.

Pre-requisite

None

Evaluation Procedure: 60/40: University Exam / Internal Assessment

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed Journal submitted timely (within 7 days): 5 marks	Internal Assessment
Major exam	60%		University Assessment

Details of course content

1. Identification of terrestrial birds
2. Identification of wetland birds
3. Vegetation analysis using quadrats and analysis in excel
4. Vegetation analysis using line transects and analysis in excel
5. Vegetation analysis by using belt transect and analysis in excel
6. Calculation of plant diversity index
7. Study of planktons.
8. Converting study area into grids and mapping transects
9. Field work in forest ecosystem (Mulshi) (assessment for forest structure, measurement of GBH, canopy estimation, vegetation analysis) (This will be completed over two classroom sessions and one field session)

- 10.. Field work in grassland ecosystem (Rehekhuri) (grassland vegetation analysis, animal census techniques by using indirect signs). (This will be completed over two classroom sessions and one field session)
11. Field work in wetland ecosystem (Pashan) (Vegetation mapping, wetland bird analysis)

References

1. Vivek M., 2014, Indian Mammals – a field guide, Hachette book publishing India, Pvt. Ltd.
 2. Brandis D., 2009, Indian Trees, Natraj Publishers.
 3. Grewal B., 2017, A naturalists guide to the mammals of India, Prakash Books.
 4. Sachdera P., 2017, A naturalists guide to the trees and shrubs of India, Prakash Books.
 5. Grewal B., 2016, A Pictorial field guide to birds of India, Om book international.
 6. Grimmett R., 1998, Birds of Indian Subcontinent, Oxford University Press.
 7. Yiqi, Luo, Desharnais, Robert, 2015, Population Dynamics and Laboratory Ecology, Elsevier.
- Rieger, John, Stanley, Traynor, Raymond, 2014, Plant Material, Washington, DC, Island Press/Center for Resource Economics

COURSE NO: GEO 111**Course Title:** Techniques in image interpretation and remote sensing**Number of Credits:** 2**Course Coordinator/Instructor:** Dr. Aravinth R.**Course Outline**

The course provides hand on expertise in satellite image interpretation and cartography.

Learning Outcomes

- Proficiency in identifying various features on the satellite images
- Ability to work with satellite images

Pre-requisite

None

Evaluation Procedure : 0.6/0.4 University

Continuous assessment during practical	40 %	Marking pattern for every practical: Performance during the practical and completion of practical in the lab itself : 5 marks Completed Journal submitted timely digitally : 5 marks	Internal Assessment
Major exam	60%		University Assessment

Details of course content

1. Study and interpretation of SOI maps (with reference to numbering, scales, grid reference, signs and symbols, colour system) and Introduction to Survey of India's Open series Maps
2. Problems based on determination of scale (i) Aerial photos (ii) Toposheet
3. Preparation of landuse pattern maps using aerial photographs.
4. Visual interpretation of satellite images for landuse/landcover
5. Field identification of features using aerial photographs and satellite images.
6. Introduction to Erdas Imagine (displaying data from different satellites and using image visualization tools)
7. Reading IRS data (BIL/BSQ formats), downloading data (GLCF, Bhuvan) and stacking images

8. Introduction to SAGA
9. Registration of satellite images (Assignment using SAGA)
10. Image to image registration (Assignment using SAGA)
11. Mosaicking satellite images (Assignment using SAGA)
12. Subsetting satellite images (Assignment using SAGA)

Suggested Reading

1. Erdas field guide, Hexagongeospatial, 2004. ERDAS imagine. *Atlanta, Georgia*. <http://web.pdx.edu/~emch/ip1/FieldGuide.pdf>
2. Erdas imagine release guide, Hexagongeospatial, 2016. <https://www.hexagongeospatial.com/technical-documents/release-guides-2016/erdas-imagine-2016-release-guide>
3. Hexagongeospatial, 2019. https://wiki.hexagongeospatial.com/index.php?title=Main_page
4. IGET, 2019. <http://dst-iget.in/>
5. Olaya, V.I.C.T.O.R., 2004. A gentle introduction to SAGA GIS. *The SAGA User Group eV, Gottingen, Germany, 208*.

COURSE NO: GEO 112**Course Title:** Techniques in Geographical Information Systems**Number of Credits:** 2**Course Coordinator/Instructor:** Dr. Madhurima Dey**Course Outline**

The course provides hand on expertise with use of open source as well as commercial GIS software through a series of well designed practical's related to cartography, building geo databases, querying data, use of GPS and multicriteria analysis.

Learning Outcomes

- Proficiency in use of open source and commercial software for basic GIS operations.
- Ability to use location based devices for data collection.
- Ability to build basic geo databases.
- Competence in querying and making GIS analysis.

Pre-requisite

None

Evaluation Procedure : 0.6/0.4 University

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed Journal submitted timely (within 7 days): 5 marks	Internal Assessment
Major exam	60%		University Assessment

Details of course content

1. Introduction to ArcGIS tools
2. Introduction to QGIS (Assignment-self study with discussion)
3. Digital cartography and Story Maps
4. Defining co-ordinate systems and projecting data sets
5. Map registration
6. On screen digitization (Assignment using QGIS)
7. Error identification, rectification
8. Working with tables (Assignment using QGIS)
9. Using the analysis tools/ data query in ArcGIS (Assignment using QGIS)
10. Use of Mobile Navigation System and input of location data (Design of Survey Form)
11. Introduction to Google Earth
12. Performing multicriteria analysis

COURSE NO: EST 104

Course Title: Basic Statistical Methods

Number of Credits: 3

No. of Lectures-Tutorial-Practical: 13-3-22

Course Coordinator/Instructor: Dr. Sougata Sadhukhan

Course Outline

The course has been designed to help biologists/environmental scientists answer questions of applications of statistics in their field of work. The course focuses on techniques for generating informative data, extraction information from data and to analyze data to get meaningful interpretations.

Learning Outcomes

After the course the student will be able to:

- Apply the appropriate technique for extraction of information from data
- Analyze data using appropriate statistical techniques and software

Pre-requisite

Students are encouraged to join and complete the free online course offered by Harvard University at <https://www.coursera.org/learn/basic-statistics#syllabus> (starts Sep 15. Enrollement is free. If you want a certificate, there is a small fee).

Evaluation Procedure : Continous assessment

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed home assignment submitted timely: 10 marks	Practicals must be in the prescribed format	Internal Assessment
Major exam	60%	Theory cum practical examination		Internal Assessment

Details of course content and allotted time

Unit	Topic	Time (Hours)		
		Lectures	T	P
1	Basic concepts in biostatistics • Terms and Terminologies • Sampling Vs Population; Types of sampling; Variables and derived variables • Concept of Frequency and Distribution	01		

	• Data in Ecology and Environment Sciences and its types • Organization of data • Representation of data – tabular and graphic			
2	Basic elements and tools of statistical analysis • Measures of central tendency – arithmetic mean, geometric mean, harmonic mean, mode, median • Measures of dispersion – Standard deviation, Coefficient of variation, coefficient of correlation • Graphical representation of data	01		
3.	Practical 1 A: Graphical representation of data and calculation of different types of mean based on different types of data Practical 1 B: Calculation of mode and median based on different types of data by different methods.			02
4.	Practical 2: Calculation of standard deviation, coefficient of variation and coefficient of correlation of different data types by different methods.			02
5.	Concepts of probability • Basic laws – Examples from Ecology – Discrete probability distribution – expectation and variance	1.5		
6.	Distribution • Binomial distribution • Normal distribution	1.5		
7.	Practical 3: To calculate simple probability and solve examples based on binomial and normal probability distribution			02
8.	Categorical Variable Test Simple Proportion Test, Chi-Square Test Single Numerical variable Test Simple t-test, Wilcoxon Test for one Sample			2
9.	Practical 4: Solve example based on Categorical or Single Numerical Variable			2
10.	Test of Dependable or Independent Variable • Paired Test: t-test, Z-test, Wilcoxon Test • Unpaired Test: t-test, Z-test and Mann-Whitney U test	2		
11.	Practical 5: Calculation of Paired test			2

12.	Practical 6: Calculation of Unpaired Test			2
13.	Hypothesis and comparison of means • Hypothesis & testing of hypothesis • Comparison of means ANOVA • One sample; Two samples	03		
14.	Practical 7: Solve examples based on one-way ANOVA			02
15.	Practical 8: Solve examples base on two-way ANOVA			02
16.	Regression analysis • Correlation and Regression • Regression coefficient • Standard errors and significance tests	03		
17.	Practical 9: Calculation of Simple Regression and Regression Coefficient			02
18.	Practical 10: Calculation Standard error and significance test			02
	Final Assessment		3	
	Total	13	3	22

Suggested Readings

1. Clark, J. S. Models for Ecological Data: An Introduction. Princeton University Press Princeton, New Jersey, USA, 2007.
2. Legendre, P., and L. Legendre. Numerical Ecology. Vol. 20. Elsevier, 2012.
3. Ott, L., and M. Longnecker. An Introduction to Statistical Methods and Data Analysis. Duxbury press, 2010.
4. Sokal, R.R. and Rohlf, F.J. 1995. Biometry: the principles and practice of statistics in biological research. 3rd edition. New York.
5. Zar J.H. 1999. Biostatistical Analysis. Prentice Hall, New Jersey, 663 pp.

COURSE NO: EST 105

Course Title: Introduction to Data Analysis

Number of Credits: 3

No. of Lectures-Tutorial-Practical: 12-3-24

Course Coordinator/Instructor: Mr. Anand Shinde

Course Outline

The course will introduce basic data analysis fundamentals in excel, visualizing data in excel, math and statistics in excel

Learning Outcomes

At the end of the course the student will:

- Have an insight into the various features for analysis available in Microsoft Excel
- Develop the ability to prepare charts, tables, and professional reports that involve complex data.
- Develop the ability to analyze and summarize data.

Pre-requisite

Students are strongly encouraged to complete the following free online course:

<https://www.edx.org/course/introduction-to-data-analysis-using-excel-2>

Evaluation Procedure : Continuous

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed home assignment submitted timely: 5 marks	Practicals must be in the prescribed assignment format	Internal Assessment
Major exam	60%	Theory cum practical examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	T	P
1	Practical 1: Introduction to Data Analysis, Overview of Database, Structure for Storing, Cleaning and Normalizing Data	1		2
2	Practical 2: Introduction to Excel - Overview of Worksheet and Workbook; Tabs and Ribbons; Creating worksheets; Copying and moving worksheets Basic text and cell formatting; Editing: Cut; copy; paste; paste special; Freeze panes Entering numbers and Formatting numbers:	1		2

	Currency format; formatting dates; Custom and Special formats; Autocompletion of series; sort and filter			
3	Practical 3: Working with External Data, importing Data from other sources, Importing Data from an Access Database, Text File, CSV files, Inserting a Hyperlink, Working with Existing Data Connections	1		2
4.	Practical 4: Introduction to formulas , Understanding cell references, creating and modifying formulas with cell references, reading a formula	1		2
5	Practical 5: Logic functions: Building standalone logical IF functions, and make them more complex by nesting AND and OR within them.	1		2
6	Practical 6: Text Functions, Date Functions and Time Functions <i>Text Functions:</i> Learn to break apart text with the LEFT, RIGHT, MID, FIND and SEARCH functions, and to combine text with the & character. <i>Understanding Dates:</i> Understand how dates work in Excel using the TODAY, YEAR, MONTH, DAY and DATE functions. <i>Understanding Time:</i> Understand how time works in Excel, and how to change from whole numbers into time increments and back again.	1		2
7	Practical 7:Data Management Basics Sorting and filtering data in a data list, using the database functions in excel, querying external databases (one to one, one to many relations), combining queries, use of power query editor			
8	Practical 8: Web and text data analysis Retrieving data from the web, retrieving data from text files			
9	Practical 9: Using the 3D Map feature in excel	1		2
10	Practical 10: Creating a pivot table, formatting a pivot table, sorting and filtering pivot table data, modifying a pivot table, creating pivot chart	1		2
11	Practical 11: Develop a automation module of worksheet using Macro	1		2
12	Practical 12: Problem analysis in excel (using all of	1		2

	the above to analyze a given dataset).			
	Major Test 1		3	
	Total	12	3	24

Suggested Readings

1. Banfield, C., Walkenbach, J., 2010. Microsoft Excel 2010 for Dummies. New York: Wiley Publishing.
2. Harvey, G., 2010. Excel 2010 Workbook for Dummies. John Wiley & Sons.
3. Jackson, M., Staunton, M., 2006. Advanced modelling in finance using Excel and VBA. John Wiley & Sons.
4. Schmuller, J., 2013. Statistical analysis with Excel for dummies. John Wiley & sons.

SEMESTER II

COURSE NO: GEO 201**Course Title: Geodatabase management****Number of Credits: 03****Number of Lectures-Assignments: 36-06****Course Coordinator: Mr. Anand Shinde****Pre-requisite**

None

Course Outline

Access to accurate data is a pre requisite for any geospatial project. This course along with GEO 211 trains students in creating, maintaining, and retrieving data from a spatially enabled database. The course covers relational database topics that are of relevance in both geographic and non-geographic contexts (e.g., Structured Query Language and database design). It then focuses on the special considerations involved in the management of a spatial database by demonstrating two broad approaches. The first utilizes open-source technologies (specifically, the Postgres database management system and its spatial extension PostGIS); the second utilizes technologies from commercial vendors.

Learning Outcomes

At the successful completion of this course and Course GEO 211, students should be able to:

- retrieve data from an existing database using SQL Select queries
- design a database schema from a set of requirements
- implement that design through the creation of related tables
- insert and update rows in a table
- create spatially enabled tables in Postgres/PostGIS
- work with PostGIS data using open-source desktop GIS software (QGIS)
- create an Esri file geodatabase
- model real-world entities through subtypes, domains, topology rules, and relationship classes
- discuss the suitability of an open-source or proprietary approach to various project scenarios

Evaluation Procedure: 60/40: University/Internal Assessment

Assignment	2	20%	Internal Assessment
Minor Test	1	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Introduction to Database System • Introduction and purpose of database, computer data organisation, level of database implementation • Database system architecture: Levels of architecture, client server architecture, centralised and distributed processing • Characteristics of Database System ➤ Concurrent Use ➤ Structured Data ➤ Data Security and Integrity constraints ➤ Transactions ➤ Keys ➤ Views ➤ Backup and Recovery • Normalisation of Data, Codd's Rules	07	
2	Database models and modelling • Introduction to database model: schema, instance • Types of data modelling: Conceptual, logical and physical • Principles and techniques of data modelling • Database relationships: logical, physical • Relational Database model • Entity relationship model • Object oriented model	10	
	Assignment 1: As given by the faculty		4
3	Introduction to Oracle and MS-Access • Introduction to Oracle architecture, history of Oracle and Oracle database system • Data Definition language • Data manipulation language • Introduction to queries • Scheme object, literals, data types, nulls, comments • SQL command syntax	13	

	- SQL Functions, Joins and Sub Queries: Types of SQL functions: Character functions and Numeric Functions - Relational operation - Logical operation, condition based on pattern matching, order by clause and group by clause		
	Assignment 2: Linked to field work in Protected Area		4
4	Spatial data and database systems - Spatial data structure and database models - Classification of spatial database systems - Characteristics of spatial database systems - ArcGIS databases - Spatial data processing; spatial data standards and standardisation - OGC spatial data standards WMS, WFS, WCS - Metadata, spatial metadata standards	7	
5	PostgreSQL and PostGIS - Introduction to PostgreSQL Database Management System - PostGIS Functions - Spatial Query - Spatial storage	08	
	Minor Test 1		03
	Total	36	09

Suggested Readings

- Koch Loney, Orachle 9i – The complete reference, Tata McGraw Hill, 2007
- Nanda Arup, Steven Feuerstein, Oracle PL/SQL for DBA, Shroff publishers and distributors pvt. Ltd., July 2008
- Feuerstein Steven, Pribyl, Oracle PL/SQL Programming, SPD publication, Fourth Edition, 2005
- Misbra Sanjay, Alan Beaulieu, Mastering Oracle SQL, SPD Publications, 2008
- Gennick Jonathan, Oracle SQL Plus - The Ditinitive Guide, SPD Publications, 2005
- Millsap Cary, Jatt Holt, Oracle Performance Optimizing, SPD Publications, 2003
- McLaughlin, Oracle Database 11g, Tata McGrawHill Publishing Company Ltd, 2008

- Bayross Ivan, Understanding oracle BPB Publications, 2004
- Bayross Ivan, Oracle Developer 2000, BPB Publications
- Loney Kevin, George Koch, Oracle 8i the complete reference, Tata McGraw Hill Edition, 2000
- Date C.J., An introduction to database systems, Pearson Education, 2007

COURSE NO: GEO 202**Course Title:** Advanced Remote Sensing**Number of Credits: 3****No. of Lectures-Tutorial:** 36-06**Course Coordinator:** Dr. Aravinth R.**Course Outline**

The course will provide opportunity to understand and work with latest developments in the Remote Sensing datasets.

Learning Outcomes

At the end of the course, student will:

- Acquire deeper knowledge about advanced remote sensing methods
- Be able to apply their knowledge of remote sensing to various applications.

Pre-requisite

GEO 101

Evaluation Procedure: 60/40: University/Internal Assessment

Assignment	2	20%	Internal Assessment
Minor Test	1	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Active and passive microwave remote sensing • History of Microwave remote sensing. • Transmission characteristics of radar signals, phase as a relative distance, coherence, interference, polarization properties, single loss through lossy medium. • SLAR system operation, Spatial resolution of SLAR system, Slant range to Ground range, Geometric characteristics of SLAR Imagery, Interpretation of SLAR imagery • Earth surface feature characteristics influencing radar returns (geometric characteristics, electrical characteristics, soil response, vegetation response, water and ice response) • Synthetic Aperture Radar Systems (SAR), Imaging modes, SAR data processing, SLC and GRD, Multi-	20	

	looking, speckle processing, interferogram, polarimetry. • SAR remote sensing from space (Seasat, Shuttle Imaging Radar SIR Series, RADARSAT, ERS-Series, JERS. • Passive microwave sensing (elements, sensors and applications), Scatterometers		
	Assignment 1: Hands on: Introduction to ESA-SNAP and basic processing of SAR data		4
2	LiDAR remote sensing • Introduction to LiDAR, Topographic, bathymetric and Multiple return LiDAR, Scanning Mechanism. • Working principal of LIDAR, Various range and time of travel (ToT) measurements. Geolocation of LiDAR measurements, LiDAR data characteristics (Zig-Zag, parallel line and elliptical patterns), Processing of LiDAR data. • Available LIDAR sensors (ALTM, ALS and Toposys etc.), LiDAR applications, Case studies of urban applications and biomass estimation.	10	
3	Hyperspectral remote sensing • Introduction, Principles of spectroscopy, Spectrometers, Image cube, preprocessing of hyperspectral data (calibration, atmospheric corrections and geometric corrections), data characteristics and quality. Noise filtering with PCA and MNF • Spectral profiles, Spectral libraries, Image endmembers, Pixel purity index, Hyper spectral mapping techniques (Binary encoding, Spectral matching, Spectral mixing, Spectral angle mapping, spectral information divergence) • Hyperspectral sensors (HIS, Hyperion, AVIRIS and IMS) it applications with case studies.	15	
	Assignment 2: Seminar presentation by individual students on pre decided topics as assigned by the		5

	Teacher OR as decided by the faculty		
4	UAV based remote sensing • Introduction to UAV remote sensing, advantages and disadvantages, regulations and challenges. • UAV sensors, flight planning, GCP control provision, geo-tagging and data processing, dense point cloud, DEM, Ortho photos. • Applications of UAV in various fields	5	
	Minor Test 1		2
	Total	36	09

Suggested Readings

1. Borengasser M, Hungate WS, Watkins R (2007) Hyperspectral Remote Sensing: Principles and Applications. CRC Press
2. Campbell JB, Wynne RH (2011) Introduction to Remote Sensing, Fifth Edition. Guilford Press
3. Du Y, Chang C-I, Ren H, et al (2004) New hyperspectral discrimination measure for spectral characterization. Opt Eng 43:1777–1786. doi: DOI: 10.1117/1.1766301
4. Eismann MT (2012) Hyperspectral Remote Sensing. SPIE
5. Jensen JR (1996) Introductory digital image processing: a remote sensing perspective. Prentice Hall
6. Jensen JR (2007) Remote sensing of the environment: an earth resource perspective. Pearson Prentice Hall
7. Lillesand TM, Kiefer RW, Chipman JW (2008) Remote sensing and image interpretation. John Wiley & Sons
8. Meer F van der, Jong SM de (2002) Imaging Spectrometry: Basic Principles and Prospective Applications. Springer Science & Business Media
9. Ridgway JR, Minster JB, Williams N, et al (1997) Airborne laser altimeter survey of Long Valley, California. Geophys J Int 131:267–280.
10. Woodhouse IH (2005) Introduction to Microwave Remote Sensing. CRC Press
11. Melgani F, Nex F (2017), Recent Trends in UAV Remote Sensing, MDPI, ISSN 2072-4292

COURSE NO: GEO 203**Course Title:** Digital Image Processing**Number of Credits:** 3**No. of Lectures-Tutorial:** 36-06**Course Coordinator:** Dr. Aravinth R.**Course Outline**

The course will provide an in-depth knowledge of satellite image fundamentals and techniques for extraction information from satellite images including preprocessing and post processing operations. This course assumes that students have prior knowledge in the basics of remote sensing, mapping, and GIS, and have experience with geospatial software. Through laboratory work, students will have opportunities to practice the concepts and techniques learnt in the lectures.

Learning Outcomes

On successful completion of this course and Course GEO 212, the students will :

- Develop a strong understanding of the tools and techniques used to display, process, and analyze remotely sensed data
- Critically assess the strengths and weaknesses of remote sensing instruments and platforms for a broad range of application scenarios and design a remote sensing program.
- Use acquired knowledge and critical thinking skills to solve a real-world problem with appropriate remote sensing data and processing methods.

Pre-requisite

GEO 101, GEO 202

Evaluation Procedure: 60/40: University/Internal Assessment

Assignment	2	20%	Internal Assessment
Minor Test	1	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	A	T/E

1	Introduction to digital image processing • Overview of remote sensing data collection and analysis • Data collection: Insitu and remote sensing data collection-biophysical and hybrid variables, analog and digital image processing • Digital remote sensor data collection: multispectral imaging using discrete detectors, scanning mirrors, linear arrays, area arrays, digital frame cameras • Digital image data formats: BIL, BIP, BSQ	02		
2	Image Quality Assessment and Statistical Evaluation • Significance of the histogram in digital image processing • Univariate descriptive image statistics: measures of central tendency, measure of dispersion, skewness • Multivariate image statistics: covariance in multiple bands, correlation between multiple bands • Feature space plots	04		
	Assignment 1: Seminar presentation by individual students on pre decided topics as assigned by the teacher OR as decided by the faculty		5	
3	Image rectification and restoration • Introduction • Radiometric correction: random bad pixels, line or column drop-outs, partial line or column dropouts, line start problems, n-line stripping • Atmospheric effects and correction • Geometric correction: Internal and external geometric error, types of geometric correction-image to map rectification, image to image registration, hybrid approach to image	05		

	rectification/registration • Intensity interpolation: nearest neighbour, bilinear interpolation • Mosaicking			
4	Image enhancement techniques • Image reduction and magnification • Contrast enhancement: linear contrast enhancement, maximum-minimum contrast stretch, percentage linear and standard deviation contrast stretching, piecewise linear contrast stretch, non-linear contrast enhancement • Edge enhancement: linear and non-linear edge enhancement • Resolution merge • Principal Component Analysis • Band ratioing, spatial filtering: spatial convolution filtering, fourier transform • Vegetation indices: Dominant factors controlling leaf reflectance, NDVI, SAVI,	10		
5	Image classification • Introduction: Parametric and non-parametric method • Supervised classification: LULC classification levels, Stage involved in classification, Minimum-Distance-to-Means Classifier, Parallelpiped Classifier, Maximum Likelihood Classifier, neural networks, and random forests etc. • Unsupervised classification methods, K-means clustering and ISODATA • Fuzzy classification • Classification based on object oriented image segmentation • Hybrid classification and Knowledge based classification by incorporating ancillary data in the	10		

	classification process Validation of classification: Error matrix and Kappa statistics			
	Assignment 2: Research paper discussion in groups of two students OR as decided by the faculty		05	
6	Hyperspectral image analysis Hyperspectral image analysis: Atmospheric correction of hyperspectral images, hyperspectral image analysis techniques.	07		
7	Digital change detection Steps required to perform change detection, change detection algorithms	07		
8	Google earth engine Introduction, Code editor, Accessing EO datasets, Visualization and analysis of remote sensing images	5		
	Minor Test 1			01
	Total	36	09	03

Suggested Readings

1. Richards J. A, Jia Xiuping, Remote Sensing Digital Image, Springer Verlag Berlin Heidelberg My., 1999
2. Chanda B., D Datta, Majumdar, Digital Image Processing and Analysis, Prentice-Hall of India , 2001.
3. Prithvish Nag, M. Kudrat, Digital Remote Sensing, Concept Publishing Company, New Delhi, 1998
4. Lecture notes, module II, Image Analysis and Interpretation, IIRS
5. Jensen John: Introductory Digital Image Processing-A remote sensing perspective, Prentice Hall Series, 2005

Google earth engine, <https://earthengine.google.com>

COURSE NO: GEO 204**Course Title:** WebGIS**Number of Credits:** 3**No. of Lectures-Tutorial:** 36-06**Course Coordinator:** Dr. Shamita Kumar**Course Outline**

Web GIS has immense applicability to e-government, e-business, e-science, and daily life. Government employees can utilize Web GIS to improve public services and enhance collaboration across agencies. Businesses can use Web GIS to enhance their existing business models and create new ones. Researchers can find new solutions to meet the challenges of the new frontiers. Web GIS has great practical value to our world today and into the future. The course provides in depth insight into the new field of Web GIS alongwith its principles and application.

Learning Outcomes

At the end of the course students will have:

- Critically assess the organizational benefits and challenges of developing Web GIS applications;
- Explain the difference between Web GIS, geospatial web services, mashups, mobile GIS solutions, geoportals, and how these are applicable to e-business and e-government;
- Evaluate current technologies or architectures that support Web GIS; and Design and implement an independent Web GIS application

Pre-requisite

None

Evaluation Procedure: 60/40: University/Internal Assessment

Assignment	2	20%	Internal Assessment
Minor Test	1	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	A	T/E
1.	Introduction • The Web and GIS • Origins and evolution • Web GIS concept • Web GIS applications	07		

	• Introduction to HTML 5.0			
2	Technical basics WebGIS fundamentals • Web GIS basic architecture and components • Thin vs thick client architecture • Introduction to GML, geoRSS, XML, WKT (Well Known text) and preferred coordinate systems (GCS84) for web GIS apps. • Use of APIs in creating web enabled GIS websites (open layers API and google map API) • User experience design	10		
	Assignment 1: Hands on session (practical) – developing a simple Web GIS application using different APIs		03	
3	Geospatial Web Services • From websites to web services • WMS, WFS and WCS; their roles in web GIS • Geospatial web service functions • Web service architecture • Introduction to Interoperability and geospatial web service standards • HTTP WebRequest • Introduction to PHP	07		
4.	Geospatial Mashups • Evolution and impact • Web contents, functions and interfaces • Mash up design and implementation • Challenges and prospects • Demonstration of mashups	07		
	Assignment 2: Hands on assignment with WebGIS		03	
5.	Web GIS applications in e-business • Introduction to e-business and geobusiness • Types of applications • Challenges and prospects	06		

6.	Web GIS applications in e-government • Introduction to e-government and geo government • Types of applications • Challenges and prospects	06		
7.	Introduction to RDBMS support in creating interactive webGIS applications	02		
	Minor Test 1			01
	Total	36	06	01

Suggested Readings

- Web GIS: Principles and Applications Paperback – Import, 15 Mar 2011, by Pinde Fu (Author), Jiulin Sun (Author)
- GIS for Web Developers: Adding 'Where' to Your Web Applications Paperback – October 19, 2007, by Scott Davis (Author)

COURSE NO: GEO 205**Course Title:** Research Methodology**Number of Credits:** 2**No. of Lectures-Assignments:** 30**Course Coordinator:** Mr. Venkatraman G**Course Outline**

The course will provide students with a critical understanding of the research process and familiarize students with the main approaches, methods and techniques of qualitative and quantitative research. The course will enable students to undertake their own independent research and apply appropriate research methodologies in order to plan, conduct and evaluate basic research as part of their degree and provide a solid foundation for further advanced research.

Learning Outcomes

- Ability to identify various sources of information and write up a literature review
- Planning and conducting basic qualitative and quantitative research
- Ability to write an introduction and literature review

Evaluation Procedure: Continuous

Assignments	1. Write an introduction chapter (2500 words) 2. Write a literature review (2500 words)

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	A
1.	Research Design: Overview • Understanding research • The qualitative/quantitative divide • Overview of different research traditions – action research, case studies, documentary analysis, ethnographic research, experiments, grounded theory, surveys	02	
2.	Planning the research • Selecting a topic • Topic to research question – problem definition,	02	

	research question, hypothesis, research objectives • Research question to research design –developing the design • Data gathering – primary and secondary		
3.	Literature Review • Introduction to literature review • Methodology of literature review • Literature sources – books and journals, electronic databases, government and industry, internet; searching on keywords • Information management – keeping records of searches • Writing a literature review • Referencing – systems, referencing websites, citations, use of software	06	
4.	Developing the methodology Types of research design structure: Experimental design structure, quasi experimental design, observational research Sampling: Sampling strategies, Probability sampling (simple, systematic, cluster stratified); Non-probability sampling (convenience sampling, quota sampling, targeted sampling, chain referral); sample size in qualitative and quantitative research	04	
5.	Qualitative Research • Collecting secondary data - journals, existing documents and records, etc.; • Collecting primary data through: Participant observation; Qualitative interviews (informal, unstructured, semi-structured, focus), interview techniques, sources of inaccuracy and dealing with them, recording data, triangulation; Questionnaires-drafting questions, building a coding list, field piloting; Documenting local environmental knowledge and change; PRA techniques; Participatory mapping	06	
6.	Preparing for fieldwork • Paperwork, permissions, equipment, travel; Role of the researchers; Ethical Considerations - Ethics committee, ethical guidelines – voluntary participation, informed consent, confidentiality and	04	

	anonymity, plagiarism, academic fraud and misinterpreting results, conflict of interests, observation, permissions, video/audio taping		
7.	Processing and analysis of qualitative data Analysis during data collection- annotations, memos, coding; Quantitative Analysis: Descriptive statistics – tools and software, types of data, visualizing data (graphs), cluster analysis, measuring the spread Quantitative Analysis: Inferential statistics – significance levels and hypothesis testing, probability distributions, comparing single variable in two or more samples, relationship between variables	06	
	Assignment 1: Writing an introduction		
	Assignment 2: Writing a literature review		
	Total	30	

Assignments

The separate assignments will result in a single document – the research proposal of the student.

Suggested Readings

1. Becker, H. S. Writing for Social Scientists: How to Start and Finish Your Thesis, Book, or Article. University of Chicago Press, 2007.
2. Creswell, J. W., and V. L. P. Clark. Designing and Conducting Mixed Methods Research. Wiley Online Library, 2007.
3. Denzin, N. K., and Y. S. Lincoln. The Sage Handbook of Qualitative Research. Sage Publications, Incorporated, 2005.
4. The SAGE Handbook of Qualitative Research (3 Rd. Thousand Oaks, CA: Sage, 2005.
5. Hart, C. Doing a Literature Review: Releasing the Social Science Research Imagination. Sage Publications Limited, 1999.
6. Malmfors, B., P. Garnsworthy, and M. Grossman. Writing and Presenting Scientific Papers. Nottingham University Press UK, 2004.
7. Morrison, M. L., B. Marcot, and W. Mannan. Wildlife-habitat Relationships: Concepts and Applications. Island Press, 2006.

8. O'Connell, A. F., J. D. Nichols, and K. U. Karanth. Camera Traps in Animal Ecology: Methods and Analyses. Springer, 2010.
 9. O'Leary, Z. The Essential Guide to Doing Research. Sage Publications Limited, 2004.
 10. The Essential Guide to Doing Your Research Project. Sage Publications Limited, 2009.
 11. Peat, J. et al. Scientific Writing: Easy When You Know How. BMJ books, 2007.
 12. Ridley, D. The Literature Review: a Step-by-step Guide for Students. Sage Publications Limited, 2012.
 13. Silverman, D. Doing Qualitative Research. Sage Publications Limited, 2009.
- Torraco, R. J. "Writing Integrative Literature Reviews: Guidelines and Examples."
Human Resource Development Review 4.3 (2005): 3

COURSE NO: GEO 211**Course Title:** Techniques in Database Management**Number of Credits:** 2**Course Coordinator:** Mr. Anand Shinde**Course Outline**

The main aim of this course is designing, using, and implementing database systems and applications. Our course stresses the use of languages and facilities provided by database management systems, and system implementation techniques.

Learning Outcomes

- Proficiency in using database management system
- Ability to analyse and create spatial database
- Competence in using spatial queries in PostGIS

Pre-requisite

None

Evaluation Procedure: 60/40: University/Internal Assessment

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed Journal submitted timely (within 7 days): 5 marks	Internal Assessment
Major exam	60%		University Assessment

Details of course content

1. To create and load Data in database system
2. To perform append, updating, backup and recovery of database.
3. Design database schema after normalizing fields and tables by assigning constraints and keys.
4. To perform conversion of Entity Relationship Diagrams into a logical database structure and implement the database into database management system.
5. To perform creating ArcGIS geodatabase.
6. To store spatial data and create relationship between two spatial objects using ArcGIS.

7. Introduction to Oracle.
8. To display data from multiple tables by using different types of joins in Oracle
9. Problem solving through use of different types of Character functions and Numeric Functions in MS-Access
10. To perform Aggregating data using group Functions in MS-Access
11. Problem solving through use of sub queries, nested Queries in Oracle
12. Introduction to PostgreSQL and PostGIS
13. To build a spatial database by using PostGIS
14. To perform Importing and exporting of spatial data and use of various Spatial SQL Queries using PostGIS
15. To perform spatial joins use PostGIS
16. To produce maps from PostGIS using open-source desktop GIS software (QGIS)
17. To execute SQL Query using pgAdmin III

Suggested Readings

- Koch Loney, Oracle 9i – The complete reference, Tata McGraw Hill, 2007
- Nanda Arup, Steven Feuerstein, Oracle PL/SQL for DBA, Shroff publishers and distributors pvt. Ltd., July 2008
- Feuerstein Steven, Pribyl, Oracle PL/SQL Programming, SPD publication, Fourth Edition, 2005
- Misbra Sanjay, Alan Beaulieu, Mastering Oracle SQL, SPD Publications, 2008
- Gennick Jonathan, Oracle SQL Plus - The Definitive Guide, SPD Publications, 2005
- Millsap Cary, Jatt Holt, Oracle Performance Optimizing, SPD Publications, 2003
- McLaughlin, Oracle Database 11g, Tata McGrawHill Publishing Company Ltd, 2008
- Bayross Ivan, Understanding oracle BPB Publications, 2004
- Bayross Ivan, Oracle Developer 2000, BPB Publications
- Loney Kevin, George Koch, Oracle 8i the complete reference, Tata McGraw Hill Edition, 2000
- Date C.J., An introduction to database systems, Pearson Education, 2007

COURSE NO: GEO 212**Course Title:** Techniques in digital image processing**Number of Credits: 2****No. of hours: Lab-Student****Practice: 36-20 Course****Coordinator:** Dr. Aravinth R**Course Outline**

The course provides skill in analysis of digital images and extraction of information from satellite images using various software such as SAGA, ERDAS Imagine, IDRISI and ENVI.

Pre-requisite

GEO 111

Evaluation Procedure: 60/40: University/Internal Assessment

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed Journal submitted timely (within 7 days): 5 marks	Internal Assessment
Major exam	60%		University Assessment

Details of course content and allotted time

1. A. To download data from Earth Explorer (demo in class) and followed by hands as self study
B. To perform pre-analysis of a satellite image using image statistics.
2. To perform radiometric correction.
3. To perform atmospheric correction.
4. To perform geometric correction.
5. Performing spatial and spectral enhancement.
6. To perform unsupervised classification using ISODATA method.
7. To perform supervised classification.

8. To perform knowledge based classification.
9. To perform hyperspectral classification.
10. To perform object oriented segmentation.
11. To use model maker in ERDAS.
12. To perform change detection using IDRISI.

COURSE NO: GEO 213**Course Title:** Programming for GIS-I**Number of Credits: 3****No. of Lectures-Tutorial:** 36-06**Course Coordinator:** Mr. Ronit Jadhav**Pre-requisite**

None

Evaluation Procedure: 60/40: University/Internal Assessment

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed Journal submitted timely (within 7 days): 5 marks	Internal Assessment
Major exam	60%		University Assessment

Practical 1: Running Python scripts

- Introduction
- Understanding Python fundamentals
- Integrated Development Environment (IDE)
- Running scripts in Python window
- Exercise 1A: Use the PyCharm/VS code IDE
 - Open and configure
 - Run the script
- The ArcPy site package
- Creating a clone Python environment
- ArcPy functions and classes
- The ArcPy modules
- Choosing a scripting environment
- Tips and best practices
- Exercise 1B: Run scripts in Python
 - Buffer schools in Python window
 - Update script in IDE
 - Verify results in ArcMap
- Lesson review

Practical 2: Describing data

- Introduction
- The Describe function
- Generic Describe object properties
- Feature class Describe properties
- Raster Describe properties
- Describing a feature class and raster
- Exercise 2: Work with the Describe object
 - Describe a feature class and a geodatabase
 - Describe a list of feature classes
 - Clip raster datasets with Describe object properties
 - Describe dataset and coordinate system properties
- Lesson review

Practical 3: Automating scripts with lists

- Introduction
- The ArcPy List functions
- Explore the ArcPy List functions
- Working with List functions
- Working with da.Walk
- List data
- Exercise 3: Automating scripts with the ArcPy List functions
 - List field properties
 - Buffer feature classes
 - Verify script results
- Lesson review

Practical 4: Working with selections

- Introduction
- Selection tools in ArcMap
- Terms commonly used when working with selections
- Tools that accept feature layers
- Working with a selection
- The MakeFeatureLayer tool
- The FieldInfo object

- The AddFieldDelimiters function
- Determining a workflow
- Creating a feature layer and get the feature count
- Exercise 4: Work with feature layers and selections
 - Create new script
 - Create feature layers
 - Perform spatial selection
 - Create feature class from selection
- Lesson review

Practical 5: Working with cursors (Part-1)

- Introduction
- The arcpy.da cursors
- Exploring the data access cursors
- Tips and best practices for arcpy.da Cursors
- Using the SearchCursor
- Exercise 5A: Evaluate data with the searchCursor
 - Work with the da.SearchCursor
 - Copy the contents of a feature class into CSV using da.SearchCursor
- Lesson review

Practical 6: Working with cursors (Part-2)

- Using the UpdateCursor
- Exercise 6A: Alter existing data with UpdateCursor
 - Work with the da.UpdateCursor
 - Use a CSV to update the contents of a feature class using da.UpdateCursor
- Using the InsertCursor
- Exercise 6B: Working with the InsertCursor
 - Work with the da.InsertCursor
 - Insert records in a feature class from a CSV using da.InsertCursor
- Error handling with Python
- Error handling with the try-except statement
- Lesson review

Practical 7: Working with geometry objects

- Introduction
- Creating geometry objects

- Creating Point geometry objects
- Creating Polyline geometry objects
- Creating Polygon geometry objects
- Constructing multipart geometry
- Constructing multipart polygons
- Creating and updating feature geometry
- Accessing geometry objects
- Exercise 6: Work with geometry objects and cursors
 - Create geometry objects
 - Access Shape geometry
 - Create and update existing features
- Lesson review

Practical 8: Creating Geoprocessing tool and Sharing Scripts

- Introduction
- Terms commonly used when sharing scripts
- Scripting advantages in ArcGIS Pro
- Making scripts Dynamic
- Debugging scripts in an IDE
- Creating and sharing a geoprocessing script tool
- Advantages of attaching a script to a custom tool
- Using the Add Script wizard
- Running a script
- Sharing a script
- Plan out a project
- Exercise 7: Sharing scripts through geoprocessing packages
 - Add pseudocode to the script
 - Write script code
 - Attach script to custom tool
 - Run script in ArcGIS Pro
 - Share results as a geoprocessing package
 - Verify the geoprocessing package
- Lesson review

Practical 9: Automating map production

- Introduction
- The arcpy.mp module
- Terms commonly used when working with the arcpy.mp module

- Use the arcpy.mp module to modify map document contents
- Referencing the map document
- Listing map document contents
- Managing layers
- Managing layout elements
- Publishing maps
- Exporting maps and reports
- Exercise 8: Work with map document contents
 - Access map document in ArcGIS Pro
 - Access map document in script
 - Update layer symbology
 - Export map content
 - Verify changes in ArcGIS Pro

Practical 10: Introduction to ArcGIS API for Python

- Introduction
- Difference between ArcPy and ArcGIS API for Python
- Introduction to Jupyter Notebooks
- Accessing Portal/ArcGIS Online content
- Exercise 10: Managing your AGOL content
 - Access properties of an item
 - Downloading your item
 - Deleting content

COURSE NO: GEO 214**Course Title:** Field Work**Number of Credits:** 2**Number of Hours:** 60**Course Coordinator:** Dr. Shamita Kumar / Dr. Sougata Sadhukhan/Dr. Rashmi Mardikar/ Dr. Aravinth R**Course Outline**

The course provides field experience in analyzing conservation problems around Protected areas through a combination of natural science and social science research techniques.

Learning Outcomes

Students will develop:

- Proficiency in use of field methods
- Ability to analyse conservation problems.
- Competency in interpretation and presentation of results.

Pre-requisite

None

Evaluation Procedure: 0.6/0.4 University

Continuous assessment	100 %	Participation and submission of field work report	Internal Assessment

Details of course content

The field work to a National Park will be done through a twelve day block course that will involve pre field work sessions and post field work sessions. The fieldwork will focus on use of field techniques, integration with GIS as well as surveys to analyse resource use, tourism related problems, conservation problems, etc.

COURSE NO: EST 201

Course Title: Biodiversity Assessment and Conservation

Number of Credits: 3

No. of Lectures-Assignments-Examination: 36-6

Course Coordinator: Dr. Sougata Sadhukhan

Course Outline

The course focuses on the essential concepts and skills related to biodiversity conservation and assessment. This includes understanding threats to biodiversity, assessing biodiversity at various levels, concepts of landscape ecology and habitat management. It elucidates the perspectives of science and management of biodiversity in the context of current and future strategies needed for biodiversity conservation.

Learning Outcomes

Students will :

- Develop a deep understanding of the threats to biodiversity
- Develop skills of assessing biodiversity with different methodologies
- Develop a comprehensive understanding of issues in planning conservation areas and managing habitats.
- Acquire the ability to construct a conservation action plan for a species or site

Pre-requisite

EST 101

Evaluation Procedure : Evaluation Procedure: 60/40: University Exam / Internal Assessment

Assignment	2	20%	Internal Assessment
Minor Test	1	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	A	T/E
1	Overview of biodiversity • Status of biodiversity • Biodiversity at regional and landscape levels • Biodiversity at ecosystem, community and population levels	04		
2	Threats to biodiversity • Loss of biodiversity – past rates of extinction, human caused extinctions, extinction rates on islands, island biogeography and extinction rates, case studies • Vulnerability to extinction – Endemic species, case studies	05		

	- Habitat destruction, fragmentation and degradation - Exotic species introductions and disease - Problems of small populations – loss of genetic variability, demographic variation, environmental variations			
3	Assessment of biodiversity - Types of sampling – Qualitative and quantitative assessment techniques for mammals, birds, butterflies, plants. - Indices associated with species diversity, species similarity, temporal and spatial rate of change in species population - Alpha, Beta and Gamma diversity - Statistical approach to assessment of biodiversity - Software for biodiversity assessment	09		
	Assignment 1: Discussion and presentation of selected research paper in groups of 2/3 students OR any assignment as given by the faculty		03	
4	Planning Conservation Areas - Criteria for conservation – Conservation status, generalists and specialists; population size, sex and age classes, species restricted in distribution, isolated populations, habitat specialists and habitat obligates, species under illegal trade; key ecological functions of species; utility of the species - Approaches to conservation – species approach (featured species), management indicator species, species guild approach, flagship species approach, keystone species, ecosystem approach - Tools used for conservation – Population assessments, Gap analysis, habitat evaluation, GIS - Design criteria – habitat constituents, reserve design, reserve shape and size, population size, need for buffers, wildlife corridors, landscape connectivity, administrative, political and economic considerations	10		
	Assignment 2: Discussion and presentation of selected research paper in groups of 2/3 students OR any assignment as given by the faculty		03	
5	Habitat Management <i>Insitu</i> management – categories of biotic factors and their pressures- livestock grazing, fire wood collection, non wood forest produce collection, fires, encroachments, mining and quarrying, weeds and weed infestations (Invasive species), large scale	08		

	monocultures, soil erosion, timber smuggling, poaching, development activities that are insensitive to ecological integrity, vandalism, unregulated tourism; • Eco-restoration- habitat restoration techniques and monitoring • Wildlife management plans.			
	Minor test 1			01
	Total	36	06	01

Suggested Readings

1. Alexander, M. Management Planning for Nature Conservation: a Theoretical Basis & Practical Guide. Springer, 2008.
2. Groves, C. Drafting a Conservation Blueprint: a Practitioner's Guide to Planning for Biodiversity. Island Press, 2003.
3. Margules, C., S. Sarkar, and C. R. Margules. Systematic Conservation Planning. Cambridge University Press, 2007.
4. McNeely, J. A. Expanding Partnerships in Conservation. Island press, 1995.
5. Postel, S. et al. Nature's Services: Societal Dependence on Natural Ecosystems. Island Press, 1997.
6. Smith, D. S., and P. C. Hellmund. Ecology of Greenways: Design and Function of Linear Conservation Areas. University of Minnesota Press, 1993.
7. Sutherland, W. J. Conservation Science and Action. Blackwell Science Ltd, 1998.
8. Sutherland, W. J., and D. A. Hill. Managing Habitats for Conservation. Cambridge University Press, 1995.
9. Sutherland, W. J., I. Newton, and R. E. Green. Bird Ecology and Conservation: a Handbook of Techniques. Oxford University Press, USA, 2004.
10. Kamaljit S. B., et. Al., 2011, Conservation Biology, Universities Press

COURSE NO: EST 206**Course Title:** Natural Resource Management**Number of Credits: 3****No. of Lectures-Tutorial: 36-6****Course Coordinator:** Dr. Kranti Yardi**Course Outline**

The course is intended to impart knowledge and skills considered crucial for natural resource managers to manage effectively in the dynamic and intricate environment. It enhances the students' understanding at diverse levels by maintaining the equilibrium between the occupation obligations and enduring growth requirements. The fundamental thrust of the course is to assist the students to obtain theoretical and logical abilities in relation to the field situations, necessary for managing natural resources efficiently.

Learning Outcomes

The student will be able to:

- Contribute in managing the resource in a comprehensive way as professionals working in this sector
- Balance the needs of people and the economy with protecting the ability of ecosystems to support soil, water, forests, wildlife, fish, recreation, and other resources

Evaluation Procedure: Continuous

Assignments	40 % (3)	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment • Completed home assignment submitted timely and excellent written presentation	Assignments must be in the prescribed format. All assignments to be submitted digitally.	Internal Assessment
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	A	T/E
1.	Natural Resources – overview • Natural Resources –global, national (role of environment ministry and congruent ministries, local (Panchayati raj) • Land, water, air ,biodiversity, energy resources , Common property resources	05		

	- Natural resource governance and policy – policy building, legislation, administrative action, judiciary - Role of NGOs and academics			
2.	Theoretical aspects of Natural Resource Management - Livelihoods and Natural Resources - Global natural resource issues (water conflicts, interstate conflicts) International collaboration to address complex natural resource issues - Natural Resource Economics - Society, Ethics and Participatory Development - Conflicts management - land, biodiversity, water	03		
	Assignment 1: Any assignment as given by the faculty		03	
3.	Integrated watershed management - Definition of watershed - Watershed development strategy - Socio-economic and natural resource information through PRA's - Land surveys through land class determination for area, slope, depth of soil, texture, erodibility; soil and water testing - Engineering surveys – topographical surveys, drainage line survey, contour survey - Ecological assessment of the area – A statement of significance; site description-significant habitat types, native species of wild plants and animals of conservation importance, significant corridors, biotic pressures and threats, significant ecological services. People and their relationship with natural areas (valid and invalid stakes). - Microplanning – microplanning process, difficulties faced during microplanning, advantages of microplanning - Principles of soil and water conservation	10		
	Assignment 2: Ecological assessment of a given area using GIS compatible technique		03	
	Assignment 3: Collection of data using GIS compatible participatory rural appraisal technique		03	
4	Analytical aspects of Natural Resource Management - Remote sensing and GIS application in NRM - Statistical analysis in NRM - Vegetation inventory and rapid assessment - Financial analysis and project management in NRM - Environmental Impact Assessment (EIA) and Auditing	05		
5	Managerial aspects of Natural Resource Management The role of communication in natural resource management; Facilitating discussions with multiple stakeholders, multiple	11		

	perspectives; Conflict management; Policy negotiation; Collaborative planning for • Wildlife conservation and management • Wetland management • Watershed management • Urban forestry • Biodiversity and landscape • Climate change and carbon trading • Agro-ecosystems and Agro forestry • Environmental modeling • Eco-tourism and other environmental services • Bio-resources – Access and benefit sharing			
	Final Assessment			03
	Total	36	9	03

Suggested Readings

1. Francois Ramade 1984. Ecology of Natural Resources. John Wiley & Sons Ltd.
2. Harris, J.M. 2006. Environmental and Natural Resource Economics: A Contemporary Approach, 2nd edition. Houghton Mifflin.
3. Coastal Ecology & Management, Mann, K.H. 2000. Ecology of Coastal Waters with Implications for Management (2nd Edition). Chap. 2-5, pp.18-78 & Chap. 16, pp.280-303.
4. Global Change and Natural Resource Management, Vitousek, P.M. 1994. Beyond global warming: Ecology and global change. Ecology 75, 1861-1876.
5. Agarwal, K.C., 2001. Environmental Biology, Nidhi Publication Ltd. Bikaner.
6. Cunningham, W.P. Cooper, T.H. Gorhani, E & Hepworth, M.T. 2001, Environmental Encyclopedia, Jaico Publishing House.
7. Heywood, V.H. & Watson, R.T. 1995. Global Biodiversity Assessment. Cambridge Univ. Press.
8. Miller T.G.Jr. Environmental Science, Wadsworth Publishing Co. (TB)
9. Townsend C., Harper J, and Michael Begon. Essentials of Ecology, Blackwell Science.
10. Barber, E. 1989. Economics: Natural Resources Scarcity and Development. Earthscan.
11. Kamaljit S. B., et. Al., 2011, Conservation Biology, Universities Press.

COURSE NO. EST 207

Course Title: Environment and Health

Number of Credits: 3

No. of Lectures-Tutorial-Practical: 36-06

Course Coordinator: Dr. Thomas Krafft, University of Maastricht, Netherlands

Course Outline

The aim of this course is to provide the students with a comprehensive understanding and applicable knowledge of health geography as a scientific concept using tools like GIS for a holistic approach to public health that promotes the wellbeing of human populations through organizing data and understanding links between environment and health. The health of human population reflects the complex interplay between population characteristics and the environment. Genetic makeup can predispose certain populations to chronic or acute conditions. Cultural factors, such as stress, economic status, and access to health care, can play a significant part on disease onset. Students will learn how to assess environment and health related issues with different methodologies and they will be able to conduct a critical analysis on health and environment related research. The use of environmental health chain to study mechanism by which environmental hazards impacts health will be discussed as well as the aspect of the governance process to mitigate or eliminate environmental health hazards. Special focus will be laid on measuring health outcomes, mortality, incidence, prevalence etc.

Outcomes

Students will develop:

- Ability to apply the theoretical frameworks offered during the course to actual cases of environmental health problems.
- Ability to prioritize different interventions to manage environmental health risks.
- Ability to formulate simple research protocols for environmental measurements, exposure assessment or health effect assessment.
- Conduct simple analysis on health and environment using Geographic Information Systems and spatial cluster detection software.
- Discuss the suitability of various study designs and approaches in environmental and health research

Pre-requisite : None

Assessment: Continuous

Assignments	40 % (3)	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment • Completed home assignment submitted timely and	Assignments must be in the prescribed format and should be submitted digitally.	Internal Assessment

		excellent written presentation		
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	T	P
1.	Outline of the course - Introduction to Health Geography and Environmental Health Introduction - Health Geography and Environmental Health Human Ecology Models - Theoretical approach to study the forces in a person's environment that affects and influences development and interaction between individuals. One Health Concept - Interconnectedness of the health of humans, animals and ecosystems; Application of a coordinated, collaborative, multidisciplinary and cross-sectoral approach to address potential or existing risks that originate at the animal-human-ecosystems interface. Emerging and Re-emerging diseases - Formerly unknown diseases that are increasing in time and a specific location; Emerging diseases and reemerging diseases . <u>Task:</u> background literature for reading till next session	3		2
2.	PBL Case 1: Environmental Health Hazards		4	2
3.	Global Environment Change, Human Health and Public Health Environmental Health Chain - Exploring relationships between environment and human health; Causes and effects, causal chain, showing the links between sources and impacts. Environmental Determinants of Health - Environmental determinants of health - external factors such as access to safe water, air pollution,	2		1

	droughts and others that can be causally linked to a change of health status. Social Determinants of Health • Social determinants of health - conditions, in which people were born, live, grow up and age. Social determinants of health and health inequities - the differences in health status within and between countries. Task: Answering questions during a group discussion round, prepare for presenting the results during the next session.			
4.	Urbanization and Health Impacts Urbanization and Migration • Urbanisation and links to health, safe water, electricity and sewerage. • Urban – Rural Health Divide • Urban-rural divide in terms of infrastructure, environmental quality and health issues. Urban Health Models • Urban health models - challenge of communicating and modeling the complex relationships and interdependencies of various determinants of health in urban areas. Healthy City Concept • Political and social agenda of cities , movements for public health at the local level, equity, participatory governance and solidarity, intersectoral collaboration and action to address the determinants of health. Health and Wellbeing in the Changing urban environment - ICSU approach • Approach of the International Council for Science (ICSU) to study the causal chain and various complex interactions between different processes and factors that influence health and wellbeing in urban environments. Ambient Particulate Matter (PM) • Particulate matter and human health, exposure in urban, industrial areas and health issues.	2		1

	<u>Task:</u> Answering questions during a group discussion round, prepare for presenting the results during the next session.			
5.	PBL Case 2: Exposure to bad Air Quality		4	2
6.	Methodologies in the field of Health Geography and Environmental Health Health Impact Assessment - Economic sectors such as transport, agriculture and housing and health impacts; Health Impact Assessment - assessing the health impacts of policies, plans and projects in diverse economic sectors using quantitative, qualitative and participatory techniques. Geographic Field Work Methodologies - Quantitative and qualitative methodologies applied in the field of health geography. Pressure and Release model - Pressure and relief model - interactions that lead to an increase of vulnerability within a society and its relation to hazards that may become a disaster through the progression of vulnerability. Introduction to Health GIS as a tool of health geography and environmental health research - Application of GIS to monitor health related data and evaluate contributing environmental factors on human health. <u>Task:</u> Paper (10 page) on one of the topics presented during the lectures or a topic of their own research interest. This paper needs to be handed before the symposium. The paper will be presented during the symposium via PowerPoint.	4	2	
7.	Vulnerability and Global Environmental Change Drivers of Change - Global environmental hazards to human health include climate change, stratospheric ozone depletion, changes in ecosystems due to loss of biodiversity and a wide range of other factor; . Drivers of global environmental change and its interdependencies. Concept of Vulnerability and Resilience - Societal response, particularly the societal capacity to	2		2

	adapt to climate change impacts and links to severity of impacts and the costs of adaptation. Vulnerable populations - Driving factors that contribute to the vulnerability of a specific population Risk Assessment - Conducting risk assessments through identification of potential hazards, vulnerable populations and measurement of the impact a potential hazard on vulnerable populations. Mitigation and Adaptation - Adaptation and mitigation with respect to climate change. Exposure - Exposure of populations to various hazards. <u>Task:</u> Practical Framing research question, design research and prepare a poster for presentation at the workshop			
8.	PBL Case 3: Exposed?		4	2
9.	Training Workshop on Health Geography and Environmental Health The training workshop will be designed including lectures on GIS application, spatial cluster detection using SaTScan, visualizing health data, design maps for health study and projection and using spatial data. The students have to present and discuss the findings of their practical tasks in a special session at the end of the training workshop. Students will learn how to address health-related challenges, from disease analysis to policy planning. During the training workshop the students will present their papers via Power Point. Further the students will present in a special session their research posters. The time duration for the training workshop will be 5 days.	8	6	8
	Total	36	09	

Assignments

Reading: The students have to get a broad overview of the topic by reading assigned background literature.

PBL elements: Answering research questions on environment and health issues in a group discussion

and presenting the results during the class based on problem-based learning (PBL).

Paper: The students will be asked to prepare a paper on one of the topics presented during the lecture or a topic of their own research interest. The paper will be a 10 page document which will be need to be handed in up to a clear deadline and will be assessed by the teachers of the course.

Poster presentation: The students will be asked to prepare a poster on one of the topics presented during the lecture or a topic of their own research interest. This poster will be presented during the symposium. The students will have 10 minutes for presentation followed by a 5 minute open discussion. The goal of this exercise is to familiarize the students with poster presentation for conferences.

Research proposal exercise: The students will be divided in small groups, the groups will be asked to design a research proposal that address one of the research issues that were presented during the lectures. The results will be presented by the groups via PowerPoint during the symposium.

Methodologies: During the course there will be a focus on methodologies to assess Environment and Health related issues. During the symposium there will be an assignment for the students to carry out a cluster detection using SaTScan software. Further there will be a special session on Health GIS were students will learn basic application of GIS for health related research questions.

Suggested Readings

1. Brown T and Moon G. (2012) Commentary- Geography and global Health, *The Geographical Journal*, 178, 13-17.
2. McMichael A, Woodruff E, Hales S. (2006) Climate Change and human Health: present and future risks, *Lancet*, 367, 859-869
3. Haines A, Kovats R S, Campbell-Lendrum D, Corvalan C. (2005) Climate Change and human health: Impacts, vulnerability and public health, *Public Health*, 120, 585-596
4. Haines A, Kovats R S, Campbell-Lendrum D, Corvalan C. (2006) Climate change and human health: impacts, vulnerability, and mitigation, *Lancet*, 367, 2101-2109
5. Atul A, Khasnis, Nettleman M D. (2005) Global Warming and Infectious Disease, *Archives of Medical Research*, 36, 689-696
6. Patz J, Campbell-Lendrum D, Holloway T, Foley A. (2005) Impact of regional Climate Change and human health, *Nature*, 438, 310-317
7. Climate Change and Health: Research Challenges for Health in the Developing Countries, *Indian Journal of Occupational and Environmental Medicine*, 14,
8. Castello A et al. (2009) Managing the health effects of climate change, *The lancet Commissions*, 373, 1693-1733
9. Kovats S, Akhtar R (2008) Climate, Climate Change and Human Health in Asian Cities, *Environment and Urbanization*, 20, 165-175
10. Allen D E, Donham R S, Bernhardt S A (2011) Problem-Based Learning, *New Direction for Teaching and Learning*, 128, 21-29
11. Thomas I (2009) Critical Thinking, Transformative Learning, Sustainable Education, and Problem-based Learning in Universities, *Journal of transformative Education*, 7, 245
12. Pawson E, Fournier E, Haigh M, Muniz O, Trafford J, Vajocki S (2011) Problem-based Learning in Geography: Towards a critical Assessment of its Purposes, Benefits and Risks, *Journal of Geography in Higher Education*, 30:1, 103-116

13. Dummer T (2008) Health Geography: supporting public health policy and planning, *Canadian Medical Association Journal*, 178:9, 1177-1180.
14. Curtis S E, Owen K J (2011) Geographies of health and climate change, *Progress in Human Geography*, 36, 654-666.
15. Smyth F (2007) Medical geography: understanding health inequalities, *Progress in Human Geography*, 32, 119-127.
16. Bei X, Nath I, Capon A, Hasan N, Jaron D (2012) Health and wellbeing in the changing urban environment: complex challenges, scientific responses and the way forward, *Current opinion in Environmental Sustainability*, 4, 465-472.

Journals

1. Lancet
2. Environment and urbanization
3. Indian Journal of Occupational and Environmental Medicine
4. Nature
5. BMC Public Health
6. International Journal of Health Geographic (<http://www.ij-healthgeographics.com/>)
7. Progress in Human Geography

COURSE NO: EST 208**Course Title:** Climate Change Science and Strategies**Number of Credits: 3****No. of Lectures-Tutorial:** 36-06**Course Coordinator:** Ms. Aditi Lanke with inputs from external faculty**Course Outline**

Global climate change is a planetary scale phenomenon that impacts upon all socioeconomic and natural systems. Despite the growing consensus about the fundamentals of climate warming, scientific understanding of the complex interactions of ocean, land, clouds, and atmosphere remains highly uncertain, particularly with respect to environmental, social, and economic disruptions affecting human societies. This course will provide students with the scientific literacy to understand the issue itself and consider existing solutions such as the Kyoto Protocol, voluntary measures, etc. The guiding principle will be to promote the understanding needed to evaluate, develop, and propose emerging and creative solutions at individual, campus, and local levels. This course will examine the dilemmas faced in climate science, politics, economics, management, and ethics – all with an eye to the implications for global and regional sustainability.

Learning Outcomes

The student will be able to:

- Think intelligently about the issue and to understand what processes are currently underway and what more can be undertaken.
- Understand the precarious feedbacks from the climate system that could create dramatic impacts.
- Understand, plan and propose creative solutions at temporal, spatial, political, scientific, and social scale.

Evaluation Procedure: Continuous

Assignments	40 % (3)	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment • Completed home assignment submitted timely and excellent written presentation	Assignments must be in the prescribed format and be submitted digitally.	Internal Assessment
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	A	T/E
1	Climate science and impacts • Introduction: overview of the topic • Climate change: cause and effect • Climate disruption • Impact analysis: freshwater sources and oceans • Impact analysis: food and forests • Economic impacts of climate change	10		
	Assignment 1: Discussion and presentation of selected research paper in groups of three students.		05	
2	Policies and market issues • International treaties • Carbon trade and taxation • Strategies for low cost carbon abatement • Climate policy: global scenario • Climate policy: Indian scenario • Green business initiatives	10		
	Assignment 2: Discussion and presentation of selected research paper in groups of three students.		05	
3	Climate solutions • Energy solutions: past and present • Transportation • Building and habitation • Industry and waste management • Land use, agriculture and forestry • Adaptation and tropical forest sequestration • Geo-engineering of earth's atmosphere • Smart Cities	15		
	Assignment 3 : Discussion and presentation of selected research paper in groups of three students.		10	
4	Future direction • Mobilizing the world to action • Trends and futures of food scarcity solutions • Trends and futures of green and clean energy supply and consumption • The negotiating challenges ahead	10		
	Final Assessment			03
	Total	45	20	03

Assignments

In the assignments the students will be expected to express their view on promise and limitations of sustainability ideas and practices for dealing with climate threats. They will also be expected to

understand and illustrate the nature of climate controversies and the positions of various stakeholders. The assignments will also help to create an interdisciplinary understanding of climate interactions with human and natural systems.

Suggested Readings

1. Stephen Schneider, Armin Rosencranz, Michael Mastrandrea, eds., 2010. Climate change science and policy. Island Press.
2. Bert Metz, 2010. Controlling climate change, Cambridge University Press.
3. Lester Brown, 2009. Plan b 4.0: mobilizing to save civilization. W.W. Norton.
4. Kerry Emanuel, 2007. What We Know About Climate Change. Boston: Boston Review/MIT Press
5. Tim Flannery, 2006. The Weather Makers. New York: Atlantic Monthly Press
6. Bill McKibben, 2010. Earth. NY: Times Books,
7. David Blockstein and Leo Weigman 2010. The Climate Solution Consensus NCSE/Island Press.
8. Monty Hempel, 1996. Environmental Governance: The Global Challenge. Washington, DC: Island Press.
9. Arnold J. Bloom, 2009. Global climate change: convergence of disciplines. Sinauer Associates.

COURSE NO: EST 209**Course Title: Data Analysis with R****Number of Credits: 3****No. of Lectures-Practical: 20-25****Course Coordinator/Instructor: Dr. Shamita Kumar****Course Outline**

The course will introduce data analysis using R. The students will be introduced to the R language fundamentals and basic syntax along with data analysis in R

Learning Outcomes

At the end of the course the student will:

- Have an insight into the various features for analysis available in R
- Develop the ability to prepare charts, tables, and professional reports that involve complex data.
- Develop the ability to analyze and summarize data using R

Pre-requisite

Students are strongly encouraged to complete the following free online course:

<https://www.edx.org/professional-certificate/microsoft-excel-fundamentals>

Evaluation Procedure : Continuous

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed home assignment submitted timely (within 7 days): 10 marks	Practicals must be in the prescribed format and be submitted digitally.	Internal Assessment
Major exam	60%	Theory cum practical examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	T	P
1	Practical 1: Introduction to Basics R and R Studio; Basic data types in R and assign variables.	1		2
2	Practical 2: Data wrangling Working with tables: Filtering observations, arranging observations and adding/changing columns.	1		2
3	Practical 3: Data Visualisation 1	1		2

	Data visualization using the ggplot2 package, using the dplyr and ggplot2 packages for creating graphs			
4	Practical 4: Grouping and Summarising Using the group by and summarize verbs, visualizing summarized data	1		2
5	Practical 5: Data visualisation Create line plots, bar plots, histograms, and boxplots using different methods of data manipulation and preparation.	1		2
6	Practical 6: Exploring your data in tidyverse Using readR and exploring data	1		2
7	Practical 7: Taming the data Basics of data taming: taming the variable types, names, and values.	1		2
8	Practical 8: Tidying the data Tidying data and combining multiple tidying functions together in a chain using the pipe operator.	1		2
9	Practical 9: Transforming the data Taming specific types of variables such as dates, strings, and factors.	1		2
10.	Practical 10: Case Study Use all the tools learnt above to solve a problem.			
	Major Test		3	
	Total	12		30

1. Chang, W., 2018. R graphics cookbook: practical recipes for visualizing data. O'Reilly Media.
2. Grolemund, G., Wickham, H., 2018. R for data science.
3. Hadley, W., Garrett, G.R., 2017. R for data science: Import, tidy, transform, visualize, and model data. O'Reilly Media.
4. Villanueva, R.A.M., Chen, Z.J., 2019. ggplot2: Elegant graphics for data analysis. Taylor & Francis.
5. Wickham, H., 2016. ggplot2: elegant graphics for data analysis. springer.

6. Wickham, H., Averick, M., Bryan, J., Chang, W., McGowan, L.D., François, R., Grolemund, G., Hayes, A., Henry, L., Hester, J., 2019. Welcome to the Tidyverse. *Journal of Open Source Software* 4, 1686.
7. Wickham, H., Grolemund, G., 2016a. *R for Data Science: Import. Tidy, Transform, Visualize, and Model Data*.
8. Wickham, H., Grolemund, G., 2016b. *R for data science: import, tidy, transform, visualize, and model data*. O'Reilly Media, Inc.

COURSE NO: GEN 201**Course Title:** General English**Number of Credits:** 2**No. of Lectures-Tutorial:** 24-8**Course Coordinator:****Learning Outcomes**

The student should be able to:

- Construct sentences with correct grammar
- Write simple reports correctly

Evaluation Procedure: Continuous

Assignment	1	100%	Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Basic language skills: grammar and usage The ability to fill in blanks, correct errors, choose correct forms out of alternative choices, join clauses, rewrite sentences as directed, replace indicated sections with single words/opposites/synonyms, etc. Skills such as punctuation of passages, changing between direct and indirect speech, expanding points into complete sentences.	08	
	Comprehension This implies (a) an understanding of the passage in question and (b) a grasp of general language skills and issues with reference to words and usage within the passage and (c) the power of short independent composition based on themes and issues raised in the passage.	08	
	Composition: Paragraph-writing Formal training in composition and précis/summary writing through instruction, discussion and written work. Letter writing, Basic report writing	08	
	Assignment		4
	Total	24	8

COURSE NO: GEN 202**Course Title:** Project Management**Number of Credits:** 2**No. of Lectures-Tutorial:** 18-20**Course Coordinator:** Mr. Parag Khatavkar**Course Outline**

The course provides an overview of techniques of project management with an emphasis on project management, organizational structures, teams, functions, planning, scheduling, cost controls, trade-offs, risk management and other related topics. The course prepares students to conceptualize, implement, monitor and evaluate the project.

Learning Outcomes

The student should be able to:

- Construct, organize and explain project management.
- Devise, plan and compile work breakdown structures (WBS) and understand life cycle phases as quantitative tools in project management.
- Design, generate and explain scheduling techniques.

Pre-requisite

None

Evaluation Procedure: Continuous

Assignment	1	50%	Internal Assessment
Assignment	2	50%	Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	A
1	Introduction to project management • Definition and attributes of project and project management • Strategy in project management – establishing objectives, scoping the boundaries, priority setting, strategic development • Understanding project management and resistance to change	06	

	• Project management life cycle • Critical success factors in project management • Best practices in project management • Project monitoring		
	Assignment 1		05
2.	Project management methodologies • Modeling the project system – WBS, responsibility, communication plan • Estimations in projects – basic, time, cost, resources, techniques, guidelines • Developing project plans – Gantt charts, evaluating and constructing networks • Overcoming development and implementation barriers • Critical components of project management • Implementing a methodology • Strategic planning for project management	06	
3.	Issues in project management • Management Styles • Project Management Skills • Involvement of senior managers and stakeholders • Identification of projects • Project management information systems • Risk management • Change management • Role of culture in project management	06	
	Assignment 2		15
	Total	18	20

Assignments

In the assignments the students will be expected to design WBS, review of best practices in project management, role of change management, etc.

Suggested Readings

1. Baker, B. N., D. C. Murphy, and D. Fisher. "Factors Affecting Project Success." Project Management Handbook, Second Edition (2008): 902–919.
2. Dyball, R., and M. Keen. Social Learning in Environmental Management: Towards a Sustainable Future. Routledge, 2012.
3. Kerzner, H. Advanced Project Management: Best Practices on Implementation. Wiley, 2003.

4. Project Management: a Systems Approach to Planning, Scheduling, and Controlling. Wiley, 2009.
5. Meredith, J. R., and S. J. Mantel Jr. Project Management: a Managerial Approach. Wiley, 2011.

SEMESTER III

COURSE NO: GEN 301**Course Title:** Spatial analysis and modeling**Number of Credits: 3****No. of Lectures-Tutorial:** 36-06**Course Coordinator:** Dr. Aravinth R.**Pre-requisite**

All core courses of semester I and II

Evaluation Procedure: 60/40: University/Internal Assessment

Assignment	2	20%	Internal Assessment
Minor Test	1	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Introduction to Spatial analysis • Significance of spatial analysis • Overview of tools for analysis • Significance of modeling	3	
2	Vector Data Analysis • Buffering: Types and applications • Overlay: Methods and applications • Distance measurement • Pattern analysis: Nearest neighbour analysis, measuring spatial autocorrelation, measuring high/low clustering, applications of pattern analysis	6	
3	Raster Data Analysis • Local operations: Local operations with single raster, reclassification, local operations with multiple rasters, applications of local operations	6	

	• Neighborhood operations and their applications • Zonal operations and their applications • Physical distance measure operations and their applications • Comparison of vector and raster based data analysis		
	Assignment 1 Discussion and presentation of selected research paper in groups of three students OR as given by the faculty		3
4	Terrain mapping and analysis • Concept of DEM, TIN and data needed • Terrain mapping: Contouring, vertical profiling, hill shading, perspective view • Slope and Aspect (from raster and TIN), influencing factors • Raster vs TIN • Applications of terrain mapping and analysis	5	
5	Viewsheds and watersheds • Viewshed analysis: Parameters of viewshed analysis, applications of viewshed analysis • Watershed analysis: filled DEM, flow direction, flow accumulation, stream network, stream links, areawide watersheds, point based watersheds, factors influencing watershed analysis	6	
6	Spatial Interpolation • Elements of spatial interpolation, control points, types of spatial interpolation • Global methods: Trend surface models, regression models • Local methods: Thiessens polygons, Density estimation, inverse distance weighted interpolation, thin plate splines • Krigging: Semivariogram, ordinary krigging, universal	8	

	krigging		
	Assignment 2 Seminar presentation by individual students on predecided topics OR as given by the faculty		3
7	Path Analysis • Concepts of source raster, cost raster, cost distance measures, least cost accumulative path • Applications of path analysis	4	
8	Modeling in GIS • Basic elements of GIS modeling: classification of GIS models, the modeling process, role of GIS in modeling • Types of models: Raster and Vector Models: Binary models, Index models; Regression models	6	
	Minor Test 1		
	Total	36	06

Suggested Readings

- Roy P. S, Geographical Information Science, Vol. I, IIRS, 2000.
- Demers M.N, Fundamentals of Geographic Information Systems, John Wiley & Sons, Second Edition, 2000.
- Burrough P. A., R. A MacDonneli, Principles of Geographical Information Systems, Oxford University Press, 2000.
- Makrewski Jacek, GIS and Multi-criteria Analysis, USA, 1999

COURSE NO: GEO 311**Course Title:** Programming for GIS -II**Number of Credits: 3****No. of Lectures-Tutorial: 36****Course Coordinator:** Mr. Ronit Jadhav**Pre-requisite**

All core courses of semester I and II.

Evaluation Procedure: 60/40: University/Internal Assessment

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed Journal submitted timely (within 7 days): 5 marks	Internal Assessment
Major exam	60%		University Assessment

Details of course content and allotted time (3 hours each)

1. Introduction: Just Get Started, Comments
2. Types, Values and Variables: Creating & Naming Variables, Numbers, Strings & Booleans, Working with variables, Null & Undefined, Type Conversions.
3. Operators: Arithmetic Operators: +, -, *, /, %, ; Logical Operators: !, ||, &&, Relational Operators: <, >, <=, >=, ==, ===, !=, !==; Assignment Expressions
4. Statements: Expression Statements, Compound and Empty Statements, Declaration Statements, conditional statement: if statement, else if statement, Switch
5. Loops: for-loops, while-loops, for-in loops, jumps
6. Functions: Introduction to Functions, Function Arguments and Parameters, Functions as values and Functions and Name Spaces, Closures, Function properties, methods and constructor, Functional programming
7. Objects: Creating Objects, Querying and Setting Properties, Deleting Properties, Testing Properties, Enumerating Properties, Property Getters and Setters, Serializing Objects, Object Methods.
8. Arrays: Creating Arrays, Reading and Writing Array Elements, Sparse Arrays, Array Length, Adding and Deleting Array Elements, Multidimensional Arrays, Array Methods.
9. Introduction to Classes, subclasses and modules
10. Uses of Javascript in GIS

Reference Textbook:

1. JavaScript: The Definitive Guide, 7th Edition [Book]. (n.d.). Retrieved January 2, 2022, from <https://www.oreilly.com/library/view/javascript-the-definitive/9781491952016/>
2. Myers, M. (n.d.). A Smarter Way to Learn JavaScript: The new approach that uses technology to cut your effort in half.

3. <https://developers.arcgis.com/javascript/latest/>
4. <https://openlayers.org/>

COURSE NO: GEO 312**Course Title:** Dissertation**Number of Credits:** 12**Evaluation Procedure: 60/40: University Exam / Internal Assessment**

Assessment 1	Internal	10%	<i>Presentation on introducing the topic and its feasibility (literature review to justify the gap)</i>
Assessment 2	Internal	15%	<i>Detailed literature review, methodology with data collection protocols</i>
Assessment 2	Internal	15%	<i>Mid-course review. Presentation of results and preliminary analysis</i>
Major Exam (Phase 1)	External	60%	University Assessment (Phase 1)

Guidelines for dissertation

Topic: Candidates will write a dissertation on issues related to environmental/geospatial issues under the guidance of their respective guides. Each student will work independently on the topic. The dissertation must consist of review of literature and produce a deep insight of the subject on the basis of personal research.

Initiation of work: Dissertation work will be initiated during the second semester during the course of the paper on Research Methodology. During the Research Methodology course in Semester II, students will be allotted guides (from within the faculty associated with the Institute) based on their area of interest. As part of their assignments in the Research Methodology course students will write their introduction and literature review. **Guides will be from empaneled faculty only.**

Evaluation of thesis: The thesis will be evaluated in **two phases** over two semesters (third and fourth). **For the first phase** (in the third semester), 12 credits are allotted. The schedule for evaluation (internal and external) is given in the table above. **The guidelines given below only pertain to the first phase.**

Submission for Phase I: For the University presentation the student is expected to submit one **spiral bound copy** of the thesis consisting of introduction, literature review, aims and objectives, methodology, data and preliminary analysis along with a content page and interim certificate signed by the guide. (See attached certificate format below).

The dissertation should be typed on A4 size bond paper with 1.5 line spacing. Illustrations and photographs should be of high quality. Font to be used is Times New Roman or Arial with the text not less than in 12 pt. Referencing must be done in Zotero or any other referencing software strictly in standard referencing style (Vancouver). The report should be flawless without any spelling mistakes and grammatical errors etc. If the dissertation contains such mistakes, the student will have to resubmit their dissertation after the necessary corrections.

Guidelines for the preliminary presentation (first): The first presentation should cover gap analysis

(supported with literature review), justification for the study, aim, objective and proposed methodology. A document covering the above points should be submitted.

Guidelines for the interim presentation (second): For every presentation students will prepare a power point presentation highlighting the objectives, research question, methodology and key findings and defend the same. The presentation must not be texty. It should be aesthetically appealing and contain relevant graphs and analysis. Wordy presentations are likely to get marked down. Students should be smartly dressed and speak in a clear voice. Do ensure that your presentations are loaded as per the given deadlines.

The student will be permitted to appear for the second phase of the thesis ONLY if he/she has cleared the first phase.

FORMAT OF INTERIM CERTIFICATE

This is to state that Mr./Ms. _____ has worked under me for his dissertation from _____ till date. During this period he/ she has completed the following tasks.

- 1.
- 2.
- 3.
- 4.
- 5.
- 6.
- 7.

I have verified the authenticity of the data that he is using for his/her presentation.

Name of guide

Signature of guide

COURSE NO: GEO 313**Course Title:** Programming for GIS – III**Number of Credits: 3****No. of Lectures-Tutorial: 60****Course Coordinator:** Dr. Aravinth R**Pre-requisite**

All core courses of semester I and II.

Course Outcomes

At the end of the course, the student should:

- know basic concepts, skills, and tools for working with the Python and R scripting environments
- receive an overview of practical Python libraries for everyday scientific and professional GIS use
- understand how to make use of integration of Python environments from other software packages
- apply Python to solve common data-related tasks in concrete GIS projects
- competent use spatial and non-spatial data in order to answer a research question
- knows how to conduct and automate different standard GIS-related tasks that support clear documentation of methods in the Python scripting environments

Evaluation Procedure: 60/40: University/Internal Assessment

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed Journal submitted timely 5 marks	Internal Assessment
Major exam	60%		University Assessment

Details of course content and allotted time

1. Getting started Python; Setup Miniconda environments; Jupyter Notebooks
2. GIS in Python; Spatial data model; Geometric Objects; Shapely
3. Introduction to Git; Working with GeoDataFrames; Working with an IDE (Spyder); Managing projections;
4. Making spatial queries and joins;
5. Reclassifying data with Pysal
6. Visualization, making static and interactive maps

7. Work with MODIS Remote Sensing Data using Open Source Python
8. Practice Opening and Plotting Landsat Data in Python Using Rasterio
9. Calculate and Plot Difference Normalized Burn Ratio (dNBR) using Landsat 8 Remote Sensing Data in Python
10. Calculate Vegetation Indices in Python

COURSE NO: GEO 314**Course Title:** Techniques in Spatial Statistics, Analysis and Modeling**Number of Credits: 3****No. of Lectures-Tutorial: 60****Course Coordinator:** Dr. Aravinth R**Outcomes**

- Understand the fundamental theory of Spatial Analysis and use of spatial statistics.
- Become proficient in the use of GIS tools to conduct spatial analyses and build maps that are fit-for-purpose and effectively convey the information they are intended to.
- Build confidence in teaching your-self how to undertake new analyses (unfamiliar to you) using GIS, troubleshooting problems in GIS, and seeking help from the GIS community to solve your problems
- Use GIS analyses to address applied problems and/or research questions

Evaluation Procedure: 60/40: University/Internal Assessment

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed Journal submitted timely in digital format: 5 marks	Internal Assessment
Major exam	60%		University Assessment

Details of course content and allotted time

1. Map algebra
2. Perform topographic analysis: Surface conversion, Contouring, derive slope, derive aspect, curvature, hillshade, visibility analysis
3. Perform hydrologic analysis: Creating hydrologically correct topographic surfaces, processing flow, identifying and filling sinks, flow direction, stream networks, drainage basins, flow length, delineate area wide watersheds
4. To create 3D data, displaying 3D data, scene properties, layer properties, TIN symbology
5. Pattern Analysis: Average Nearest Neighbour, Hot spot analysis, Spatial Autocorrelation
6. Network analysis : creating Network database, Creating a multimodal network dataset
7. Toolbox model development for process automation
8. Test
9. Perform spatial interpolation using trend surface models, IDW, ordinary kriging
10. Modeling: Raster and Vector Models: Binary and Index Models; use python scripts

COURSE NO: GEO 302**Course Title:** Geospatial Modeling**Number of Credits: 3****No. of Lectures-Tutorial: 36****Course Coordinator: Dr. Aravinth R.****Course Outline**

The environmental problems result from a complex interaction of physical, chemical and biological processes, involving land, water, air and energy resources that significantly affect human activities and attitudes. The complex and multidisciplinary nature of environmental problems requires that they are dealt in an objective and integrated manner. Quantitative tools provide the requisite objectivity in environmental decision-making. These tools help in investigating, understanding, representing the current and predicting the future state of environment and generating 'what-if' scenarios under alternative policy interventions. These are crucial for any integrated environmental assessment and management strategy. This course aims to provide introduction to the fundamental modeling concepts through use of geospatial technologies for application in various sectors.

Learning Outcomes

At the end of the course, students will:

- Be proficient in designing models
- Test the accuracy of their models, perform sensitivity and uncertainty analyses

Evaluation Procedure : Continuous

Assignments	40 %	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment : 5 marks • Completed home assignment submitted timely and excellent written presentation: 5 marks	Assignments must be in the prescribed journal format digitally.	Internal Assessment
Major exam	60%	Theory examination		Internal Assessment

Details of sessions

1. LULC Temporal-Spatial Change Analysis (IDRISI)
- 2 Land Change Modeling
- 3 Habitat Suitability Analysis (HSI)
- 4 Species modeling (MAXENT)
- 5 Connectivity Analysis /Corridor (ArcGIS)
- 6 Vector based modeling – Regression Analysis (Linear and Regression) (ArcGIS)
- 7 Time Space Modeling using SATSCAN
- 8 Climate Change Modeling
9. Urban Modeling Cellular Automata
10. Hydrological Modeling (SWAT)

Suggested Readings

All relevant material will be provided as handouts. Students can also refer to the following books.

1. Maguire, Batty, & Goodchild: GIS, Spatial Analysis, and Modeling. ESRI Press, 2005.
2. Clarke, K. et. al.: Geographic Information Systems and Environmental Modeling. Prentice Hall, 2001.
3. DeMers, M.: GIS Modeling in Raster. Wiley, 2002.
4. Goodchild et. al.: GIS and Environmental Modeling: Progress and Research Issues. GIS world, Inc., 1996.

COURSE NO: GEO 303**Course Title:** Applications of geospatial technologies**Number of Credits:** 3**No. of Lectures-Tutorial:** 36-06**Course Coordinator:** Dr. Lakshmi KantaKumar**Pre-requisite**

GEO 102

Evaluation Procedure : Continuous

Assignments	40 % (3)	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment • Completed home assignment submitted timely and excellent written presentation	Assignments must be in the prescribed I format. One journal may contain assignments of different elective courses separated by a separator. Index must reflect all the assignments duly signed by the concerned teacher. Marks for every assignment must reflect on the assignment itself.	Internal Assessment
Major exam	60%	Theory Examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Remote sensing and GIS applications in ecosystem, forest studies and conservation	8	

	• Key concepts in ecosystem studies: ecosystem services, threats to ecosystems, management of ecosystems, classification levels • Key concepts of forest types, distribution, forestry practices, forest management • Satellites commonly used in forest studies • Satellites commonly used in ecosystem studies: global, national, regional, local, micro levels • Vegetation Indices used- NDVI, SAVI, Tassel Capped Index • Agencies involved (ancillary data sources) Case studies • Biodiversity characterization • Monitoring ecosystems (forests, wetlands) • Landuse/landcover classification (state level) • Human - Wildlife conflicts • EIA using GIS & RS • Habitat evaluation, Corridor mapping • Eco-tourism using advanced techniques like PDA • Forest fire risk zone mapping • Forest / vegetation classification and mapping. • Forest inventory and sampling technique. • Forest carbon management/sequestration • Using LIDAR data in forestry management • Wildlife Habitat Suitability Analysis with respect to : Statement of problem, feasibility of RS and GIS, methodology (flow chart) for each case study, RS needs (satellite, resolution, seasons, method of classification, vegetation indices), field studies needed and methodology used for the same, GIS database building (layers-sources, methods), analysis tools (GIS, statistical).		
	Assignment 1 Hands on session with any one application (demo followed by an exercise and presentation)		3
2	Remote sensing and GIS applications in agricultural applications • Key concepts in agriculture: problems in agriculture,	8	

	agricultural impact on the environment, sustainable agriculture, global significance of agriculture • Satellites commonly used for agricultural studies • Vegetation Indices - NDVI, SAVI, TasselCapped Index, remote sensing properties of soil • Agencies involved (ancillary data sources) Case studies • Crop yield estimation • Crop disease monitoring • Crop water requirement • Soil Mapping • WebGIS for agriculture • Precision farming with respect to : Statement of problem, feasibility of RS and GIS, methodology (flow chart) for each case study, RS needs (satellite, resolution, seasons, method of classification, vegetation indices), field studies needed and methodology used for the same, GIS database building (layers-sources, methods), analysis tools (GIS, statistical).		
	Assignment 2 Hands on session with any one application (demo followed by an exercise and presentation)		3
3	Remote sensing and GIS applications in urban application • Satellites commonly used for urban studies • Agencies involved (ancillary data sources) Case Studies • Urban Sprawl • Land Information Systems • Utilities management (water, sewage) • Fringe Area Development • Planning of facilities (green spaces, hospitals, etc) • Emerging Technologies • Urban heat islands with respect to : Statement of problem, feasibility of RS and GIS, methodology	8	

	(flow chart) for each case study, RS needs (satellite, resolution, seasons, method of classification, vegetation indices), field studies needed and methodology used for the same, GIS database building (layers-sources, methods), analysis tools (GIS, statistical).		
4	Remote sensing and GIS applications in water resources and related applications • Satellites used • Agencies involved (ancillary data sources) Case Studies • Groundwater modeling • Bathymetric mapping • Watershed development and management • Water Resource Assessment and Preparation of Management Planning Strategy • Water pollution monitoring/assessment • Vulnerability assessment of rivers/ waterbodies with respect to : Statement of problem, feasibility of RS and GIS, methodology (flow chart) for each case study, RS needs (satellite, resolution, seasons, method of classification, vegetation indices), field studies needed and methodology used for the same, GIS database building (layers-sources, methods), analysis tools (GIS, statistical).	8	
	Assignment 3 Hands on session with any one application (demo followed by an exercise and presentation)/ Hands on session with any one application (demo followed by an exercise and presentation)		3
5	Remote sensing and GIS applications in health studies 6. Key concepts: causes of epidemics, basic concepts of epidemiology-transmission of diseases, responsible environmental factors, challenges in disease / health management 7. Agencies involved (ancillary data sources) Case studies	8	

	8. Disease mapping (3 case studies from different parts of the world) 9. WebGIS for human health issues 10. GIS as a tool for monitoring Health Management Information System Environment Mapping for Viral Disease Survey 11. Emergency Medical Systems 12. Access to health care with respect to : Statement of problem, feasibility of RS and GIS, methodology (flow chart) for each case study, RS needs (satellite, resolution, seasons, method of classification, vegetation indices), field studies needed and methodology used for the same, GIS database building (layers-sources, methods), analysis tools (GIS, statistical).		
6	Remote sensing and GIS applications in Utilities Case studies • GIS in management of electricity distribution network • GIS for power plant site selection (hydro, thermal) • GIS in telecommunications • GIS in transportation design and management • Managing sewage/water supply systems through GIS • GIS in monitoring of infrastructure projects • GIS in business applications (2 case studies) with respect to : Statement of problem, feasibility of RS and GIS, methodology (flow chart) for each case study, RS needs (satellite, resolution, seasons, method of classification, vegetation indices), field studies needed and methodology used for the same, GIS database building (layers-sources, methods), analysis tools (GIS, statistical).	8	
	Final Assessment		
	Total	36	09

Reference Books

- Subudhi A P, B. S. Sokhi, P. S. Roy, Remote Sensing and GIS Application in Urban and Regional Studies, IIRS, 2001
- Roy. P. S, Natural Disaster and their Mitigation, IIRS, 2000.
- Roy P S, Biodiversity Characteristics at Landscape Level in North East using satellite Remote And Geographical Information System, IIRS, 2002.
- Roy P S, Forest Cover Assessment in Asia, IIRS, 2002.
- Roy P S, Biodiversity and Environment, IIRS, 2000.
- Sudershana R, D Mitra, Mishra, P.S Roy., D.P Rao, Subtle Issues in Coastal Management, IIRS, 2000.
- Deekshatulu B. L., Description and use of Landuse/ Landcover, NRSA, 1990.
- Remote Sensing for Sustainable Development, Proceedings of National Symposium organized by ISRS and RSAC, ISRS, Nov 1992.
- Proceeding of National Symposium on RS for Agricultural Application held at New Delhi, ISRS/IARI, Dec 1990.
- Proceedings of ISPRS Commission VII Symposium Resource and Environmental Monitoring, Hyderabad, Dec 2002.
- Pre-Symposium Tutorial on Sustainable Agriculture (Volume of Lectures), Dec 2002, NRSA
- National Agricultural Drought Assessment and Monitoring System, India, Summary Report, Sept 2001.
- ISPRS Technical Commission VII Symposium on Resource and Environmental Monitoring and ISRS Annual Convention- ABSTRACTS, NRSA, Dec 2002.
- Spatial Technologies for Natural Hazards Management (Proceedings of ISRS National Symposium Nov 21-22, 2000, IIT Kanpur)
- Application of RS and GIS in Disaster Management, Lectures notes by CSSTEAP, IIRS.
- Forest Resource Management, Lectures notes by CSSTEAP, IIRS.
- Application of RS and GIS in Marine Sciences, Lectures notes by CSSTEAP, IIRS.
- Application of RS and GIS in Urban Mapping, Lectures notes by CSSTEAP, IIRS.
- Application of RS and GIS in Geosciences, Lectures notes by CSSTEAP, IIRS.
- Application of RS and GIS in Water Resources, Lectures notes by CSSTEAP, IIRS.

COURSE NO: GEO 304**Course Title:** Photogrammetry**Number of Credits:** 3**No. of Lectures-Tutorial:** 36-09**Course Coordinator:****Pre-requisite**

None

Evaluation Procedure : Continuous

Assignments	40 %	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment : 5 marks • Completed home assignment submitted timely and excellent written presentation: 5 marks	Assignments must be in the prescribed journal format digitally.	Internal Assessment
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Introduction to photogrammetry • Types of photogrammetry: analog and digital photogrammetry • Elements of photogrammetry • Aerial photogrammetry • Satellite photogrammetry • Aerial vs satellite photogrammetry	10	
2	Practical Assignment 1	9	

2	Photogrammetric sensing systems • Types of aerial camera, scale • Basic geometric characteristics of aerial photographs • Scale and height measurement on serial photographs, stereoscopic measurement of object height • Aerial photo errors: classification of errors, least square adjustment • Image parallax and stereoscopy • Triangulation: Space resection, exterior orientation, interior orientation, bundle block adjustment • DEM, Orthophotos and planimetric features from soft copy photogrammetry: collection of data, image digitizing, DEMs, creation of digital orthoimages, extraction of thematic features of interest, area measurement • Dynamic terrain visualization, Flythrough	12	
4	Practical Assignment 2	9	
5	Applications of photogrammetry • Surveying • Monitoring Structures • Archeological documentation and cultural heritage conservation • UAV Photogrammetry	5	
6	Practical Assignment 3 and 4		2
	Total	36	09

COURSE NO: GEO 305**Course Title:** Water Management and Geospatial Technologies**Number of Credits: 03****No. of Lectures-Tutorial: 36****Course Coordinator:****Course Outline**

This course will expose the students to (i) Introduction to water resources evaluation and assessment - SPAC, WUE, methods of assessment, sectoral water use and demand, assessment of water stress and need for water conservation and (ii) Water resources conservation and management including institutional and policy aspects such as rainwater harvesting, conjunctive water use, catchment planning, watershed management, irrigation use and efficiency, advanced treatment systems and zero discharge, participatory irrigation management including methods of minimizing evaporation losses, water pricing, river basin organizations, collective action and decentralization etc.

Learning Outcomes

Students will:

- Develop the technical skills for methods of assessment and demand of water resources
- Technical skills in setting up water harvesting mechanisms

Pre-requisite

None

Assignments	40 % (3)	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment • Completed home assignment submitted timely and excellent written presentation	Assignments must be in the prescribed I Format digitally.	Internal Assessment
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Introduction to water conservation and assessment, Severity of water crisis, importance of conservation • Soil, Plant, Atmosphere Continuum (SPAC); Water use efficiency (WUE) • Methods of water resources assessment (hydrology cycle, surface flow assessment, groundwater recharge assessment) • Water stress: principles and indicators for assessing water stress • Water quality assessment: indicators for assessing water quality	10	
	Assignment 1: Assessment of water resources		5
2	• Water resources conservation and management, Water conservation measures • Soil moisture retention and conservation (cover crop, mulching, etc) • Traditional systems and man-made structures (ponds, tanks, reservoirs, Minimizing evaporation losses • Rainwater harvesting and groundwater recharging • Irrigation: types, scheduling, efficiency and designing	10	
	Assignment 2: Setting up rain water harvesting systems		2
3	• Water auditing; Water treatment, recycling and reuse leading to water conservation, Industrial and urban water management leading to cleaner production, Institutional mechanisms for water management, programmes and policies for integrated water management	10	
	Assignment 3: Conducting a water audit		4
	Total	36	09

Suggested Readings

1. Larry M. (2003) *Urban Storm Water Management Tools*, McGraw Hill Publication.
2. Michael A.M. (2008) *Irrigation Theory and Practices*, 2nd Edition, Vikas Publishing House Private Limited, Noida.
3. Suresh R. (2005) *Soil and Water Conservation Engineering*, 2nd edition, Standard Publishers Distributors. GEN@)

COURSE NO: GEN 301**Course Title:** Technical Writing**Number of Credits:** 2**No. of Lectures-Tutorial:** 24-8**Course Coordinator:** Mr. Venkatnarayan Ganpati**Course Outline**

The course provides an outline of how to develop communication skills with an emphasis on scientific writing, proposal preparation and scientific but attractive way of presentation of research findings along with proper means of audio-visual documentation. The course prepares students to think, read and write scientific papers; conceptualize, frame and prepare complete project proposals and also will help them to realize the basics of audio-visual communication systems.

Learning Outcomes

The student will be able to:

- Think, read and prepare scientific manuscripts
- Conceptualize, frame and prepare project proposals
- Prepare oral presentations and posters
- Document, edit and publish findings in field and related topics

Pre-requisite

None

Evaluation Procedure

Assignment	1	50%	Internal Assessment
Assignment	2	50%	Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Technical writing Outlining content • Organizing content: Checklist for components of journal articles and research papers • Difference between Abstract and Executive Summary • Writing an Introduction and Conclusion • Using logic to present content: the building blocks of analytical writing	8	

	• Using graphics to represent data: making data more readable and using graphics to present analysis • Using keywords to enhance search: Effective use of keywords to enhance online reach of your articles Using language effectively • Using effective words and editing content: Using a tool kit for writing; what to avoid when writing • Creating flow of information: understanding the difference between listing or cataloguing details and analyzing and interpreting them for your reader Submitting papers • Understanding submission guidelines • Using appropriate resources • Handling manuscript rejections		
	Assignment 1		
2	Preparing project proposals • Mapping the donor needs to organisational needs • Structuring content • Specifying deliverables and timelines • Asking for commitment • Checklist for a complete proposal	6	
3	Oral and Poster Presentations • Designing the presentation and flow of content • Communicating with the audience: verbal and non-verbal soft skills • Using visuals effectively: basics of using graphics, illustrations and copyright issues	4	
	Assignment 2		
4	Visual Documentation • Methods	6	

COURSE NO: GEN 302

Course Title: Soft Skills

Number of Credits: 2

No. of Lectures: 30

Course Coordinator: External Consultant

Evaluation Procedure : Continuous

Assignment	1	50%	Internal Assessment
Assignment	2	50%	Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Introduction to Personality a) Basic of Personality b) Human growth and Behavior c) Theories in Personality d) Motivation Communication skills and Personality Development a) Intra personal communication and Body Language b) Inter personal Communication and Relationships c) Leadership Skills d) Team Building and public speaking	07	
	Assignment 1		4
2	Techniques in Personality development I a) Self confidence b) Mnemonics c) Goal setting d) Time Management and effective planning	07	
3.	Techniques in Personality Development II a) Stress Management b) Meditation and concentration techniques c) Self hypnotism d) Self-acceptance	08	
	Assignment 2		4
	Total	22	8

SEMESTER IV

COURSE NO: GEO 411**Course Title:** Dissertation**Number of Credits:** 12**Evaluation Procedure: 0.6/0.4 University**

Assessment by guide	40%	Internal Assessment
Major Exam	60%	University Assessment

This course is the second phase of the dissertation. A student cannot appear for the exam of this course unless he/she has cleared Phase I.

Evaluation of thesis: The second phase of the thesis will be evaluated for 14 credits. The internal and external assessment will be as indicated in the table above. Students have to appear for a final external viva to defend their thesis after submission of the thesis.

The dissertation will have to be submitted as per the dates indicated in Academic Calendar for appraisal and acceptance by the University. The students should submit their dissertation in the following format.

Thesis Organisation

Cover Page

Inner Cover Page

Certificate duly signed by guide and head of institution

Acknowledgements

Abbreviations

Contents

Chapter 1 – Introduction

A background with historical information and a review of existing material or data on the subject.

Chapter 2- Aims and Objectives

This chapter must contain the overall study design and aims and objectives of the study.

Chapter 3 – Literature Review

Detailed review of all existing literature related to the topic justifying the topic with a comprehensive bibliography generated using Zotero.

Chapter 3 –Methodology

Description of the issues, environmental setting and methodology adopted for the study etc.

Chapter 3 – Results

Presentation of results.

Chapter 4 – Discussion

Discussion on the data and results obtained and presentation of method suggested to solve the problem.

Chapter 5 – Summary and Conclusions

A summary of the dissertation and important conclusions drawn at the end of the investigation and a list of references cited in the text.

Chapter 6 - Bibliography

The dissertation should be typed on A4 size bond paper with 1.5 line spacing. Illustrations and photographs should be of high quality. Font to be used is Times New Roman or Arial with the text not less than in 12 pt. Referencing must be done in Zotero or any other referencing software in standard referencing style (Vancouver) for both intext citing and bibliography. The report should be flawless without any spelling mistakes and grammatical errors etc. If the dissertation contains such mistakes, the student will have to resubmit their dissertation after the necessary corrections. The dissertation should be bound in hard black mounted cover. **Dissertations with spiral binding and paper cover will not be accepted. The front matter should be embossed and not on a sticker.**

The students are expected to prepare 3 copies (4 in case of a co-guide). If the guide gives a written consent that he/she does not need a hard copy a soft copy may be provided. The soft copy must contain a sticker with the cover page information. **The thesis will only be accepted after the relevant data used has been submitted to the faculty nominated and verified by them. It is mandatory that all data collected be submitted to the Institute for verification.**

Students must submit the plagiarism report before submission. Students making special efforts to present their papers at conferences or publishing it will receive marks as below:

1.	Poster presented at a National level UGC recognized conference	5 marks
3.	Paper presented at a national level conference	10 marks
4.	Paper published in a SCOPUS/ WEB of SCIENCE indexed journal ONLY	25 marks

Guidelines for final presentation: The final presentation must consist of gap analysis (inbrief), aim, objectives, research question, methodology and key findings and action plan (if any) and defend the same.

The presentation must not be texty. It should be aesthetically appealing and contain relevant graphs and analysis. Wordy presentations are likely to get marked down. Students should be smartly dressed and speak in a clear voice. Do ensure that your presentations are loaded as per the given deadlines.

Guidelines for poster (to be submitted digitally)

For the final presentation students will prepare a poster as per the guidelines given below.

Poster size: 2ft (W) x 3ft (H)

Content: Aim, Objective, Method (in brief in a flow chart), findings (key graphs to be included), publications (if any), conclusion, suggestion

Name of the student and guide as well as institutional affiliation should be included.

FORMAT OF FINAL CERTIFICATE (Times New Roman 12 pt; Line spacing 1.5)

CERTIFICATE (14 pt)

This is to certify that **NAME OF STUDENT**, final year student at the Bharati Vidyapeeth (Deemed to be University) Institute of Environment Education and Research, Pune has successfully completed the dissertation titled, '**Topic**' under the guidance of **Guide name**, in partial fulfilment of the Master Degree in Environment Science And Technology during the academic year **2019-20**.

The work has been completed to our satisfaction and standards. The said dissertation has not been submitted for any other degree or diploma and any such material which has been obtained from other sources has been duly acknowledged in the dissertation.

Guide name and designation

Prof. Dr. Erach Bharucha
Director
Bharati Vidyapeeth (Deemed to be
University) Institute of Environment
Education and Research, Pune Satara
Road, Pune 43

COURSE NO: GEO 412**Course Title:** Internship**Number of Credits:** 10**Course Coordinator:** Dr. Aravinth R**Course Outline**

The internship of six month (minimum 5 months) duration to be completed in the fourth semester is an opportunity for students to develop research skills and/or gain professional expertise as well as academic knowledge. Students must plan for the internship towards the end of the second semester itself. While the Institute will facilitate the placement for internships, students are encouraged to find placements for internships and make initial contact with prospective organization as this builds skills of communication.

Learning Outcomes

Students will learn to:

- Plan, execute and present findings of tasks completed in the six month period.
- Write concisely and effectively in order to communicate concepts and ideas in a logical and coherent manner.
- Produce effective data presentations and use them to enhance the communication of quantitative information.
- Work effectively in a team.

Pre-requisites

The student must apply for the internship/scan internship opportunities atleast six to eight months in advance. Requisite correspondence with the concerned organization is the responsibility of the student. The Institute will support with a letter of intent. Throughout the internship, the student must maintain a work log that includes dates, time spent on site, and a summary of the work performed and its relevance. An updated copy of the log must be turned into the supervisor (at the place of work) and the faculty supervisor in the form of monthly reports. The student must meet with the supervisor (at the place of work) on a regular schedule (determined by the supervisors at their discretion). The supervisor must be willing to submit a written evaluation of the student at the conclusion of the internship.

Evaluation: Continous

Midterm report submitted with signature of the supervisor and a letter of appointment	Three month from time of commencement of internship	20%	Details of tasks assigned, tasks completed till date
End project report submitted with a report by the supervisor	Within seven days of completion of the internship	40%	
Presentation on internship	As per University schedule	40%	Detailed presentation of tasks completed with concrete outcomes and learnings.

Format of Internship Report

- Cover page with title, your name and name of company
- Certificate from the employer on employer letterhead stating tasks completed and level of achievement (see certificate format below).
- (on a new page)

Name of the student

Place of internship

Supervisor

Duration of internship (Date of commencement of internship – date of completion)

1.0 Introduction

Para about the organization

Para about your work in general

2.0 Objectives

3.0 Tasks done with methodology and date

4.0 Outputs

4.1

4.2

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5.0 Learnings (to be added only for final report, not interim report) This is an important section for you to reflect on your learnings.

- **Work experience**
- **Academic and scientific and experience**
- **Social and cultural experience**

Kindly add photographs of yourself at your workplace/ field. Videos maybe taken

*The internship report should be typed on A4 size bond paper with 1.5 line spacing. Illustrations and photographs should be of high quality. Font to be used is Times New Roman or Arial with the text not less than in 12 pt. Referencing must be done in Zotero or any other referencing software in standard referencing style (Vancouver) for both intext citing and bibliography. The report should be flawless without any spelling mistakes and grammatical errors etc. If the report contains such mistakes, the student will have to resubmit their dissertation after the necessary corrections. The students are expected to prepare 3 copies (Spiral Bound/ Wiro Bound). **Two copies of the report with original certificates** in both must be submitted. Good photos of the student in the place of internship (in action) must also be included in the report apart from other relevant photos.*

CERTIFICATE

This is to certify that _____, a student of the Masters in Geoinformatics (M.Sc.) at the Institute of Environment Education and Research, Bharati Vidyapeeth Deemed University, Pune has successfully completed his/her internship in partial fulfillment for the course at _____ under the mentorship of _____ from _____ to _____.

He/She has completed the following tasks... /was involved in (as per suitability to be filled in by the candidate and supervisor)

____XXX

(Name and designation of mentor/ supervisor with seal on the University/Company letterhead)

COURSE NO. GEN 401**Course Title:** Entrepreneurship Development**Number of Credits:** 2**No. of Lectures-Tutorial-Practical:** 15-15**Course Coordinator:** External Experts**Course Description**

This course is designed to help students evaluate the business skills and commitment necessary to successfully operate an entrepreneurial venture and review the challenges and rewards of entrepreneurship. Students will learn about themselves, their decisions, and their goals to determine how entrepreneurship can play a role in their lives. Students will also be introduced to entrepreneurship from an economic perspective and the concepts of environmentally sustainable practices and social entrepreneurship.

Learning Outcomes

On completion of this course, the student will:

- Develop an understanding of personal attributes and skills that characterize the 'successful' entrepreneur.
- Be able to assess and compare their personal characteristics and interests to that of the 'successful' entrepreneur.
- Be able to identify and assess sources of support for small businesses and entrepreneurs. Be able to research and explain issues relevant to entrepreneurs such as 'green' business practices, environmental sustainability.
- Be able to identify the financial, marketing, legal, human resource, operations, and general management skills that are necessary to successfully launch and operate a successful new venture.

Evaluation Procedure: Continuous

Assignment	1	100 %	Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	• Entrepreneurship-Enterprise: Conceptual issues. Entrepreneurship vs. Management. Roles and functions in relation to the enterprise and in	05	

	relation to the economy. Small business as seedbed of Entrepreneurship.		
2	• Opportunity scouting and idea generation: role of creativity and innovation and business research. Sources of business ideas. • Entrepreneur opportunities in contemporary business environment, for example opportunities in net-work marketing, franchising, business process outsourcing in the early 21 century. • The process of setting up a small business: Preliminary screening and aspects of the detailed study of the feasibility of the business idea and financing/non-financing support agencies to familiarize themselves with the policies/programs and procedures and the available schemes. • Preparation of Project Report and Report on Experiential Learning of successful and unsuccessful entrepreneurs.	05	
	Assignment 1		08
3.	• Issues in small business marketing. The concept and application of product life cycle, advertising and publicity, sales and distribution management. • The idea of consortium marketing, competitive bidding/tender marketing, negotiating with principal customers. • The contemporary perspectives on Infrastructure development, Product and Procurement Reservation, Marketing Assistance, Subsidies and other Fiscal and Monetary Incentives. National state level and grass-root level financial and non-financial institutions in support of small business development.	05	
	Assignment 1		07
	Total	15	15

COURSE NO: GEN 402**Course Title:** Soft Skills**Number of Credits:** 2**No. of Lectures:** 30**Course Coordinator:** External Consultant**Evaluation Procedure : Continuous**

Assignment	1		50%	Internal Assessment
Assignment	2		50%	Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Introduction to Personality a) Basic of Personality b) Human growth and Behavior c) Theories in Personality d) Motivation Communication skills and Personality Development a) Intra personal communication and Body Language b) Inter personal Communication and Relationships c) Leadership Skills d) Team Building and public speaking	07	
	Assignment 1		4
2	Techniques in Personality development I a) Self confidence b) Mnemonics c) Goal setting d) Time Management and effective planning	07	
3.	Techniques in Personality Development II a) Stress Management b) Meditation and concentration techniques c) Self hypnotism d) Self-acceptance	08	
	Assignment 2		4
	Total	22	8

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**BHARATI VIDYAPEETH
(DEEMED TO BE UNIVERSITY), PUNE**

**FACULTY OF SCIENCE
M.Sc - Environment Science and Technology
Old Syllabus**

BHARATI VIDYAPEETH UNIVERSITY, PUNE

M.Sc. (Wildlife Conservation Action)

**COURSE STRUCTURE AND DETAILED SYLLABUS
OF
SEMESTER I, II, III and IV (UNDER CREDIT SYSTEM)
EFFECTIVE FROM 2015-16 AT SEMESTER I**

At the
INSTITUTE OF ENVIRONMENT EDUCATION AND RESEARCH
BHARATI VIDYAPEETH UNIVERSITY, PUNE
In collaboration with
WILDLIFE TRUST OF INDIA, NEW DELHI

INTRODUCTION

The course has a multidisciplinary approach that integrates the science of wildlife conservation with social issues in managing and mitigating wildlife conflict and natural resource management. The course provides in depth knowledge of ecosystem and biodiversity conservation and management along with wildlife rescue and rehabilitation as well as legal instruments for wildlife conservation. It includes the cognitive aspects and technological skills necessary to further a career in the wildlife field. It trains the candidate in skills required for assessment and monitoring of biodiversity as well as wildlife management through a combination of course work, intensive field work and internships. The program also builds skills in conducting research and communicating for wildlife conservation. The course provides multiple exit points. The course is administered by the Faculty of Interdisciplinary Studies.

This course will be implemented in close collaboration with the Wildlife Trust of India, premier organization involved in action based wildlife research and advocacy.

OBJECTIVE

The course has a rapidly expanding horizon in both national and international level. Government and Non-Governmental organizations such as Wildlife Trust of India, World Wide Fund for Nature, ATREE, WII, IUCN, etc. employ candidates with these qualifications as wildlife researchers as well as wildlife managers. The multidisciplinary foundation prepares the student to pursue a career in a variety of conservation related jobs and produces a broad based scientist. It also provides opportunities for people who are already working in the field to further their career through a formal Diploma course and a Master's program.

ELIGIBILITY FOR ADMISSION TO THE COURSE

- a. The candidate should have obtained the Bachelors degree in any Science subject such as Botany, Zoology, Chemistry, Physics, Statistics, Geography, Geology, Life Sciences, Environment Sciences, Microbiology, Biotechnology, Fisheries, Marine Biology, Horticulture, Agriculture, Computer Science, Veterinary Science or any branch of engineering or any relevant Social Science subject.
- b. If the candidate has a degree in any other subject than the ones mentioned above he/she should have a working experience of minimum of three years in the area of conservation field to be eligible for the Master's program.
- c. The candidate should have secured at least 50% in the aggregate at undergraduate level and 45% for SC /ST / OBC candidates.

DURATION OF THE COURSE

This program consists of a minimum of 120 credits that may be completed in two years consisting of four semesters. The medium of instruction and examination will be only English.

RULES AND REGULATIONS

1. **Commencement and Conclusion:** The dates for the commencement and conclusion of each semester shall be determined by the University authorities. The terms can be kept only by duly admitted students. Each semester is of 15 weeks duration. Students must check the academic calendar for exact dates of commencement and conclusion.

Credits: The entire Course is of 120 credits and will be executed in four semesters. 30 and 27 credits are offered in Semester I and II respectively while 30 and 33 credits are offered in Semester III and IV. In the second semester the student will opt for a combination of electives with a total weightage of 12 credits while the third semester is a six month dissertation program (four months field/lab work and two months for data analysis and writing) for 30 credits. In the fourth semester the student will have a mandatory internship and opt for a combination of electives of 8 credits. The total weightage for the fourth semester is 33 credits. The number of students for each elective should not be less than five. One credit is equivalent to 15 hrs of interaction of student with facilitator for theory, while one credit for practical is equivalent to 30 hrs of practical work.

2. **Dissertation:** The student will undertake a dissertation in semester III spanning six months (four months for field work and two months for analysis and writing) for which 30 credits have been allotted. The topic for the research must be finalized by the end of Semester II after thorough literature review.
3. **Field Visits:** The field / academic Institute visits will be organized for demonstration of advance experimental techniques wherever necessary along with the courses. Attendance for these are mandatory and will form part of internal assessment as indicated in the syllabus.
4. **Internship:** The student can opt for a one month internship of four credits in the second semester and/or of six months duration in semester IV which will entail 4 credits and 25 credits respectively. Communication about the intent to opt for this must come in writing by the end of October in Semester II and the end of July in the third semester.
5. **Attendance:** A student must have minimum 75% attendance in theory and attendance in the practical courses to fulfill the term. A student who does not have the required attendance may not be allowed to appear for the university term and the respective monthly internal assessments.

RULES FOR EXAMINATION

1. Examination for the theory and practical courses will be conducted at the end of each respective semester or as continuous assessment as indicated in the syllabus.
2. The weightage allotted for internal assessment is 40%. Thus 40 marks out of 100 will be allotted for internal assessment which will be conducted throughout the semester in the form of tests/ tutorials/ seminars/ oral presentations /assignments /debates/Field Visits, etc. as indicated in the syllabus. There is an equal emphasis on providing theoretical understanding and developing practical skills. Classroom lectures, assignments, group discussions and extended field visits are therefore given equal importance. The university shall conduct theory / practical examination for 60 marks.

3. Internal assessment for the practical course is through continuous assessment. Each practical is evaluated for ten marks. Of this performance in the class is assessed for five marks and timely submission of journal within a week of the practical being conducted) as per instructions given by the concerned teacher is assessed for five marks. Based on the number of practicals total marks are converted to 40 marks as internals.
4. The general courses will be evaluated by the institute on the basis of continuous assessment/assignments as indicated in the syllabus.

STANDARD OF PASSING

1. For all courses, both UE and IA constitute separate heads of passing. In order to pass in such courses and to earn the assigned credits, the learner must obtain a minimum grade point of 5.0 (40% marks) at UE and also a minimum grade point of 5.0 (40% marks) at IA.
2. If a student fails in IA, the learner passes in the course provided he/she obtains a minimum of 25% in IA and GPA for the course atleast 6.0 (50% in aggregate). The GPA for a course will be calculated only if the learner passes at the UE.
3. A student who fails at UE in a course has to reappear only at UE as a backlog candidate and clear the head of passing. Similarly, a student who fails in a course at IA has to reappear only at IA as a backlog candidate and clear the head of passing.
4. The 10-point scale Grades and Grade Points according to the following table.

Range of Marks (Out of 100)	Grade	Grade Point
$80 \leq \text{Marks} \leq 100$	O	10
$70 \leq \text{Marks} < 80$	A+	9
$60 \leq \text{Marks} < 70$	A	8
$55 \leq \text{Marks} < 60$	B+	7
$50 \leq \text{Marks} < 55$	B	6
$40 \leq \text{Marks} < 50$	C	5
Marks < 40	D	0

5. The performances at UE and IA will be combined to obtain the Grade Point Average (GPA) for the course. The weights for performance at UE and IA shall respectively be 60% and 40%.
6. GPA is calculated by adding the UE marks out of 60 and IA marks out of 40. The total marks out of 100 are converted to grade point, which will be the GPA.

Formula to calculate Grade Points (GP)

- a. Suppose that 'Max' is the maximum marks assigned for an examination or evaluation based on which GP will be computed. In order to determine the GP, Set $x = \text{Max} / 10$ (since we have adapted 10-point system). Then GP is calculated by the formulas shown as below.

Range of Marks at the evaluation	Formula for the Grade Point
$8x \leq \text{Marks} \leq 10x$	10
$5.5x \leq \text{Marks} < 8x$	Truncate (Marks / x) + 2
$4x \leq \text{Marks} < 5.5x$	Truncate (Marks / x) + 1

- b. Two kinds of performance indicators, namely, the Semester Grade Point Average (SGPA) and the Cumulative Grade Point Average (CGPA) shall be computed at the end of each term. The SGPA measures the cumulative performance of a learner in all the courses in a particular semester, while the CGPA measures the cumulative performance in all courses since his/her enrolment. The CGPA of learner when he/she completes the programme is the final result of the learner

The Formula to compute equivalent percentage marks for specified CGPA:

% Marks (CGPA) =	$10 \times \text{CGPA} - 10$	if $5.00 \leq \text{CGPA} \leq 6.00$
	$5 \times \text{CGPA} + 20$	if $6.00 \leq \text{CGPA} \leq 8.00$
	$10 \times \text{CGPA} - 20$	if $8.00 \leq \text{CGPA} \leq 9.00$
	$20 \times \text{CGPA} - 110$	if $9.00 \leq \text{CGPA} \leq 9.50$
	$40 \times \text{CGPA} - 300$	if $9.50 \leq \text{CGPA} \leq 10.00$

New guidelines for Standards of Passing

Standards of Passing

1. For all courses, both UE and IE constitute separate heads-of-passing (HoP). In order to pass in such courses and to 'earn' the assigned credits
 - a. The learner must obtain a minimum grade point of 5.0 (40% marks) at UE and also a minimum grade point of 5.0 (40% marks) at IA;

OR

- b. If he / she fails in IA, the learner passes in the course provided he / she obtains a minimum of 25% in IA and GPA for the course is atleast 6.0 (50% in aggregate). The GPA for a course will be calculated only if the learner passes at the UE. The following examples illustrate this rule for passing in a course under.

Illustration of Passing Rule specified

Case No.	UE Marks Out of 60	IA Marks Out of 40	Total Marks Out of 100	GP of UE	GP of IA	GPA	Remarks
1	24	16	40	5.0	5.0	5.0	Pass
2	40	10	50	7.0	0	6.0	Pass
3	40	06	46	7.0	0	5.0	Fails at IA
4	20	40	--	0	10.0	0	Fails at UE
5	34	12	46	7.0	0	5.0	Fails at IA
6	20	15	--	0	0	0	Fails at both UE & IA

2. A student who fails at UE in a course has to reappear only at UE as a backlog candidate and clear the HoP. Similarly, A student who fails in a course at IA has to reappear only at IA as a backlog candidate and clear the HoP.
3. Subject to the Rules E1-E2, the ATKT and other rules may be framed by respective BOS and faculty.

Award of Honours

A student who has completed the minimum credits specified for the program shall be declared to have passed in the programme. The final result will be in terms of letter grade only and is based on the CGPA of all courses studied and passed. The criteria for the award of honours are given below.

Range of CGPA	Final Grade	Performance Descriptor	Equivalent Range of Marks (%)
$9.50 \leq \text{CGPA} \leq 10.00$	O	Outstanding	$80 \leq \text{Marks} \leq 100$
$9.00 \leq \text{CGPA} \leq 9.49$	A+	Excellent	$70 \leq \text{Marks} < 80$
$8.00 \leq \text{CGPA} \leq 8.99$	A	Very Good	$60 \leq \text{Marks} < 70$
$7.00 \leq \text{CGPA} \leq 7.99$	B+	Good	$55 \leq \text{Marks} < 60$
$6.00 \leq \text{CGPA} \leq 6.99$	B	Average	$50 \leq \text{Marks} < 55$
$5.00 \leq \text{CGPA} \leq 5.99$	C	Satisfactory	$40 \leq \text{Marks} < 50$
CGPA Below 5.00	F	Fail	Marks Below 40

SEMESTER WISE COURSE INFORMATION

Semester I

Course Number	Course Title	Credit Value	No. of lectures per week	No. of Tutorials per month	No of Lab per week	Internal Assessment	University Exam
EST 101	Ecosystem Studies	4	4	1		40	60
CA 101	Human Ecology	4	4	1		40	60
CA 102	Wildlife law and trade control	4	4	1		40	60
EST 104	Fundamentals of Geospatial Technologies	4	4	1		40	60
EST 111	Field Techniques I	2	4	1	1	40	60
EST 114	Geospatial techniques	2	4	1	1	40	60
	Open Courses						
EST 106	Statistical Methods	4	4	1	1	100	-
EST 107	Fundamentals of computing and database	4	4	1	1	100	-
GEN 103	General Course I Communication	2	4	1	1	100	-

Total Credits offered in Semester I : 30

Semester II

Course Number	Course Title	Credit Value	Lectures/ week	Tutorials/ month	Lab /week	Internal Assessment	University Exam
EST 201	Biodiversity Assessment and Conservation	4	4	1	1	40	60
CA 201	Wildlife health, rescue and rehab	4	4	1	1	40	60
EST 203	Research Methodology	2	4	1	1	100	
GEN 105	Project Management	2	4	1	1	100	
CA 211	Field Techniques II	3	4	1	1	40	60
	Electives (minimum 12 credits)						
EST 205	Natural Resource Management	4	4	1	1	100	
EST 402	Ecorestoration, Ecodevelopment and Ecotourism	4	4	1	1	100	-
EST 210	Climate Change Science and Strategies	4	4	1	1	100	-
GEO 203	Digital Image Processing	4	4	1	1	100	-
CA 212	Internship	4	4			100	-
CA 213	Minor Project	4	4			100	-
GEO 212	Techniques in Digital Image Processing	4	4	1	1	100	-

Total Credits offered in Semester II: 27

Total credits in two semesters: 57

Semester III

Course Number	Course Title	Credit Value	No. of hours per week	IA	UE
	Core Courses				
CA 311	Dissertation	30	42	40	60
	Total	30	42		

Total Credits offered in Semester III : 30

Semester IV

Course Number	Course Title	Credit Value	Hours per week	IA	UE
	Core Courses				
CA 411	Internship	25	40	40	60
	Electives (any two)				
CA 401	Urban Biodiversity Conservation	4	4	100	
CA 402	Wildlife Conservation Communication	4	4	100	
CA 403	Wildlife Management	4	4	100	
EST 403	Corporate Social Responsibility	4	4	100	
	Total	33	48		

Total Credits offered in Semester IV : 33

Course No: EST 101

Course Title: Ecosystem Studies

Number of Credits: 4

No. of Lectures-Tutorial: 45-15

Course Coordinator/Instructor: Dr. Kranti Yardi with inputs from Dr. Rahul Mungikar

Course Outline

Ecosystems provide a vast range of services, from food and medicines to a stable climate, clean water and storm protection. This course provides an introduction to the functioning of ecosystems underlying these services, in particular looking at how ecosystems are structured and how they function. The course has a practical ethos and involves fieldwork and analysis of real data. The course looks at the dynamic nature of ecosystems, which often behave as complex systems. The course provides students with the core ecosystem knowledge needed for management.

Learning Outcomes

Student will develop:

- An understanding of the fundamental principles of ecosystem ecology including how ecosystem structure relates to function and the dynamics of ecosystems.
- Appreciation of the diversity of ecosystem functions across time, space and biomes.
- Appreciation of how ecosystems respond to global change drivers including climate change, land use change and biodiversity loss.
- An understanding of ecosystem services, principles of ecosystem valuation and its importance

Pre-requisite

None

Evaluation Procedure: 0.6/0.4 University

Assignment	2	20%	Internal Assessment
Minor Test	3	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1.	Biogeography and evolution • Patterns of species distribution – evolutionary relicts, climatic relicts, endemic organisms, environmental gradients, interaction of factors, species interactions • Natural selection, Darwin's theory	04	

	• Plate tectonics and evolution of biodiversity • Species diversity in the tropics		
2.	Ecological Concepts and Ecosystem • Evolution of natural environment • Introduction: Biotic and abiotic factors • Ecosystem productivity • Food chains and food webs and trophic levels • Energy flows– pyramid of number, pyramid of energy and pyramid of biomass • Patterns and types of bio-geochemical cycles – oxygen, nitrogen, carbon, sulphur and phosphorus • Water cycle • Principles of limiting factors- Liebig's law of Minimum, Shelfords law of tolerance, Combining concepts of limiting factors, limiting factors in ecosystem context • Ecological indicators, Ecotones and concept of edge effect, successional patterns (grasslands to old growth) and response of wildlife	06	
3.	Biodiversity • Definition: species richness, species diversity, biological diversity • Levels of biodiversity: genes to landscapes • Values of biodiversity – direct and indirect • Biogeographic zones of India	02	
	Assignment 1 Discussion and presentation of selected research paper in groups of two students.		4
	Minor test 1		2
4.	Ecosystems • Forests – Biogeography of forests in India, vegetation structure and functions, food chain and food webs, plant-animal interaction, productivity and nutrient cycling, biological diversity of tropical forests, limiting factors, gap theory, threats and conservation. • Grasslands – Biogeography of grasslands in India, structure and function, food chains and food webs, animal population dynamics, limiting factors, threats and conservation • Deserts – Biogeography of deserts in India, structure and function, limiting factors, environmental factors	10	

	and plant-animal distributions, threats and conservation • Mountains – Tropical mountains, structure and function, plant and animal ecophysiology, threats and conservation • Mangroves – structure and function, ecological adaptations of mangroves, plant and animal diversity and interactions, mangrove productivity, food chains and food webs, threats and conservation • Marine ecosystems – structure and function, plant and animal diversity with reference to India, food chains and food webs, threats and conservation • Coral reefs – Distribution, structure and function, coral reef biology, coral reef communities, coral reef biodiversity, threats and conservation • Wetlands/Rivers - Biogeography, structure and function, stratification, food chains and food webs, catchment area concept, threats and conservation.		
5.	Taxonomy • Study of identification and classification characters / Concepts of Taxonomic characters • Morphological features • Overview of the classification systems for each group • Major Classification systems preferred for identification of cryptogams and phanerogams up to order level ▪ Alexopolus, Mims & Blackwell – For Fungi ▪ Natural classification system and APG III • Types of keys and use of floras or identification keys • Plant nomenclature - ICBN Animal taxonomy • Brief classification of animals up to class level for invertebrates and up to order level for vertebrates • Use of Taxonomic Keys for Identification of the animal specimen	12	
	Assignment 2 Seminar presentation by individual students on predecided topics.		5
	Minor Test 2		2
6.	Ecosystem services and ecosystem dynamics	05	

	Ecosystem services - Ecosystem functioning and ecosystem services provided by different ecosystems at present – provisioning services, regulating services, habitat or supporting services, cultural services - Species population and ecosystem services-the connections - Millennium Ecosystem Assessment, TEEB with case studies Ecosystem dynamics - Definition of ecosystem dynamics and its relevance - Changes in ecosystems over different time scales, drivers of ecosystem dynamics (natural and human induced), patterns and elements of ecosystem dynamics with examples		
7.	Valuation of Ecosystem Services - Overview of economic valuation of ecosystems - Key issues in valuation of economics of ecosystems-identifying key stakeholders, key development goals, assessing the status and trends of key ecosystems, engaging stakeholders - Valuation methods – preference based approaches, biophysical based approaches and their limitations - Selecting valuation method and indicators, developing an implementation plan, Capturing the value of ecosystem services, implementing and monitoring - Payments for ecosystem services - Case studies	06	
	Minor test 3		2
	Total	45	15

Suggested Readings

1. Groom M.J., Meffe G.K. and Carroll C.R. (2006) *Principles of Conservation Biology* (3rd edition), Sinauer Associates, Sunderland
2. Gopal, R., 2011. *Fundamentals of Wildlife Management*. Natraj Publishers, New Delhi.
3. Sawarkar, V.B., 2005. *A guide to planning wildlife management in protected areas & managed landscapes*. Natraj Publishers.
4. Primack R.B. (2006) *Essentials of Conservation Biology* (4th ed.), Sinauer Associates, Sunderland.
5. Carabias Julia and Kishore Rao, *Capacity Needs to Manage Protected Areas*, The Nature Conservancy, 2003.
6. Champion S., Seth S, (2005). *Revised survey of forest types of India*. Nataraj Publishers, New Delhi.
7. *Estuaries of India*, ENVIS, 2002.

8. Sustainable management of wetland, biodiversity and beyond. Jyoti Parikh & Hemant Date.
9. Mangroves of India, ENVIS, 2002.
10. Hunter Malcom. Jr, Maintaining Biodiversity in Forest Ecosystems, Cambridge University Press, 1999.
11. Townsend Colin. R, John. L. Harper and Michael Begon, Essentials of Ecology, Blackwell Science, 2000.
12. Owen Oliver. S, Daniel. D. Chiras and John. P. Reganold, Natural Resource Conservation, 7th Edition, 1998.
13. Keddy Paul. A, Wetland Ecology – Principles and Conservation, Cambridge University Press, 2000.
14. Botkin Daniel. B and Edward. A. Keller, Environment Science – Earth as a living Planet, John Wiley and Sons, 2005.
15. Nebel Bernard. J. and Richard. T. Wright, Environment Science, Pearson Custom Publishing, 8th Edition, 2003.
16. Alfred J. R.B, A.K.Das and A.K.Sanyal, Ecosystems of India, ZSI, 2001.
17. Puri, G.S., Gupta, R.K., Meher-Homji, V.M., Puri, S., others, 1989. Forest ecology. Volume 2. Plant form, diversity, communities and succession. Oxford & IBH Publishing Co. Pvt. Ltd.
18. Puri, G.S., Meher-Homji, V.M., Gupta, R.K., Puri, S., others, 1983. Forest ecology. Volume I. Phytogeography and forest conservation. Forest ecology. Volume I. Phytogeography and forest conservation.
19. Venkataraman K., 2012. Fauna of Maharashtra Part 1: Vertebrates Zoological Survey of India
20. Sahara V.B. (2001) *Wildlife in India*, Natraj Publishers, Dehra Dun.
21. Enger, E.D., Ross, F.C., Bailey, D.B., 2003. Concepts in biology. McGraw-Hill Science / Engineering/Math.
22. Grimmett R., Inskipp C. and Inskipp T. (2001) *Pocket Guide to the Birds of the Indian Subcontinent*, Oxford University Press, Oxford.
23. Menon, V., 2014. Indian mammals: a field guide. Hachette India.
24. Sharma, B.D., Karthikeyan, S., Singh, N.P., Flora of Maharashtra State. Botanical Survey of India.
25. Miller, G., Spoolman, S., 2007. Environmental Science: Problems, Connections and Solutions. Cengage Learning.

Journals (to be accessed through JGATE)

1. Ecology
2. Conservation Biology

Course No: CA 101

Course Title: Human Ecology

Number of Credits: 4

No. of Lectures-Tutorial: 42-9

Course Coordinator: Dr. Kranti Yardi

Course Outline

The course applies the principles of ecosystem sciences to the study of the human environment. The emphasis is on the significance and function of ecosystems, how humans have affected these systems over time, and what are the opportunities of and barriers to making positive changes. Dynamical systems' thinking is introduced as a means of comprehending the behaviour of these complex situations. Human-nature interactions over human history are critically reviewed, including hunter gatherer societies, early agricultural societies and modern globalised urban and industrial societies through relevant case studies. Field trips allow students to experience firsthand the complexity of these human-ecological interactions and the challenges of managing them sustainably.

Learning Outcomes

Students will:

- Demonstrate a good understanding of human ecology, including knowledge of the history and background to the topic
- Demonstrate an understanding of key ecosystem and social processes and how they relate to human-nature interactions, and to integrate this understanding with knowledge drawn from their own undergraduate, workplace or research backgrounds
- Use systems approach to 'get at' an understanding of the complex, multi-scaled, interactions that characterize human-ecological situations, and their associated problems
- Understand both opportunities of and barriers to making positive changes in human-nature interaction.
- Develop an ability to critically analyze, evaluate and judge competing perspectives on the environment and development.

Pre-requisite

None

Evaluation Procedure

Assignments	40 % (3)	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment • Completed home assignment submitted timely	Assignments must be in the prescribed I format. One journal may contain assignments of different elective courses separated by a separator. Index must reflect all the assignments	Internal Assessment

		and excellent written presentation	duly signed by the concerned teacher. Marks for every assignment must reflect on the assignment itself.	
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Introduction - Fundamental principles of human ecology - Understanding habitat, community and landscape - Understanding sustainable development	4	
2.	Evolution and human society - Evolution of the ecosystem and growth of human society in different landscapes; hunters and gatherers, pastoralism, agricultural development, urbanization (from prehistory to present) - Human population history; Exponential population growth; positive and negative feedback	10	
2	Perceptions towards nature - Common perceptions of nature; traditional ecological knowledge - Attitudes of religions towards nature - Coevolution and coadaptation of human social systems and ecosystems – coadaptation in traditional social systems and modern systems	8	
	Minor test 1		1
	Assignment 1		4

	Discussion and presentation of selected research paper in groups of three students.		
3	Control, Conflict and Development ▪ Early environment and community debate (forest and community) ▪ Ecological change, development and social tension, human –wildlife conflict ▪ Critical review of community based practices in India using case studies	10	
	Minor test 2		1
	Assignment 2 Seminar presentation by individual students on predecided topics.		2
5	Community Resource Management in practice Joint Forest Management – principles, problems, advantages using case studies Ecodevelopment – Success and the way forward Case studies of national and international practices in community resource management: Critical Analysis	10	
	Minor test 3		1
	Total	42	9

Assignments

In the assignments the students will carry out a review of community-nature interactions that are related to the subject or topics students have worked on during the field trips or any current issue.

Suggested Readings

1. Bernis, C. and M. Sandin. 1987. *Prospecting Human Ecology*. Madrid: Universidad Autonoma de Madrid.
2. Borden, R.J. 1984. *Directory of Human Ecologists*. College Park, MD: Society for Human Ecology.
3. Borden, R.J., J. Jacobs and G.L. Young (eds.). 1985. *Human Ecology: A Gathering of Perspectives*. College Park, MD: Society for Human Ecology.
4. Borden, R.J., J. Jacobs and G.L. Young (eds.). 1988. *Human Ecology: Research and Applications*. College Park, MD: Society for Human Ecology.
5. Borden, R.J. and J. Jacobs. 1989. *International Directory of Human Ecologists*. Bar Harbor, ME: Society for Human Ecology.

6. Cohen, J. 1995. *How Many People Can the Earth Support?* New York: Norton and Co.
7. Eisenberg, E. 1998. *The Ecology of Eden*. New York: Knopf.
8. Grossman, E. 2006. *High Tech Trash: Digital Devices, Hidden Toxics and Human Health*. Washington, D.C.: Island Press.
9. Huib, E. (ed.). 1994. *Pathways to Human Ecology: From Observations to Commitment*. Bern, Switzerland: P. Lang.
10. McDonnell, M.J. and S.T. Pickett. 1993. *Humans as Components of Ecosystems: The Ecology of Subtle Human Effects and Populated Areas*. New York: Springer-Verlag.
11. Miller, J.R., R.M. Lerner, L.B. Schiamberg and P.M. Anderson. 2003. *Encyclopedia of Human Ecology*. Santa Barbara, CA: ABC-CLIO.
12. Nathawat, G.S., Z. Daysh and G.J. Unnithan (eds.). 1985. *Human Ecology: An Indian Perspective*. Jaipur, India: Indian Human Ecology Council.
13. Ostrom, E., T. Dietz, N. Dolsak, P.C. Stern, S. Stonich, and E.U. Weber(eds.). 2002. *The Drama of the Commons*. Washington D.C.: National Academy Press.
14. Pratt, J., G.L. Young and J. Jacobs. 1990. *Human Ecology: Steps to the Future*. Sonoma, CA: Society for Human Ecology.
15. Sargent, F. (ed.). 1974. *Human Ecology*. New York: American Elsevier.
16. Siniarska, A. and F. Dickinson. 1996. *Annotated Bibliography in Human Ecology*. Delhi, India: Kamla-Raj Enterprises.
17. Sontag, M.S., S.D. Wright, G.L. Young and M. Grace. 1991. *Human Ecology: Strategies for the Future*. Ft. Collins, CO: Society for Human Ecology.
18. Suzuki, T. and R. Otsuka. 1987. *Human Ecology of Health and Survival in Asia and the South Pacific*. Tokyo, Japan: University of Tokyo Press.
19. Theodorson, G.A. 1961. *Studies in Human Ecology*. Evanston, IL: Row, Peterson and Co.
20. Wang, R. 1990. *Human Ecology in China*. Beijing, China: China Science and Technology Press.
21. Wright, S.D., R. Borden, M. Bubolz, L. Hens, J. Taylor and T. Webler. 1995. *Human Ecology: Progress Through Integrative Perspectives*. Fort Collins, CO: Society for Human Ecology.
22. Young, G.L. (ed.). 1989. *Origins of Human Ecology*. Stroudsburg, PA: Hutchinson Ross.

Course No: CA 102

Course Title: Wildlife law and trade control

Number of Credits: 4

No. of Lectures-Tutorial: 45-15

Course Coordinator: Adv. Gouri Joshi and Mr. Jose Louis

Course Outline

The course provides an introduction to the wildlife trade scenario in the country/world and the legal instruments available for control of wildlife trade in India. An overview of the international agreements along with in-depth knowledge of anti-poaching plans, wildlife crime investigations are included.

Learning Outcomes

- Demonstrate a good understanding of wildlife trade and contributory factors.
- Develop a deep insight into various legal provisions for control of wildlife trade.
- Demonstrate an understanding of role of forest personnel and communities in prevention of wildlife crime
- Develop skills for conducting a wildlife crime scene search and identifying wildlife parts and products

Pre-requisite

None

Evaluation Procedure

Assignment	2	20%	Internal Assessment
Minor Test	3	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

Unit	Topic	Time (Hours)	
		L	T
1	Overview of wildlife crime in India • Defining wildlife and wildlife crime • Difference between subsistence and sport hunting and commercial poaching and trade • Important species in the illegal wildlife trade- tiger, leopard, lesser cats, canids, otter, civets, martens, rhino, elephant,, musk deer, Tibetan antelope, whale shark, reptiles and amphibia • Global wildlife trade scenario • Methods of poaching-trapping, poisoning,	04	

	shooting, electrocution, netting and snaring, destruction of sites, marine poaching, plant collection		
2	The Indian Wildlife Protection Act (1972) • Understanding various definitions under the WPA • Interpretation of sections under the WPA with detailed examples • Use of case scenarios to understanding applications of sections of WPA	12	
	Minor Test 1		2
3	Forest Acts • The Indian Forest Act 1927 • The Forest (Conservation) Act 1980	6	
4	Other Legal Instruments • Coastal Zone Regulations • Biodiversity Act	6	
	Assignment 1:		5
5	Identification of wildlife parts and products Identification of parts, products and fakes	4	
	Minor Test 2		2
6	Preparing an antipoaching plan for the PA Understanding the ecosystem, conservation history of the area, boundaries of the area , major wildlife species, sensitive area and threats	04	
7	Conducting a criminal investigation • Overview of a criminal investigation • Maintaining of an informer network, intelligence gathering and intelligence analysis • Conducting a sting operation • Conducting a search • Interrogation techniques • Steps for investigating a crime scene • Collecting evidence from crime site • Disposal of confiscated specimens	04	

	Assignment 2		4
8	Legal Control at International Level • CITIES • TRAFFIC • Convention on Biological Diversity • Ramsar Convention • Convention on Migratory Species	05	
	Minor Test 3		2
	Total	45	15

Assignments

In the assignments the students will carry out a review of legal instruments for wildlife conservation or any issue related to wildlife crime or any current issue.

Suggested Readings

1. Mohanty S. K., Environment and Pollution Law Manual, Universal Law Publishing Vompany Ltd., 3rd edition, 2002.
2. Environment and Pollution Laws, Law Publishers, 2000.
3. Leelakrishnan P, Environmental Law in India, Butterworths, 2000.
4. Singh Kuldeep, Environmental Jurisprudence, Modern Law House, 2nd edition 2002.
5. Choudhuri S.K, Environmental Legislations in India, Oxford and IBH Publishing 1996.
6. Pollution Control Acts, Rules and Notifications, Pollution Control Law Series – Volume – I, Central Pollution Control Board, 1992.
7. Conserving Life – Implications of Biodiversity conservations for India, Kalpavriksh, 1994.
8. Convention of Biological Diversity, World Wide Fund for Nature India 1992.
9. Singh Kuldeep, Handbook of Environment, Forest and Wildlife Protection Laws in India Natraj Publishers, 1998.
10. The Environment (Protection) Act and Rules 1986, Law Publishers.
11. Traffic Bulletin, Traffic International.
12. Vanguri Kishore, Environmental Laws in India – A guide, C.P.R. Environmental Education Centre, Madras, 1994.
13. The Water (Prevention and Control of Pollution) Act, 1974 and Rules 1975, Akalank Publications, 1999.
14. The Air (Prevention and Control of Pollution) Act, 1981 Akalank Publication 1999.

15. The Indian Forest Act, 1927 along with Forest (Conservation) Act 1980, Indira Gandhi National Forest Academy, Natraj Publishers 2002.
16. The Wildlife (Protection) Act 1972, Natraj Publishers, 1994.
17. Understanding Biodiversity Law Module, Center of Environmental Education Research and Advocacy (CEERA)
18. Trivedy R.K., Handbook of Environmental Law, Acts, Guidelines, Compliances and Standards, Volume Environment Media, 1996.
19. Nair Manju, The Montreal Protocol – in the Indian Context, Centre for Environmental Law, WWF India, 1996.
20. Environmental Legislation in India – A guide for Industry and Business, Environment Management Division, Confederation of Indian Industry, 1999.

Course No: GEO 102

Course Title: Fundamentals of Geoinformatics

Number of Credits: 4

No. of Lectures-Tutorial: 45-15

Course Coordinator/Instructor: Dr. Shamita Kumar

Course Outline

The course provides a firm understanding of the conceptual and technical issues of geospatial technologies and an overview of applications in various aspects of wildlife, natural resource management, environment management, etc. It introduces the students to the fundamentals of geographic information systems, navigation systems, data models, data sources, cartography as well as multi-criteria analysis.

Learning Outcomes

Students will:

- Demonstrate a good understanding of the use of geospatial technologies in various sectors.
- Demonstrate an understanding of building geo-databases.
- Develop abilities to think about and implement geographic data management and analysis for research and a variety of planning and management applications.

Pre-requisite

None

Evaluation Procedure: 0.6/0.4 University

Assignment	2	20%	Internal Assessment
Minor Test	3	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Introduction to GIS • Overall introduction to the concept of geoinformatics and its application	02	
2	Geographic data and data measurement • Data types and scales of data measurement, sampling methods Map basics • History of cartography, basic characteristics of maps, categories of maps, map scale • Typography and lettering the map, elements of generalization-classification, simplification and	08	

	exaggeration, symbolization-point, line, area, volume Basic geographic concepts Basic geodesy: Spherical, ellipsoidal and geoidal earth, geographical co-ordinates, Co-ordinate systems: Plane co-ordinate system, Geographic co-ordinate system • Map projections: Scale factor and transformation, distortions resulting from map transformations, properties of map projections, classification of map projections, aspects of map projections, some commonly used projections, selection of a particular projection, geo-referencing, relationship between co-ordinate systems and map projections • Geodetic datum-concept and types • Nature of geographic phenomena and measurement of geographical variables		
3	Data Models, data structures and data input • GIS data models: Raster data models-nature, characteristics of raster data, principles of raster data compression • GIS data models: Vector and raster data models-nature, characteristics • Concept of topology, topological relationships between spatial objects • Data input (raster and vector), metadata, data sources for GIS, input of methods of data input, digitization, error identification, types and sources of errors, correction, data editing, topology building.	08	
	Assignment 1 Discussion and presentation of selected research paper in groups of two students.		4
	Minor test 1		2
4	Satellite Navigation Systems (SNS) • Global positioning systems: introduction, GPS segments, GPS satellite generations, current GPS satellite constellation working principle • GPS working principle, GPS signal structure, types of GPS receivers, pseudorange measurements, carrier phase measurements, cycle slips • SNS errors and biases • Methods of SNS observations • SNS applications	06	

4.	Database Management • Introduction to database and database management systems, importance of databases in GIS • Database structures • Database data models: Hierarchical model, network model, relational database model, object oriented data model • Database creation, linking spatial and attribute data, GIS database applications	04	
	Assignment 2 Seminar presentation by individual students on predecided topics.		5
	Minor test 2		2
5.	Data analysis • Measurements • Queries • Buffering and neighbourhood functions • Map overlay • Spatial analysis • Multicriteria analysis • Network Analysis	15	
6.	Application of Geoinformatics • Applications in forestry and wildlife management • Applications in mining • Applications in urban planning • Applications in disaster management • Applications in health studies • Business applications	06	
7.	GIS project design and management • Introduction to GIS project design and management • Problem identification, designing a data model, project management, project design including data sources, image analysis, GIS operations, spatial analysis, time management and implementation problems.	04	
	Minor test 3		
	Total	45	15

Suggested Readings

1. Burrough P. A., R. A MacDonneli, Principles of Geographical Information Systems, Oxford University Press, 2000.
2. Lo. C. P., A.W. Yeung, Concepts and Techniques of Geographical Information Systems, Prentice- Hall of India Pr. Ltd., 2002.
3. Heywood I., S. Cornelius, S. Carrer, An Introduction to Geographical Information Systems, Pearson Education Pvt. Ltd, 2002.
4. Kang-stung-Chang, Introduction to Geographical Information System, Tata McGraw Hill Pub. Comp, 2002.
5. Demers M.N, Fundamentals of Geographic Information Systems, John Wiley & Sons, 2000.
6. Roy P.S., Dwivedi R.S., Vijayan D., 2010 Remote Sensing Applications National Remote Sensing Centre, India
7. Reddy, M.A., 2008. Textbook of remote sensing and geographical information systems. BS publications.
8. El-Rabbany, A., 2002. Introduction to GPS: the global positioning system. Artech House.
9. Arthur Robinson, H., 1958. Elements of cartography, John Wiley and Sons Inc.

Course No: EST 111

Course Title: Field techniques I

Number of Credits: 2

Course Coordinator/Instructor: Dr. Kranti Yardi

Course Outline

The course provides hand on expertise in identifying flora and fauna as well as in depth understanding of ecosystem structure and function through a combination of field visits and lab work.

Learning Outcomes

Students will:

- Develop skills in identifying birds, mammals and major plant species
- Develop an ability to analyze structure of ecosystems.
- Acquire competence in design and implementation of sampling techniques.

Pre-requisite

None

Evaluation Procedure : 0.6/0.4 University

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed Journal submitted timely (within 7 days): 5 marks	Internal Assessment
Major exam	60%		University Assessment

Details of course content

1. Sampling techniques for vegetation analysis using quadrats.
2. Sampling techniques for vegetation analysis using line and belt transects.
- 3A. Identification of birds
- 3B. Identification of birds
4. Identification of bird calls (30 calls)
5. Identification of insects (atleast 30)
- 6A. Identification of plants -visual identification (atleast50)
- 6B. Identification of plants –visual identification
7. Study of identification of non-chordates and Chordates (20 specimens from different Phyla)

8. Study of planktons.
9. Preparation for field work (Use of google earth and other sources for gathering information, planning methods)
10. Methods for assessment and evaluation of ecosystems (frequency, abundance, density, GBH, canopy cover and diversity index)
11. Field work in forest ecosystem – field work in Mulshi (assessment and evaluation)
12. Field work in grassland ecosystem – field work in Supe (assessment and evaluation)
13. Field work in wetland ecosystem – field work in Bhigwan (assessment and evaluation)

Course No: GEO 112

Course Title: Techniques in GIS and GPS

Number of Credits: 2

Course Coordinator/Instructor: Dr. Shamita Kumar

Course Outline

The course provides hand on expertise with use of open source as well as commercial GIS software through a series of well designed practical's related to cartography, building geo databases, querying data, use of GPS and multicriteria analysis.

Learning Outcomes

- Proficiency in use of open source and commercial software for basic GIS operations.
- Ability to use GPS for data collection.
- Ability to build basic geo databases.
- Competence in querying and making GIS analysis.

Pre-requisite

None

Evaluation Procedure : 0.6/0.4 University

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed Journal submitted timely (within 7 days): 5 marks	Internal Assessment
Major exam	20%		University Assessment

Details of course content

1. Introduction to ArcGIS tools
2. Introduction to QGIS (Assignment-self study with discussion)
3. Digital cartography
4. Defining co-ordinate systems and projecting data sets
5. Map registration
6. On screen digitization (Assignment using QGIS)
7. Error identification, rectification
8. Working with tables (Assignment using QGIS)
9. Using the analysis tools in ArcGIS (Assignment using QGIS)

10. Use of GPS and input of GPS data
11. Introduction to Google Earth
12. Data query in ArcGIS (Assignment using QGIS)
13. Performing multicriteria analysis

Course No: EST 104

Course Title: Statistical Methods

Number of Credits: 4

No. of Lectures-Tutorial-Practical: 32-3-22

Course Coordinator/Instructor: Dr. Rahul Mungikar

Course Outline

The course has been designed to help biologists/environmental scientists answer questions of applications of statistics in their field of work. The course focuses on techniques for generating informative data, extraction information from data and to analyze data to get meaningful interpretations.

Learning Outcomes

After the course the student will be able to:

- Apply the appropriate technique for extraction of information from data
- Analyze data using appropriate statistical techniques and software

Pre-requisite

Students are encouraged to join and complete the free online course offered by Harvard University at : <https://www.coursera.org/learn/basic-statistics#syllabus>

Evaluation Procedure : Continuous assessment

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed home assignment submitted timely (within 7 days): 5 marks	Practicals must be in the prescribed journal format	Internal Assessment
Major exam	60%	Theory cum practical examination		Internal Assessment

Details of course content and allotted time

Unit	Topic	Time (Hours)		
		Lectures	T	P
1	Data in Ecology and Environment Sciences • Samples and populations • Accuracy and precision	4		

	- Variables - Derived variables - Frequency distribution - Types of sampling Statistical techniques - Data collection - Organization of data - Representation of data – tabular and graphic			
2	Basic elements and tools of statistical analysis - Measures of central tendency – arithmetic mean, geometric mean, harmonic mean, mode, median - Measures of dispersion – Standard deviation, - Coefficient of variation	2		
3.	Practical 1: Tabulation and graphical representation of the data, estimation of mean, mode, median of different data types using statistical formulae and by graphs			2
4.	Practical 2: Calculation of Standard deviation, coefficient of variation of different data types by different methods.			2
5.	Correlation of measurement - Estimated correlation coefficient - Significance tests for correlation coefficients	2		
6.	Practical 3: Correlation Coefficient and test of significance			2
7.	Concepts of probability Basic laws – Examples from Ecology – Discrete probability distribution – expectation and variance	2		
8.	Practical 4: Calculation of Simple probabilities, Expected Probabilities & Variance, Binomial probability distribution			2
9.	Distribution - Binomial distribution - Normal distribution	5		

	• Poisson distribution • t – test • Chi square test			
10.	Practical 5: Problems based on Poisson and Normal probability distribution			2
11.	Non Parametric • Non parametric tests (Mann-Whitney, Kruskal Wallance, Wilcoxin signed ranks, Spearman etc.)	1		
12.	Contingency tables and χ^2 • Contingency tables • Special case of a table with only two rows • Special case of 2 X 2 tables, exact test for 2 X 2 tables	2		
14.	Practical 6: Problems based ont-test analysis and Chi-square test			2
15.	χ^2- test of goodness – of – fit and homogeneity • Testing the fit of a whole frequency distribution data • Test of homogeneity • Small samples for normal distribution • Binomial and Poisson distribution • Additive property of χ^2 • Normal approximation	3		
16.	Practical 7: Problem based onTest of goodness of fit			2
17.	Practical 8: Introduction to SPSS/R for calculation of various test of statistics			2
19.	Comparison of means • t-test, ANOVA	2		
20	Practical 9: Problems based on ANNOVA – One way, Two way			2
21.	Regression analysis • Regression coefficient • Standard errors and significance tests	4		
22.	Practical 10: Problems based on regression analysis			2

23.	Introductory Multivariate Statistics and Partial correlation	5		
24.	Practical 11: Problems based on Regression coefficient, standard errors			2
	Final Assessment		3	
	Total	32		22

Suggested Readings

1. Clark, J. S. Models for Ecological Data: An Introduction. Princeton University Press Princeton, New Jersey, USA, 2007.
2. Legendre, P., and L. Legendre. Numerical Ecology. Vol. 20. Elsevier, 2012.
3. Ott, L., and M. Longnecker. An Introduction to Statistical Methods and Data Analysis. Duxbury press, 2010.
4. Sokal, R.R. and Rohlf, F.J. 1995. Biometry: the principles and practice of statistics in biological research. 3rd edition. New York.
5. Zar J.H. 1999. Biostatistical Analysis. Prentice Hall, New Jersey, 663 pp.

Course No: EST 105

Course Title: Fundamentals of computing and database

Number of Credits: 4

No. of Lectures-Tutorial-Practical: 26-10-24

Course Coordinator/Instructor: Mr. Anand Shinde

Course Outline

The course will introduce basic software programming and use of database software. It focuses on the fundamentals of computer science, database systems, programming languages, data types, etc.

Learning Outcomes

At the end of the course the student will:

- Have a understanding of databases and building databases
- Ability to write simple programs

Pre-requisite

Students are strongly encouraged to complete the following free online courses:

<http://www.studytonight.com/dbms/>

<https://www.learnstreet.com/lessons/study/javascript>

http://www.w3schools.com/js/js_intro.asp

Evaluation Procedure :Continuous

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed home assignment submitted timely (within 7 days): 5 marks	Practicals must be in the prescribed journal format	Internal Assessment
Major exam	60%	Theory cum practical examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	T	P
1	Hardware and Software • Memory management and File associations • Computer languages • Overall functioning of operating system and other application software's	2		

2	Problem Solving techniques - Algorithms - Flowcharts	6		
	Practical 1 : Preparing flowcharts and algorithm based on specific problems			2
3	Database fundamentals - Properties of a database - Database models and objects - Components of DBMS, DBMS Functions - Advantages and disadvantages of DBMS - Data types - Introduction to Fields, Tables, Database, Understanding forms and its controls	6		
	Practical 2: Creating Database (table, records, fields and data types). Data sorting, Data filtration, pivot table, graphs and reports			2
	Practical 3: Create module and reports using tables			2
4	Relational Database Components - Logical/Physical database design components - Form based database queries – creating queries - Introduction to SQL – Data Query Language - Designing tables and constraints	6		
	Practical 4: Create database schema, append data, update data and schema, delete data and structure. Assigning constraints to table			2
5	Programming using macros in excel - Introduction to macro programming - Macros with worksheet, forms and controls	4		
	Practical 5: Developing and testing macros in VBE. Excel macro recorder			2
	Practical 6: Working with statements, functions, variables, events			2
	Practical 7: Working with forms, controls and events			2
6	Introduction to programming Introduction to Javascript programming	10		

	• Understanding structure of JavaScript code • Understanding types and objects • Control statements and functions • Understanding Object-Oriented Features, Class and Objects, Data Hiding and Encapsulation, Structures, Data members and Member functions. • Data Members and Member Functions, Constructors & Destructors, Roles and types of Constructors, Roles of Destructors			
	Practical 8: Study of javascriptstructure, types and objects			2
	Practical 9: Study of data members , functions, controls statements, Operators			2
	Practical 10: Study of object oriented concepts			2
	Minor Test 3		2	
	Total	34	6	20

Suggested Readings

1. Microsoft Excel 2010, 1 edition. ed, 2010. . Microsoft Press, Redmond, Wash.
2. Hunt Roger, Computer and Common senses, Prentice Hall of India, New Delhi, 1995.
3. Oka Milind M, Computer Fundamentals, Everest Publishing House, Pune, 2001.
4. Rajaraman V, Fundamentals of Computers, Prentice Hall of India Pvt.Ltd, New Delhi, 2000.
5. Jain V. K, Basic Computer Programming, Pustak Mahal, 1992.
6. Sinha Pradeep and Priti Sinha, Computer Fundamentals, BPB Publications, 2006.
7. Groff James and Paul Weinberg, The Complete Reference, Tata McGraw Hill Edition, 2003.
8. Paul Wilton & Jeremy McPeak, Beginning JavaScript (4th Edition), Wrox Press
9. David Flanagan, JavaScript - The Definitive Guide (6th Edition), O'Reilly
10. Roger Hunt & John Shelley, Computer and Commonsenses, Prentice Hall of India Pvt. Ltd
11. Dr.Milind M. Oka, Computer Fundamentals, Prentice Hall of India Pvt.Ltd.
12. Paul Wilton Johncolby, Beginning SQL, 2005, Wiley Publishing Inc. India Pvt Ltd.
13. James R. Groff and Paul N, Weinbery, The Complet Reference SQL,2002, Tata McGraw Hill New Delhi
14. Sumathi, S., 2008. Fundamentals of Relational Database Management Systems. Springer.

SEMESTER II

Course No: EST 201

Course Title: Biodiversity Assessment and Conservation

Number of Credits: 4

No. of Lectures-Assignments-Tutorial/Examination: 45-20-03

Course Coordinator: Dr. Kranti Yardi

Course Outline

The course focuses on the essential concepts and skills related to biodiversity conservation and assessment. This includes understanding threats to biodiversity, assessing biodiversity at various levels, concepts of landscape ecology and habitat management. It elucidates the perspectives of science and management of biodiversity in the context of current and future strategies needed for biodiversity conservation.

Learning Outcomes

Students will :

- Develop a deep understanding of the threats to biodiversity
- Develop skills of assessing biodiversity with different methodologies
- Develop a comprehensive understanding of issues in planning conservation areas and managing habitats.
- Acquire the ability to construct a conservation action plan for a species or site

Pre-requisite

EST 101

Evaluation Procedure : 0.6/0.4 University

Assignment	2	20%	Internal Assessment
Minor Test	3	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	A	T/E
1	Overview of biodiversity • Status of biodiversity • Biodiversity at regional and landscape levels • Biodiversity at ecosystem, community and population levels	05		
2	Threats to biodiversity • Loss of biodiversity – past rates of extinction, human caused extinctions, extinction rates on islands, island biogeography and extinction rates,	06		

	case studies • Vulnerability to extinction – Endemic species, case studies • Habitat destruction, fragmentation and degradation • Exotic species introductions and disease • Problems of small populations – loss of genetic variability, demographic variation, environmental variations			
	Minor Test 1			01
3	Assessment of biodiversity • Types of sampling – Qualitative and quantitative assessment techniques for mammals, birds, butterflies, plants. • Estimation of density, frequency and abundance of the species • Indices associated with species diversity, species similarity, temporal and spatial rate of change in species population • Alpha, Beta and Gamma diversity • Statistical approach to assessment of biodiversity • Software for biodiversity assessment	12		
	Minor Test 2			01
4	Planning Conservation Areas • Criteria for conservation – Conservation status, generalists and specialists; population size, sex and age classes, species restricted in distribution, isolated populations, habitat specialists and habitat obligates, species under illegal trade; key ecological functions of species; utility of the species • Approaches to conservation – species approach (featured species), management indicator species, species guild approach, flagship species approach, keystone species, ecosystem approach • Tools used for conservation – Population assessments, Gap analysis, habitat evaluation, GIS • Design criteria – habitat constituents, reserve design, reserve shape and size, population size, need for buffers, wildlife corridors, landscape	12		

	connectivity, administrative, political and economic considerations			
	Assignment 1 and 2: Field work in National Park followed by presentation		20	
5	Habitat Management • <i>Insitu</i> management – categories of biotic factors and their pressures- livestock grazing, fire wood collection, non wood forest produce collection, fires, encroachments, mining and quarrying, weeds and weed infestations (Invasive species), large scale monocultures, soil erosion, timber smuggling, poaching, development activities that are insensitive to ecological integrity, vandalism, unregulated tourism; • Eco-restoration- habitat restoration techniques and monitoring • Wildlife management plans.	10		
	Minor test 3			01
	Total	45	20	03

Suggested Readings

1. Alexander, M. Management Planning for Nature Conservation: a Theoretical Basis & Practical Guide. Springer, 2008.
2. Groves, C. Drafting a Conservation Blueprint: a Practitioner's Guide to Planning for Biodiversity. Island Press, 2003.
3. Margules, C., S. Sarkar, and C. R. Margules. Systematic Conservation Planning. Cambridge University Press, 2007.
4. McNeely, J. A. Expanding Partnerships in Conservation. Island press, 1995.
5. Postel, S. et al. Nature's Services: Societal Dependence on Natural Ecosystems. Island Press, 1997.
6. Smith, D. S., and P. C. Hellmund. Ecology of Greenways: Design and Function of Linear Conservation Areas. University of Minnesota Press, 1993.
7. Sutherland, W. J. Conservation Science and Action. Blackwell Science Ltd, 1998.
8. Sutherland, W. J., and D. A. Hill. Managing Habitats for Conservation. Cambridge University Press, 1995.
9. Sutherland, W. J., I. Newton, and R. E. Green. Bird Ecology and Conservation: a Handbook of Techniques. Oxford University Press, USA, 2004.

Course No: CA 201

Course Title: Wildlife Health, Rescue and Rehabilitation

Number of Credits: 4

No. of Lectures-Tutorial: 45-20-03

Course Coordinator: Dr. Kazveen Umrigar

Course Outline

The course provides in depth understanding of the various issues involved in wildlife health, capturing and handling wild animals, wildlife forensics and conservation breeding along with wildlife rehabilitation.

Learning Outcomes

At the end of the course, students will:

- Demonstrate a basic knowledge of complexities involved in animal welfare, wild animal health, conservation breeding, rehabilitation of wild animals
- Resolve applied ecological problems using basic biological information

Pre-requisite

EST 101, EST 201

Evaluation Procedure : 0.6/0.4 University

Assignment	2	20%	Internal Assessment
Minor Test	3	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Wildlife Health • Introduction to disease and epizootiology • Determinants of disease and disease transmission, disease and population dynamics • Review of major viral, bacterial, protozoan, fungal and parasitic diseases of Indian wild mammals, birds, amphibians and reptiles. • Noninfectious diseases – nutritional diseases, poisoning, stress, shock, capture, myopathy, physical trauma	8	

	- Emerging and reemerging diseases, zoonosis - Assessment of condition, health and nutritional status in free ranging populations, disease control operations.		
2	Capture and handling of wild animals - Capture and handling of wild animals –purpose, restraint techniques, different capture methods and animal barriers - Drug immobilization – drug delivery equipment and accessories - Immobilization drugs – action, dosage, response and side effects, safety measures, complications - Handling and transport of wild animals, designing sledge, crate and holding enclosures	5	
	Minor Test 1		1
	Assignment 1 Discussion and presentation of selected research paper in groups of two students.		4
4	Conservation Breeding - Captive breeding and propagation; Founder population, rehabilitation, education, utilization, gene banks - Ex-situ and in-situ linkages - Conservation breeding management plans - Role of scientific institutions and NGOs in conservation breeding programs - Principles of conservation breeding – understanding biological requirements of species, design of facilities, food, hygiene, disease control, breeding - Propagation of threatened plants ; Case studies - Case studies on conservation breeding program of endangered wild animals	10	

5	Wildlife Utilization • Non-consumptive and consumptive utilization, their economic benefit • Game ranching and controlled off-take from wild population, rationale, management design, harvesting by management or hunting licenses, marketing procedures • Use of wildlife products – skins, meat, musk, etc. • Wildlife tourism – objectives, planning and economics	06	
	Assignment 2 Seminar presentation by individual students on predecided topics.		5
	Minor Test 2		2
6	Wildlife rehabilitation • Approaches to establish new populations - Wildlife introduction, reintroduction and rehabilitation programs • Considerations for successful programs - social behavior of released animals, selection of animals, enabling field conditions, monitoring of released animals • Case studies	06	
	Minor Test 3		1
	Total	45	15

Assignments

In the assignments the students will carry out a review of issues involved in wildlife capture and rehabilitation or present a poster synthesizing any aspect of the course demonstrating an ability to use varied literature sources and present a coherent story of applied or theoretical interest.

Suggested Readings

1. Atkinson, C. T., N. J. Thomas, and D. B. Hunter. Parasitic Diseases of Wild Birds. Wiley Online Library, 2008.

2. Avise, J. C. "The History, Purview, and Future of Conservation Genetics." Conservation biology: evolution in action. Oxford University Press, New York (2008): 5–15. Print.
3. Avise, J. C., and J. L. Hamrick. Conservation Genetics. Springer, 1996.
4. Frankham, R., J. D. Ballou, and D. A. Briscoe. A Primer of Conservation Genetics. Cambridge University Press, 2004.
5. Introduction to Conservation Genetics. Cambridge University Press, 2002.
6. Grenfell, B. T., and A. P. Dobson. Ecology of Infectious Diseases in Natural Populations. Vol. 7. Cambridge University Press, 1995.
7. Hoff, G. L., and J. W. Davis. Noninfectious Diseases of Wildlife. Iowa State University Press, 2121 South State Avenue, 1982.
8. Hudson, P. J. et al. Ecology of Wildlife Diseases. Oxford University Press, 2002.
9. Loeschcke, V., and J. Tomiuk. Conservation Genetics. Vol. 68. Birkhäuser, 1994.
10. Nielsen, L., and R. D. Brown. "Translocation of Wild Animals." Translocation of wild animals. (1988)
- 11.** Nunn, C. L., and S. Altizer. Infectious Diseases in Primates: Behavior, Ecology and Evolution. Oxford University Press, 2006.

Course No: EST 205

Course Title: Research Methodology

Number of Credits: 2

No. of Lectures-Assignments: 20-50

Course Coordinator: Dr. Shamita Kumar

Course Outline

The course will provide students with a critical understanding of the research process and familiarize students with the main approaches, methods and techniques of qualitative and quantitative research. The course will enable students to undertake their own independent research and apply appropriate research methodologies in order to plan, conduct and evaluate basic research as part of their degree and provide a solid foundation for further advanced research.

Learning Outcomes

- Ability to identify various sources of information and write up a literature review
- Planning and conducting basic qualitative and quantitative research
- Ability to write an introduction and methodology

Evaluation Procedure: Continuous

Assignments	1. Chapter on literature review of the individual students' thesis 2. Chapter on Methodology of the individual students' thesis

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	A
1.	Research Design: Overview • Understanding research • The qualitative/quantitative divide • Overview of different research traditions – action research, case studies, documentary analysis, ethnographic research, experiments, grounded theory, surveys	02	
2.	Planning the research • Selecting a topic • Topic to research question – problem definition, research question, hypothesis, research objectives • Research question to research design –developing the design	02	

	• Data gathering – primary and secondary		
3.	Literature Review • Introduction to literature review • Methodology of literature review • Literature sources – books and journals, electronic databases, government and industry, internet • Writing a literature review • Referencing – systems, referencing websites, citations, use of software	04	
5.	Qualitative Research • Qualitative data collection techniques: collecting secondary data - journals, existing documents and records, etc.; collecting primary data – sampling need and design, pilots, techniques- surveys, questionnaires and rating scales, checklists, observations, interviews-structures, semi structured and open • Analyzing data: quantitative analysis, qualitative analysis	06	
6.	Ethical Considerations • Ethics committee, ethical guidelines – voluntary participation, informed consent, confidentiality and anonymity, plagiarism, academic fraud and misinterpreting results, conflict of interests, observation, permissions, video/audio taping	02	
	Exercise 2: Designing/ formatting a questionnaire/interview for a given problem Conducting a semi structured interview and analyzing data (with the upcoming field work in March)		10
7.	Writing up the research • Grammar, punctuation and conventions of academic writing -Tense, gender neutral language, referencing, use of notes and footnotes, English and American spellings, abbreviations, consistency • Writing an introduction	04	

	• Writing the methodology		
	Assignment 1: Writing the introduction chapter of the students own thesis		10
	Assignment 2: Writing the literature review and methodology chapter of the students own thesis		20
	Total	20	50

Assignments

The separate assignments will result in a single document – the research proposal of the student.

Suggested Readings

1. Becker, H. S. Writing for Social Scientists: How to Start and Finish Your Thesis, Book, or Article. University of Chicago Press, 2007.
 2. Creswell, J. W., and V. L. P. Clark. Designing and Conducting Mixed Methods Research. Wiley Online Library, 2007.
 3. Denzin, N. K., and Y. S. Lincoln. The Sage Handbook of Qualitative Research. Sage Publications, Incorporated, 2005.
 4. The SAGE Handbook of Qualitative Research (3 Rd. Thousand Oaks, CA: Sage, 2005.
 5. Hart, C. Doing a Literature Review: Releasing the Social Science Research Imagination. Sage Publications Limited, 1999.
 6. Malmfors, B., P. Garnsworthy, and M. Grossman. Writing and Presenting Scientific Papers. Nottingham University Press UK, 2004.
 7. Morrison, M. L., B. Marcot, and W. Mannan. Wildlife-habitat Relationships: Concepts and Applications. Island Press, 2006.
 8. O'Connell, A. F., J. D. Nichols, and K. U. Karanth. Camera Traps in Animal Ecology: Methods and Analyses. Springer, 2010.
 9. O'Leary, Z. The Essential Guide to Doing Research. Sage Publications Limited, 2004.
 10. The Essential Guide to Doing Your Research Project. Sage Publications Limited, 2009.
 11. Peat, J. et al. Scientific Writing: Easy When You Know How. BMJ books, 2007.
 12. Ridley, D. The Literature Review: a Step-by-step Guide for Students. Sage Publications Limited, 2012.
 13. Silverman, D. Doing Qualitative Research. Sage Publications Limited, 2009.
- Torraco, R. J. "Writing Integrative Literature Reviews: Guidelines and Examples." Human Resource Development Review 4.3 (2005): 3

Course No: GEN 302

Course Title: Communication

Number of Credits: 2

No. of Lectures-Tutorial: 24-8

Course Coordinator: Dr. Shamita Kumar

Course Outline

The course provides an outline of how to develop communication skills with an emphasis on scientific writing, proposal preparation and scientific but attractive way of presentation of research findings along with proper means of audio-visual documentation. The course prepares students to think, read and write scientific papers; conceptualize, frame and prepare complete project proposals and also will help them to realize the basics of audio-visual communication systems.

Learning Outcomes

The student will be able to:

- Think, read and prepare scientific manuscripts
- Conceptualize, frame and prepare project proposals
- Prepare oral presentations and posters
- Document, edit and publish findings in field and related topics

Pre-requisite

None

Evaluation Procedure

Assignment	1	50%	Internal Assessment
Assignment	2	50%	Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Technical writing Outlining content • Organizing content: Checklist for components of journal articles and research papers • Difference between Abstract and Executive Summary • Writing an Introduction and Conclusion • Using logic to present content: the building blocks of analytical writing • Using graphics to represent data: making data more readable and using graphics to present analysis	8	

	• Using keywords to enhance search: Effective use of keywords to enhance online reach of your articles Using language effectively • Using effective words and editing content: Using a tool kit for writing; what to avoid when writing • Creating flow of information: understanding the difference between listing or cataloguing details and analyzing and interpreting them for your reader Submitting papers • Understanding submission guidelines • Using appropriate resources • Handling manuscript rejections		
	Assignment 1		
2	Preparing project proposals • Mapping the donor needs to organisational needs • Structuring content • Specifying deliverables and timelines • Asking for commitment • Checklist for a complete proposal	6	
3	Oral and Poster Presentations • Designing the presentation and flow of content • Communicating with the audience: verbal and non-verbal soft skills • Using visuals effectively: basics of using graphics, illustrations and copyright issues	4	
	Assignment 2		
4	Visual Documentation • How to take a good picture • Videos • Video documentation and editing clips with movie maker • Using keywords for cataloguing and for online search engine optimization	6	

Course No: GEN 202

Course Title: Project Management

Number of Credits: 2

No. of Lectures-Tutorial: 18-20

Course Coordinator: Mr. Parag Khataavkar

Course Outline

The course provides an overview of techniques of project management with an emphasis on project management, organizational structures, teams, functions, planning, scheduling, cost controls, trade-offs, risk management and other related topics. The course prepares students to conceptualize, implement, monitor and evaluate the project.

Learning Outcomes

The student will:

- Construct, organize and explain project management.
- Devise, plan and compile work breakdown structures (WBS) and understand life cycle phases as quantitative tools in project management.
- Design, generate and explain scheduling techniques.

Pre-requisite

None

Evaluation Procedure: Continuous

Assignment	1	100%	Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	A
1	Introduction to project management • Definition and attributes of project and project management • Strategy in project management – establishing objectives, scoping the boundaries, priority setting, strategic development • Understanding project management and resistance to change • Project management life cycle • Critical success factors in project management • Best practices in project management	06	

	• Project monitoring		
2.	Project management methodologies • Modeling the project system – WBS, responsibility, communication plan • Estimations in projects – basic, time, cost, resources, techniques, guidelines • Developing project plans – Gantt charts, evaluating and constructing networks • Overcoming development and implementation barriers • Critical components of project management • Implementing a methodology • Strategic planning for project management	06	
3.	Issues in project management • Management Styles • Project Management Skills • Involvement of senior managers and stakeholders • Identification of projects • Project management information systems • Risk management • Change management • Role of culture in project management	06	
	Assignment		15
	Total	18	20

Assignments

In the assignments the students will be expected to design WBS, review of best practices in project management, role of change management, etc.

Suggested Readings

1. Baker, B. N., D. C. Murphy, and D. Fisher. "Factors Affecting Project Success." Project Management Handbook, Second Edition (2008): 902–919.
2. Dyball, R., and M. Keen. Social Learning in Environmental Management: Towards a Sustainable Future. Routledge, 2012.
3. Kerzner, H. Advanced Project Management: Best Practices on Implementation. Wiley, 2003.

4. Project Management: a Systems Approach to Planning, Scheduling, and Controlling. Wiley, 2009.
5. Strategic Planning for Project Management Using a Project Management Maturity Model. Wiley, 2002.
6. Meredith, J. R., and S. J. Mantel Jr. Project Management: a Managerial Approach. Wiley, 2011.

Course No: EST 211

Course Title: Field Techniques II

Number of Credits: 2

Course Coordinator: Dr. Kranti Yardi

Course Outline

The course provides hand on expertise with using various quantification techniques and tools for wildlife assessment including use of advanced equipment's like camera traps, bat detectors, mobile mappers, etc.

Learning Outcomes

Students will develop:

- Proficiency in using quantitative assessment techniques
- Ability to use mobile mappers, camera traps and other equipment for data collection.

Evaluation Procedure: 0.6/0.4 University

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed Journal submitted timely (within 7 days): 5 marks	Internal Assessment
Major exam	60%		University Assessment

Details of course content

1. Assessing plant diversity by belt transect method.
2. Assessing plant diversity by point count and PCQ method.
3. Calculating plant diversity index.
4. Estimating bird density by distance sampling –line transect and point count methods
5. Assessment of selected sites for measurement of species richness and diversity of birds.
6. Calculation of bird diversity index.
7. Planning a census operation
8. Estimation of animal populations using any one of (block counts, road counts, King census method)
9. Estimation of animal population using indirect evidence (pugmarks, dung)
10. Ecological assessment of a given area
11. Conducting Participatory Rural Appraisal using household surveys.
12. Conducting Participatory Rural Appraisal using participatory mapping.
13. Conducting Participatory Rural Appraisal using matrix scoring.
14. Conducting Participatory Rural Appraisal using seasonality calendar

Course No: EST 206
Course Title: Natural Resource Management
Number of Credits: 4
No. of Lectures-Tutorial: 45-20-03
Course Coordinator: Dr. Kranti Yardi

Course Outline

The course is intended to impart knowledge and skills considered crucial for natural resource managers to manage effectively in the dynamic and intricate environment. It enhances the students' understanding at diverse levels by maintaining the equilibrium between the occupation obligations and enduring growth requirements. The fundamental thrust of the course is to assist the students to obtain theoretical and logical abilities in relation to the field situations, necessary for managing natural resources efficiently.

Learning Outcomes

The student should be able to:

- Contribute in managing the resource in a comprehensive way as professionals working in this sector
- Balance the needs of people and the economy with protecting the ability of ecosystems to support soil, water, forests, wildlife, fish, recreation, and other resources

Evaluation Procedure: Continuous

Assignments	40 %	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment : 5 marks • Completed home assignment submitted timely and excellent written presentation (within 7 days): 5 marks	Assignments must be in the prescribed journal format. One journal may contain assignments of different elective courses separated by a separator. However each course must have a separate index duly signed by teacher. Marks for every assignment must reflect on the	Internal Assessment

			assignment itself.	
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	A	T/E
1.	Fundamental of Natural Resources - Ecology and ecosystems: concept of sustainability - Earth and water resources - Environment, energy and technology - Natural resource governance and policy	8		
2.	Theoretical aspects of Natural Resource Management - Environmental Monitoring Assessment – basic, time, cost, resources, techniques, guidelines - Natural Resource Economics - Society, Ethics and Participatory Development - Environmental Impact Assessment (EIA) and Auditing - Livelihoods and Natural Resources	8		
	Assignment 1: Discussion and presentation of selected research paper in groups of two/three students.		05	
3.	Integrated watershed management - Definition of watershed - Watershed development strategy - Socio-economic and natural resource information through PRA's - Land surveys through land class determination for area, slope, depth of soil, texture, erodability; soil and water testing - Engineering surveys – topographical surveys, drainage line survey, contour survey - Ecological assessment of the area – A statement of significance; site description-significant habitat types,	12		

	native species of wild plants and animals of conservation importance, significant corridors, biotic pressures and threats, significant ecological services. People and their relationship with natural areas (valid and invalid stakes). • Microplanning – microplanning process, difficulties faced during microplanning, advantages of microplanning • Principles of soil and water conservation			
	Assignment 2: Ecological assessment of a given area		05	
	Assignment 3: Collection of data using GIS compatible participatory rural appraisal technique		05	
4	Analytical aspects of Natural Resource Management • Remote sensing and GIS application in NRM • Statistical analysis in NRM • Vegetation inventory and rapid assessment • Financial analysis and project management in NRM	09		
5	Managerial aspects of Natural Resource Management • Wildlife conservation and management • Wetland management • Watershed management • Urban forestry, biodiversity and landscape • Climate change and carbon trading • Agro-ecosystems and Agro forestry • Environmental modeling • Eco-tourism and other environmental services • Bio-resources	18		
	Assignment 4: Field visit report		05	
	Final Assessment			03
	Total	45	20	03

Assignments

In the assignments the students will be expected to review the fundamental aspects of NRM, to solve hypothetical/practical NRM related problems using theoretical and statistical knowledge gained, to design management plans for different natural resources in specific areas and to discuss advanced aspects of NRM in Indian context.

Suggested Readings

1. Francois Ramade 1984. Ecology of Natural Resources. John Wiley & Sons Ltd.
2. Coastal Ecology & Management, Mann, K.H. 2000. Ecology of Coastal Waters with Implications for Management (2nd Edition). Chap. 2-5, pp.18-78 & Chap. 16, pp.280-303.
3. Global Change and Natural Resource Management, Vitousek, P.M. 1994. Beyond global warming: Ecology and global change. Ecology 75, 1861-1876.
4. Agarwal, K.C., 2001. Environmental Biology, Nidhi Publication Ltd. Bikaner.
5. Cunningham, W.P. Cooper, T.H. Gorhani, E & Hepworth, M.T. 2001, Environmental Encyclopedia, Jaico Publishing House.
6. Heywood, V.H. & Watson, R.T. 1995. Global Biodiversity Assessment. Cambridge Univ. Press.
7. Miller T.G. Jr. Environmental Science, Wadsworth Publishing Co. (TB)
8. Townsend C., Harper J, and Michael Begon. Essentials of Ecology, Blackwell Science.
9. Barber, E. 1989. Economics: Natural Resources Scarcity and Development. Earthscan.
10. Harris, J.M. 2006. Environmental and Natural Resource Economics: A Contemporary Approach, 2nd edition. Houghton Mifflin.

Course No: EST 401

Course Title: Eco-restoration, Eco-development and Ecotourism

Number of Credits: 4

No. of Lectures-Tutorial/Assignment: 35-25

Course Coordinator: Dr. Rahul Mungikar

Course Outline

The objectives of the course are to make students familiar with the restoration methods of different fragile ecosystems such as wetlands as well as develop an understanding of restoring degraded waste land in urban landscape. The ecotourism section of the syllabus will familiarize students with using this approach for community involvement in the conservation scenario with special emphasis on Indian context.

Learning Outcomes

The student should be able to:

- Have a deep understanding of eco-restoration including different approaches applicable for the restoration practices of different landscapes.
- Design an eco restoration program for a specific ecosystem
- Design an ecotourism plan for a given location.

Pre-requisite

None

Evaluation Procedure : Continuous

Assignments	40 %	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment : 5 marks • Completed home assignment submitted timely and excellent written presentation (within 7 days): 5 marks	Assignments must be in the prescribed journal format. One journal may contain assignments of different elective courses separated by a separator. However each course must have a separate index duly signed by teacher. Marks for every assignment must	Internal Assessment

			reflect on the assignment itself.	
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T/A
1	Fundamentals of Eco-restoration • Definition and different concepts of eco-restoration • Restoration of degraded waste land • Restoration of degraded forests and soil fertility • Groundwater restoration • Restoration of wetlands and coastal habitats • Restoration of habitats in urban and industrial areas • Indicators for restoration and reclamation	10	
	Assignment 1		05
2	Fundamentals of Eco-development • Definition and concepts of development and concepts of sustainability • Brundtland commission • Sustainable agriculture and forestry • Sustainable fisheries • Sustainable earth economy • Environmental world-views and ethical issues in eco-development concept	08	
	Assignment 2		05
3	Fundamentals of Ecotourism • Definition and historical background	10	

	• Identification of potential sites for ecotourism • Conventional and mass tourism • Role of parks and gardens • Community involvement in the process of ecotourism		
	Assignment 3		05
4	Ecotourism development and management • Role of photography in promotion of ecotourism • Measures of minimizing environmental impacts • Trends and future of ecotourism • Impact of ecotourism—Awareness, Education, Recreation, Conservation and Economic development	07	
	Assignment 4		07
	Final assessment exam		03
	Total	35	25

Assignments

In the assignments the students will be expected to review the fundamental aspects of eco-restoration, to create hypothetical/practical ecologically sound developmental schemes, and to develop ecotourism plans for new areas and to review the existing ecotourism practices in India.

Suggested Readings

1. Hammitt, W.E. & Cole D.N. 1998. Wildland Recreation: Ecology and Management, 2nd Ed. New York: John Wiley & Sons. 361 pp. (ISBN: 0-471- 19461).

Liddle M. 1997. Recreation Ecology: The Ecological Impact of Outdoor Recreation and Ecotourism. New York: Chapman & Hall. 639 pp.

3. Mieczkowski, Z. 1995. Environmental Issues of Tourism and Recreation. Lanham, MD: University Press of America. 552 pp.

4. Wall G. & Wright C. 1977. The Environmental Impact of Outdoor Recreation. Publication Series No. 11. Department of Geography. Waterloo, Ontario: University of Waterloo. 69 pp.

5. Higgs, E. 1997. What is Good Ecological Restoration? *Conservation Biology*, pp. 338-348.
6. Egan, B. 1998. Ecological Restoration for British Columbia. *British Columbia Environmental Report*, pp. 7-9.
7. Martha Honey 1999. *Ecotourism and sustainable development*, Island Press, Washington DC
8. Martin Mowforth and Ian Munt 1998. *Tourism and sustainability*, Routledge, U.K.
9. B.K. Tiwari, Surendra Singh 1995. *Ecorestoration of degraded hills*.
10. Robert U Ayres, Paul M Weaver. *Ecorestructuring: Implications for sustainable development*. IN-05457.
11. R.B. Jain. *Environmental Stewardship and Sustainable Development* IN-04021.
12. G. Tyler Miller, Jr. 1996. *Living in the Environment*, Wadsworth Publishing Company, California.

Course No: EST 208

Course Title: Climate change science and strategies

Number of Credits: 4

No. of Lectures-Tutorial: 45-20-03

Course Coordinator: Mr. Parag Khatavkar

Course Outline

Global climate change is a planetary scale phenomenon that impacts upon all socioeconomic and natural systems. Despite the growing consensus about the fundamentals of climate warming, scientific understanding of the complex interactions of ocean, land, clouds, and atmosphere remains highly uncertain, particularly with respect to environmental, social, and economic disruptions affecting human societies. This course will provide students with the scientific literacy to understand the issue itself and consider existing solutions such as the Kyoto Protocol, voluntary measures, etc. The guiding principle will be to promote the understanding needed to evaluate, develop, and propose emerging and creative solutions at individual, campus, and local levels. This course will examine the dilemmas faced in climate science, politics, economics, management, and ethics – all with an eye to the implications for global and regional sustainability.

Learning Outcomes

The student should be able to:

- Think intelligently about the issue and to understand what processes are currently underway and what more can be undertaken.
- Understand the precarious feedbacks from the climate system that could create dramatic impacts.
- Understand, plan and propose creative solutions at temporal, spatial, political, scientific, and social scale.

Evaluation Procedure: 0.6/0.4 University

Continuous assessment during assignments	40 %	Marking pattern for every assignment: • Evidence of clear line of thinking, written up well • Excellent presentation	Internal Assessment
Major exam	60%		University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	A	T/E
1	Climate science and impacts • Introduction: overview of the topic • Climate change: cause and effect • Climate disruption • Impact analysis: freshwater sources and oceans • Impact analysis: food and forests • Economic impacts of climate change	10		
	Assignment 1: Discussion and presentation of selected research paper in groups of three students.		05	
2	Policies and market issues • International treaties • Carbon trade and taxation • Strategies for low cost carbon abatement • Climate policy: global scenario • Climate policy: Indian scenario • Green business initiatives	10		
	Assignment 2: Discussion and presentation of selected research paper in groups of three students.		05	
3	Climate solutions • Energy solutions: past and present • Transportation • Building and habitation • Industry and waste management • Land use, agriculture and forestry • Adaptation and tropical forest sequestration • Geo-engineering of earth's atmosphere	15		
	Assignment 3 : Discussion and presentation of selected research paper in groups of three students.		05	
4	Future direction • Mobilizing the world to action • Trends and futures of food scarcity solutions • Trends and futures of green and clean energy supply and consumption • The negotiating challenges ahead	10		
	Assignment 4: Discussion and presentation of selected		05	

	research paper in groups of three students.			
	Final Assessment			03
	Total	45	20	03

Assignments

In the assignments the students will be expected to express their view on promise and limitations of sustainability ideas and practices for dealing with climate threats. They will also be expected to understand and illustrate the nature of climate controversies and the positions of various stakeholders. The assignments will also help to create an interdisciplinary understanding of climate interactions with human and natural systems.

Suggested Readings

1. Stephen Schneider, Armin Rosencranz, Michael Mastrandrea, eds., 2010. Climate change science and policy. Island Press.
2. Bert Metz, 2010. Controlling climate change, Cambridge University Press.
3. Lester Brown, 2009. Plan b 4.0: mobilizing to save civilization. W.W. Norton.
4. Kerry Emanuel, 2007. What We Know About Climate Change. Boston: Boston Review/MIT Press
5. Tim Flannery, 2006. The Weather Makers. New York: Atlantic Monthly Press
6. Bill McKibben, 2010. Earth. NY: Times Books,
7. David Blockstein and Leo Weigman 2010. The Climate Solution Consensus NCSE/Island Press.
8. Monty Hempel, 1996. Environmental Governance: The Global Challenge. Washington, DC: Island Press.
9. Arnold J. Bloom, 2009. Global climate change: convergence of disciplines. Sinauer Associates.

Course No: GEO 203

Course Title: Digital Image Processing

Number of Credits: 4

No. of Lectures-Tutorial: 45-10-03

Course Coordinator: Dr. Shamita Kumar

Course Outline

The course will provide an indepth knowledge of satellite image fundamentals and techniques for extraction information from satellite images including pre processing and post processing operations. This course assumes that students have prior knowledge in the basics of remote sensing, mapping, and GIS, and have experience with geospatial software. Through laboratory work, students will have opportunities to practice the concepts and techniques learnt in the lectures.

Learning Outcomes

On successful completion of this course and Course GEO 212, the students will :

- Develop a strong understanding of the tools and techniques used to display, process, and analyze remotely sensed data
- Critically assess the strengths and weaknesses of remote sensing instruments and platforms for a broad range of application scenarios and design a remote sensing program.
- Use acquired knowledge and critical thinking skills to solve a real-world problem with appropriate remote sensing data and processing methods.

Pre-requisite

GEO 101, GEO 202

Evaluation Procedure : 0.6/0.4 University

Continuous assessment during assignments	40 %	Marking pattern for every assignment: • Evidence of clear line of thinking, written up well • Excellent presentation	Internal Assessment
Major exam	60%		University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	A	T/E
1	Introduction to digital image processing - Overview of remote sensing data collection and analysis - Data collection: Insitu and remote sensing data collection-biophysical and hybrid variables, analog and digital image processing - Digital remote sensor data collection: multispectral imaging using discrete detectors, scanning mirrors, linear arrays, area arrays, digital frame cameras - Digital image data formats: BIL, BIP, BSQ	02		
2	Image Quality Assessment and Statistical Evaluation - Significance of the histogram in digital image processing - Univariate descriptive image statistics: measures of central tendency, measure of dispersion, skewness - Multivariate image statistics: covariance in multiple bands, correlation between multiple bands - Feature space plots	04		
	Practical 1: Assignment 1		5	
3	Image rectification and restoration - Introduction - Radiometric correction: random bad pixels, line or column drop-outs, partial line or column dropouts, line start problems, n-line stripping - Atmospheric correction - Geometric correction: Internal and external geometric error, types of geometric correction-image to map rectification, image to image registration, hybrid approach to image rectification/registration - Intensity interpolation: nearest neighbour,	05		

	bilinear interpolation • Mosaicking			
	Practical 2: Assignment 2		5	
4	Image enhancement techniques • Image reduction and magnification • Contrast enhancement: linear contrast enhancement, maximum-minimum contrast stretch, percentage linear and standard deviation contrast stretching, piecewise linear contrast stretch, non-linear contrast enhancement • Band ratioing, spatial filtering: spatial convolution filtering, fourier transform • Edge enhancement: linear and non-linear edge enhancement • Principal Component Analysis • Vegetation indices: Dominant factors controlling leaf reflectance, NDVI, SAVI,	10		
5	Image classification • Introduction: Parametric and non-parametric method • Supervised classification: LULC classification levels, Classification stage-Minimum-Distance-to-Means Classifier, Parallelpiped Classifier, Maximum Likelihood Classifier, Nearest Neighbour; Training Stage • Unsupervised classification; Classification accuracy assessment, error matrix • Fuzzy classification • Classification based on object oriented image segmentation • Hybrid classification, incorporating ancillary data in the classification process • Knowledge based classification • Classification using neural networks	10		
	Practical 3: Assignment 3		5	
6	Hyperspectral image analysis	07		

	Hyperspectral image analysis: Atmospheric correction of hyperspectral images, hyperspectral image analysis techniques			
7	Digital change detection Steps required to perform change detection, change detection algorithms	07		
	Practical 4: Assignment 4		5	
	Total	45	10	03

Suggested Readings

1. Richards J. A, Jia Xiuping, Remote Sensing Digital Image, Springer Verlag Berlin Heidelberg New York, 1999
2. Chanda B., D Datta, Majumdar, Digital Image Processing and Analysis, Prentice- Hall of India , 2001.
3. Prithvish Nag, M. Kudrat, Digital Remote Sensing, Concept Publishing Company, New Delhi, 1998
4. Lecture notes, module II, Image Analysis and Interpretation, IIRS
5. Jensen John: Introductory Digital Image Processing-A remote sensing perspective, Prentice Hall Series, 2005

Course No: CA 212

Course Title: Internship

Number of Credits: 4

Course Coordinator: Dr. Kranti Yardi

Course Outline

The internship of 30 days duration to be completed in the second semester is an opportunity for students to develop research skills and/or gain professional expertise as well as academic knowledge. Students must plan for the internship towards the end of the first semester itself. While the Institute will facilitate the placement for internships, students are encouraged to find placements for internships and make initial contact with prospective organization as this builds skills of communication.

Learning Outcomes

- Plan, execute and present findings of tasks completed in the internship period.
- Write concisely and effectively in order to communicate concepts and ideas in a logical and coherent manner.
- Produce effective data presentations and use them to enhance the communication of quantitative information.
- Work effectively in a team.

Pre-requisites

The student can opt for this either in the gap between the first and second semester or if local he/she can work over the weekends for three months to ensure that the requisite duration is fulfilled. The student must apply for the internship/scan internship opportunities atleast six to eight months in advance. Requisite correspondence with the concerned organization is the responsibility of the student. The Institute will support with a letter of intent.

Throughout the internship, the student must maintain a work log that includes dates, time spent on site, and a summary of the work performed and its relevance. An updated copy of the log must be turned into the supervisor (at the place of work) and the faculty supervisor in the form of monthly reports. The student must meet with the supervisor (at the place of work) on a regular schedule (determined by the supervisors at their discretion). The supervisor must be willing to submit a written evaluation of the student at the conclusion of the internship.

Evaluation: Continous

End project report submitted with a report by the supervisor	Within fifteen days of completion of the internship	40%	Details of tasks assigned, tasks completed till date
Presentation on internship	As per University schedule	40%	Detailed presentation of tasks completed with concrete outcomes and learnings.

Format of Internship Report

1. Cover page with title, your name and name of company
2. Certificate from the employer on employer letterhead stating tasks completed and level of achievement and

Name of the student

Place of internship

Supervisor

Duration of internship (Date of commencement of internship – date of completion)

3. Background of the organisation
4. Introduction
5. Objectives
6. Tasks done with methodology and date
7. Outputs
8. Learnings (to be added only for final report, not interim report)
 - A. Work experience
 - B. Academic and scientific and experience
 - C. Social and cultural experience

The internship report should be typed on A4 size bond paper with 1.5 line spacing. Illustrations and photographs should be of high quality. Font to be used is Times New Roman or Arial with the text not less than in 12 pt. Referencing must be done in Zotero or any other referencing software in standard referencing style (Vancouver) for both intext citing and bibliography. The report should be flawless without any spelling mistakes and grammatical errors etc. If the report contains such mistakes, the student will have to resubmit their dissertation after the necessary corrections. The students are expected to prepare 3 copies (Spiral Bound/ Wiro Bound). Two copies of the report with original certificates in both must be submitted. Good photos of the student in the place of internship (in action) must also be included in the report apart from other relevant photos.

Logo of the Bharati Vidyapeeth University must be inserted on the cover page. Take care to see that it is not stretched.

Course No: CA 213
Course Title: Minor Project
Number of Credits: 8
Course Coordinator: Dr. Kranti Yardi

Course Outline

This course is meant for students who opt for the Diploma in Wildlife Conservation Action. Students will be involved in the conceptualization and implementation of a minor research project spanning a total of three months. This project will set the foundation for future research.

Learning Outcomes

At the end of the course students will learn to:

- Plan, execute and present findings of the minor research project
- Write concisely and effectively in order to communicate concepts and ideas in a logical and coherent manner.
- Produce effective data presentations and use them to enhance the communication of quantitative information.
- Understand the requirement of funding applications and go about preparing one.
- Use standard project management tools in order to deliver to predetermined goals effectively
- Create, present and defend a poster at a scientific meeting.

Evaluation

Assessment 1 (December)	Internal	10%	<i>Presentation on introducing the topic and its feasibility (literature review and methodology to prove feasibility of the project)</i>
Assessment 2 (January)	Internal	15%	<i>Detailed literature review, methodology with data collection protocols,</i>
Assessment 3 (February)	Internal	15%	<i>Mid-course review. Presentation of results and preliminary analysis</i>
Major Exam (April-May)	External	60%	University Assessment

Guidelines for minor project

Topic: Candidates will write a project on issues related to any wildlife conservation issue/ action project under the guidance of their respective guides. Each student will work independently on the topic. The dissertation must consist of review of literature and produce a deep insight of the subject on the basis of personal research.

Initiation of work: The project work will be initiated at the end of the first semester.

Students will be allotted guides (from within the faculty associated with the Institute) based on their area of interest.

Evaluation of the work done: The schedule for evaluation (internal and external) is given in the table above.

The project work should be typed on A4 size bond paper with 1.5 line spacing. Illustrations and photographs should be of high quality. Font to be used is Times New Roman or Arial with the text not less than in 12 pt. Referencing must be done in Zotero or any other referencing software strictly in standard referencing style (Vancouver). The report should be flawless without any spelling mistakes and grammatical errors etc. If the report contains such mistakes, the student will have to resubmit their dissertation after the necessary corrections.

Guidelines for presentation: For every presentation students will prepare a power point presentation highlighting the objectives, research question, methodology and key findings and defend the same. The presentation must not be texty. It should be aesthetically appealing and contain relevant graphs and analysis. Wordy presentations are likely to get marked down. Students should be smartly dressed and speak in a clear voice. Do ensure that your presentations are loaded as per the given deadlines.

Guidelines for poster

For the final presentation students will prepare a poster as per the guidelines given below.

Poster size: 2ft (W) x 3ft (H)

Material: Vinyl (top quality)

Content: Aim, Objective, Method (in brief in a flow chart), findings (key graphs to be included), publications (if any), conclusion, suggestion

Name of the student and guide as well as institutional affiliation should be included.

The project work document will have to be submitted as per the dates indicated in Academic Calendar for appraisal and acceptance by the University. The students should submit their report in the following format.

Cover Page

Inner Cover Page

Certificate duly signed by guide and head of institution

Acknowledgements

Contents

Chapter 1 – Introduction

A background with historical information and a review of existing material or data on the subject/ problem analysis.

Chapter 2- Aims and Objectives

This chapter must contain the overall study design and aims and objectives of the study/ action project.

Chapter 3 – Literature Review

Detailed review of all existing literature related to the topic justifying the topic with a comprehensive bibliography generated using Zotero.

Chapter 3 –Methodology

Description of the issues, environmental setting and methodology adopted for the study /action project, etc.

Chapter 3 – Results

Presentation of results.

Chapter 4 – Discussion

Discussion on the data and results obtained and presentation of method suggested to solve the problem / difficulties encountered and solutions arrived at

Chapter 5 – Summary and Conclusions

A summary of the dissertation and important conclusions drawn at the end of the investigation and a list of references cited in the text.

Chapter 6 - Bibliography

The report should be typed on A4 size bond paper with 1.5 line spacing. Illustrations and photographs should be of high quality. Font to be used is Times New Roman or Arial with the text not less than in 12 pt. Referencing must be done in Zotero or any other referencing software in standard referencing style (Vancouver) for both intext citing and bibliography. The report should be flawless without any spelling mistakes and grammatical errors etc. If the report contains such mistakes, the student will have to resubmit the same after the necessary corrections. The report should be bound in hard black mounted cover. Reports with spiral binding and paper cover will not be accepted.

The students are expected to prepare 3 copies (4 in case of a co-guide). If the guide gives a written consent that he/she does not need a hard copy a soft copy may be provided on a CD. The CD must contain a sticker with the cover page information. **The report will only be accepted after the relevant data used has been submitted to the faculty nominated and verified by them.** Students making special efforts to present their papers at conferences or publishing it will receive marks as below:

1.	Poster presented at a National level UGC recognized conference	5 marks
3.	Paper presented at a national level conference	10 marks
4.	Paper published in a SCOPUS/ WEB of SCIENCE indexed journal ONLY	25 marks

SEMESTER III

Course No: CA 311
Course Title: Dissertation
Number of Credits: 30

Evaluation Procedure: 0.6/0.4 University

Assessment 1 (February)	Internal	10%	<i>Presentation on introducing the topic and its feasibility (literature review and methodology to prove feasibility of the project)</i>
Assessment 2 (May)	Internal	15%	<i>Detailed literature review, methodology with data collection protocols,</i>
Assessment 3 (August-September)	Internal	15%	<i>Mid-course review. Presentation of results and preliminary analysis</i>
Major Exam (November-December)	External	60%	University Assessment

Guidelines for dissertation

Topic: Candidates will write a dissertation on issues related to environmental/geospatial issues under the guidance of their respective guides. Each student will work independently on the topic. The dissertation must consist of review of literature and produce a deep insight of the subject on the basis of personal research.

Initiation of work: Dissertation work will be initiated during the second semester during the course of the paper on Research Methodology. During the Research Methodology course in Semester II, students will be allotted guides (from within the faculty associated with the Institute) based on their area of interest. As part of their assignments in the Research Methodology course students will write their introduction and literature review.

Evaluation of thesis: The thesis will be as per the schedule given above. For the mid course review, the student is expected to submit one spiral bound copy of the thesis consisting of introduction, literature review, aims and objectives, methodology, data and preliminary analysis along with a content page and interim certificate signed by the guide. The dissertation should be typed on A4 size bond paper with 1.5 line spacing. Illustrations and photographs should be of high quality. Font to be used is Times New Roman or Arial with the text not less than in 12 pt. Referencing must be done in Zotero or any other referencing software strictly in standard referencing style (Vancouver). The report should be flawless without any spelling mistakes and grammatical errors etc. If the dissertation contains such mistakes, the student will have to resubmit their dissertation after the necessary corrections.

Students have to appear for a final external viva to defend their thesis after submission of the thesis.

The dissertation will have to be submitted as per the dates indicated in Academic Calendar for appraisal and acceptance by the University. The students should submit their final dissertation in the following format.

Cover Page

Inner Cover Page

Certificate duly signed by guide and head of institution

Acknowledgements

Contents

Chapter 1 – Introduction

A background with historical information and a review of existing material or data on the subject.

Chapter 2- Aims and Objectives

This chapter must contain the overall study design and aims and objectives of the study.

Chapter 3 – Literature Review

Detailed review of all existing literature related to the topic justifying the topic with a comprehensive bibliography generated using Zotero.

Chapter 3 –Methodology

Description of the issues, environmental setting and methodology adopted for the study etc.

Chapter 3 – Results

Presentation of results.

Chapter 4 – Discussion

Discussion on the data and results obtained and presentation of method suggested to solve the problem.

Chapter 5 – Summary and Conclusions

A summary of the dissertation and important conclusions drawn at the end of the investigation and a list of references cited in the text.

Chapter 6 - Bibliography

The dissertation should be typed on A4 size bond paper with 1.5 line spacing. Illustrations and photographs should be of high quality. Font to be used is Times New Roman or Arial with the text not less than in 12 pt. Referencing must be done in Zotero or any other referencing software in standard referencing style (Vancouver) for both intext citing and bibliography. The report should be flawless without any spelling mistakes and grammatical errors etc. If the dissertation contains such mistakes, the student will have to resubmit their dissertation after the necessary corrections. The dissertation should be

bound in hard black mounted cover. Dissertations with spiral binding and paper cover will not be accepted.

The students are expected to prepare 3 copies (4 in case of a co-guide). If the guide gives a written consent that he/she does not need a hard copy a soft copy may be provided on a CD. The CD must contain a sticker with the cover page information. **The thesis will only be accepted after the relevant data used has been submitted to the faculty nominated and verified by them.** Students making special efforts to present their papers at conferences or publishing it will receive marks as below:

1.	Poster presented at a National level UGC recognized conference	5 marks
3.	Paper presented at a national level conference	10 marks
4.	Paper published in a SCOPUS/ WEB of SCIENCE indexed journal ONLY	25 marks

Guidelines for presentation: For every presentation students will prepare a power point presentation highlighting the objectives, research question, methodology and key findings and defend the same. The presentation must not be texty. It should be aesthetically appealing and contain relevant graphs and analysis. Wordy presentations are likely to get marked down. Students should be smartly dressed and speak in a clear voice. Do ensure that your presentations are loaded as per the given deadlines.

Guidelines for poster

For the final presentation students will prepare a poster as per the guidelines given below.

Poster size: 2ft (W) x 3ft (H)

Material: Vinyl (top quality)

Content: Aim, Objective, Method (in brief in a flow chart), findings (key graphs to be included), publications (if any), conclusion, suggestion

Name of the student and guide as well as institutional affiliation should be included.

SEMESTER IV

Course No: CA 411

Course Title: Internship

Number of Credits: 14

Course Coordinator: Dr. Kranti Yardi

Course Outline

The internship of six month (minimum 5 months) duration to be completed in the fourth semester is an opportunity for students to develop research skills and/or gain professional expertise as well as academic knowledge. Students must plan for the internship towards the end of the second semester itself. While the Institute will facilitate the placement for internships, students are encouraged to find placements for internships and make initial contact with prospective organization as this builds skills of communication.

Learning Outcomes

Students will learn to:

- Plan, execute and present findings of tasks completed in the six month period.
- Write concisely and effectively in order to communicate concepts and ideas in a logical and coherent manner.
- Produce effective data presentations and use them to enhance the communication of quantitative information.
- Work effectively in a team.

Pre-requisites

The student must apply for the internship/scan internship opportunities atleast six to eight months in advance. Requisite correspondence with the concerned organization is the responsibility of the student. The Institute will support with a letter of intent. Throughout the internship, the student must maintain a work log that includes dates, time spent on site, and a summary of the work performed and its relevance. An updated copy of the log must be turned into the supervisor (at the place of work) and the faculty supervisor in the form of monthly reports. The student must meet with the supervisor (at the place of work) on a regular schedule (determined by the supervisors at their discretion). The supervisor must be willing to submit a written evaluation of the student at the conclusion of the internship.

Evaluation: Continous

Midterm report submitted with signature of the supervisor and a letter of appointment	Three month from time of commencement of internship	20%	Details of tasks assigned, tasks completed till date
End project report submitted with a report by the supervisor	Within seven days of completion of the internship (1 st August)	40%	
Presentation on internship	As per University schedule	40%	Detailed presentation of tasks completed with concrete outcomes and learnings.

Format of Internship Report

3. Cover page with title, your name and name of company
4. Certificate from the employer on employer letterhead stating tasks completed and level of achievement and

Name of the student

Place of internship

Supervisor

Duration of internship (Date of commencement of internship – date of completion)

3. Background of the organisation
4. Introduction
5. Objectives
6. Tasks done with methodology and date
7. Outputs
8. Learnings (to be added only for final report, not interim report)
 - A. Work experience
 - B. Academic and scientific and experience
 - C. Social and cultural experience

The internship report should be typed on A4 size bond paper with 1.5 line spacing. Illustrations and photographs should be of high quality. Font to be used is Times New Roman or Arial with the text not less than in 12 pt. Referencing must be done in Zotero or any other referencing software in standard referencing style (Vancouver) for both intext citing and bibliography. The report should be flawless without any spelling mistakes and grammatical errors etc. If the report contains such mistakes, the student will have to resubmit their dissertation after the necessary corrections. The students are expected to prepare 3 copies (Spiral Bound/ Wiro Bound). Two copies of the report with original certificates in both must be submitted. Good photos of the student in the place of internship (in action) must also be included in the report apart from other relevant photos.

Logo of the Bharati Vidyapeeth University must be inserted on the cover page. Take care to see that it is not stretched.

Course No: CA 401

Course Title: Urban Biodiversity Conservation

Number of Credits: 4

No. of Lectures-Tutorial: 48-12

Course Coordinator: Dr. Shamita Kumar

Pre-requisite

None

Evaluation Procedure : Continuous

Continuous assessment during assignments	40 %	Marking pattern for every assignment: - Evidence of clear line of thinking, written up well - Excellent presentation	Internal Assessment
Major exam	60%		University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Fundamentals of Urban Biodiversity Introduction, biodiversity in urban areas, typologies of urban biodiversity, biodiversity of urban industrial areas, urbanization of terrestrial ecosystems, cultural aspects of urban biodiversity, social aspects of urban biodiversity, urban patterns and biodiversity, history and development of urban biodiversity.	10	
2	Social integration and programmes to enhance urban biodiversity Use of urban green spaces- natural, man made and accessible, attracting interest in biodiversity, services provided by green spaces; Values of urban biodiversity	8	
3	Impacts on urban biodiversity Constraints of urbanization on biodiversity- vegetation, flora and fauna, role of non native species, avian diversity, encroachments., climate change and its impacts, environmental history and urban colonization	6	
	Assignment 1		3

4	Conservation of urban biodiversity Legal tools for conservation of urban biodiversity India's Biological Diversity Act, 2002; Role of the Ministry of Environment and Forests and Ministry of Urban Development, Government of India; Role of the Biodiversity Management Committee in an urban area Tools for analyzing and evaluating impacts on urban biodiversity Urban agriculture and urban sustainability; Urban parks and biodiversity; urban forestry – role in biodiversity conservation; Use of remote sensing and GIS in measuring impacts, analysis of plantation and other man made vegetation, green roofs , balcony gardens, vertical gardens, coridoring; Street coridoring; Case Studies	10	
	Assignment 2		3
	Assignment 3: Field Visit		3
5	Conservation, Restoration and Design for Urban Biodiversity Integration of natural vegetation in urban design, forest parks, gardens and parks as jump sites for urban biodiversity, establishing corridors for urban biodiversity conservation, near natural restoration strategies , landscape design changes to urban climatic conditions, financial incentives to encourage conservation of Biodiversity as per Convention on Biodiversity; Role of Citizen Science and Citizen Networks; Staekholders and their roles in conservation of urban biodiversity; Case Studies	10	
	Assignment 4		3
	Total	48	12

Reference Books

Urban Biodiversity And Design (Conservation Science And Practice) by Norbert Muller , Wiley-Blackwell

The Ecological City: Preserving and Restoring Urban Biodiversity, Rutherford H. Platt, Rowan A. Rowntree, Pamela C. Muick, University of Massachusetts Press, 1994

Course No: CA 402

Course Title: Wildlife Conservation Communication

Number of Credits: 4

No. of Lectures-Tutorial: 48-12

Course Coordinator:

Pre-requisite

None

Evaluation Procedure : Continuous

Continuous assessment during assignments	40 %	Marking pattern for every assignment: • Evidence of clear line of thinking, written up well • Excellent presentation	Internal Assessment
Major exam	60%		University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Conservation Education Need, scope, objectives, approaches for conservation education, curricula and conservation education, history of conservation education, formal and non-formal conservation education programs, Government and NGO initiatives curricula	8	
	Assignment 1		3
2	Techniques for conservation education- principles and implementation Non formal techniques in environment education - Games, puppetry, poster making, exhibit development, and nature trails , nature camps, field visits; Social media; internet communication; leadership programs; Case Studies	10	
	Assignment 2: Design of a conservation communication program		3

3	Training programmes: Principles, design, planning, implementation, evaluation and monitoring .	10	
	Assignment 3		3
4	Designing a wildlife communication program Concept, principles, case study analysis, best practices; Campaigns, action projects, community activities; Developing material- activity sheets, booklets, educational material Interpretations and nature education centers- planning and budgeting;	12	
	Assignment 4: Implementation of the conservation communication program		3
	Total	48	12

Reference Books

Course No: CA 403

Course Title: Wildlife Management

Number of Credits: 4

No. of Lectures-Tutorial: 48-12

Course Coordinator: WTI faculty with inputs from Mr. Vishwas Sawarkar (Retd. IFS)

Pre-requisite

None

Evaluation Procedure : Continuous

Continuous assessment during assignments	40 %	Marking pattern for every assignment: - Evidence of clear line of thinking, written up well - Excellent presentation	Internal Assessment
Major exam	60%		University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1.	Wildlife management plan Functions of management plan, goals, objectives and strategies, management plans in the Indian context, hierarchies in management planning; Constraints in planning	6	
1.	Physical and Cultural Influences on Habitat Patterns Forests as Habitat, Historical Approaches to Managing Forests as Habitat; Relationship between Habitat Quality and Demographics ; Forage Availability and Quality, Dead and Damaged Trees, Proximity to Water; Case Studies	10	
	Assignment 1		3
3.	Strategies for biological and people related issues in wildlife management Corridors and linkages; viable populations; limiting factors; localized overabundance; people's participation; ecodevelopment; enclaved villages and their relocation Significance of landscapes, biodiversity and landscapes, mechanism for landscape based planning and management;	14	

	addressing biodiversity concerns in forest working plans		
	Assignment 2		3
4.	Habitat Management Buffer area management; Silvicultural systems; Firewood harvest and collection; Non-wood Forest Produce Collection; Forest Protection – Poaching and other illegal activities, illegal cutting of trees, illegal removal of NWP; Livestock grazing, fires, wildlife health management Management of key stone resources; waterhole management, Case Studies	10	
	Assignment 3		3
5	In situ and ex situ conservation efforts - ex situ measures- conservation breeding; Rescue and rehabilitation of wildlife; Case studies Research, monitoring and training Ecodevelopment; Ecotourism, interpretation and Conservation education	6	
	Assignment 4		3
	Total	48	12

Reference Books

Fundamentals of wildlife management, by Rajesh Gopal, by Nataraj publishers.

Wildlife Habitat Management: Concepts and Applications in Forestry

Brenda C. McComb , Published: 2007 by CRC Press

Planning wildlife management in protected areas and managed landscapes by Vishwas Sawarkar . Nataraj publishers

Forest Wildlife Ecology and Habitat Management, Author : David R. Patton, Publisher : Crc Pr Inc

BHARATI VIDYAPEETH UNIVERSITY, PUNE

MASTER OF GEOINFORMATICS

COURSE STRUCTURE AND DETAILED SYLLABUS
OF
SEMESTERS I,II,III and IV
(UNDER CREDIT SYSTEM)
TO BE EFFECTIVE FROM 2013-2014

BHARATI VIDYAPEETH UNIVERSITY, PUNE
FACULTY OF INTERDISCIPLINARY STUDIES

Course Structure of
Master of Geoinformatics (Under Credit System)
Effective from 2013-2014 at

INTRODUCTION

Geoinformatics is the technology for decision support for management of resources and facilities. Due to the highly spatial nature of data handled by a GI system, it is able to provide outputs to facilitate visualization of choices made thus enabling quick and accurate decision making. Geoinformatics is an extended branch of information technology and involves the use of remote sensing, digital image processing, GPS technology, programming, etc. to build a geospatial database that can be queried to get the relevant answers. Geoinformatics combines geospatial analysis and modeling, development of geospatial databases, information systems design. Geoinformatics uses geocomputation and geovisualization for analyzing geoinformation. Many fields benefit from geoinformatics, including urban planning, land use management, in-car navigation systems, environmental modeling and analysis, military, transport network, planning and management, agriculture, meteorology and climate change, oceanography, business location planning, telecommunications, crime simulation, aviation and maritime transport.

The importance of the spatial dimension in assessing, monitoring and modeling various issues and problems related to sustainable management of natural resources is recognized all over the world. Geoinformatics becomes very important technology to decision-makers across a wide range of disciplines, industries, commercial sector, environmental agencies, local and national government, research, and academia, national survey and mapping organizations, International organizations, emergency services, public health and epidemiology, crime mapping, transportation and

infrastructure, information technology industries, tourist industry, utility companies, market analysis and e-commerce, mineral exploration, etc.

Many government and non-government agencies have started to use spatial data for managing their day to day activities.

OBJECTIVES

- To build knowledge on various aspects related to applications of geospatial technologies.
- To foster inter-disciplinary approach by building scientific, technological, legal, economic, social and policy perspectives.
- To develop relevant analytical and field skills in resolving various problems through the use of geospatial techniques.

SCOPE

A career in geoinformatics will have a tremendous positive impact on the world. Geoinformatics can be applied in every imaginable discipline and highly paid opportunities exist in several sectors. Career opportunities lie in the field of land resource management, integrated emergency management, water management, disaster management, risk assessment, transportation, urban planning, environment, hydrology, forestry, agriculture, military, mining, business, health, defence, space research, geology and several related fields.

India entered the space age in 1972 with the establishment of the Department of Space and is among the top ten countries of the world in this field. In India we have Space Application Centre at Ahmedabad, the National Remote Sensing Agency in Hyderabad that are the hotbed of geoinformatics research. Besides this every state has a Regional Remote Sensing Centre. Post graduate holders in Geoinformatics can apply for the post of Jr. Scientist, Scientist, Project Coordinator, Project Scientist, Scientific /Technical Assistant, GIS Programmer, Research Scholar, etc. Besides these the rapidly growing GIS

industry with ESRI, Rolta, Intergraph, Wipro, TCS, Infosys, TomTom, Genesys and others recruit regularly where post graduates can start work as Project Manager, Sr. System Executive, System Analyst, GIS Engineer, Image Analyst, GIS Programmer etc.

Jobs also exist in allied institutes working in the field of environment, biodiversity conservation, forestry, landscape studies, water management, health, etc. where geoinformatics is an indispensable tool. There is also a huge demand for geo professionals from countries like Malaysia, Australia, Canada, France, Germany, Netherlands, China, etc. This field has tremendous scope for entrepreneurship and with bank loans being easily available, for the enterprising individual the sky is the limit.

ELIGIBILITY FOR ADMISSION TO THE COURSE

1. The candidate should have obtained the Bachelors degree in any Science with any of the subjects of Botany, Zoology, Chemistry, Physics, Statistics, Geography, Geology, Geography, Life Sciences, Environment Sciences, Microbiology, Biotechnology, Fisheries, Marine Biology, Horticulture, Agriculture, Computer Science, Veterinary Science or any branch of engineering or any relevant Social Science subject.
2. The candidate should have secured at least 50% in the aggregate undergraduate exam

DURATION OF THE COURSE

The duration of this course is two years consisting of four semesters. The medium of instructions and examination will be only English.

RULES AND REGULATIONS

1. **Commencement and Conclusion:** The dates for the commencement and conclusion of each semester shall be determined by the University authorities. The terms can be kept by only duly admitted students. Each semester is of 15 weeks duration. Students must check the academic calendar for exact dates of commencement and conclusion.

2. **Total credits:** The entire Course is of 132 credits and will be executed in 4 semesters.
3. One credit is equivalent to 15 hours of interaction of student with facilitator for theory, while one credit for practical is equivalent to 20 hours of practical work or 30 hours of field work.
4. **Dissertation:** The student will undertake dissertation in Semester III and continue the same in Semester IV for which 28 credits have been allotted. The topic for the research must be finalized by the end of Semester II after thorough literature review.
5. **Field visits:** The field / industrial / academic Institute visits will be organized for demonstration of advance experimental techniques wherever necessary along with the courses. Attendance for these are mandatory and will form part of internal assessment as indicated in the syllabus.
6. **Internship:** Internship will be carried out by the student in the fourth semester. Students can also undertake additional internship in the break between the second and the third semester. This will however not be assessed.
7. **Attendance:** A student must have minimum 80% attendance in theory and 100% attendance in the practical courses to fulfill the term. A student who does not have the required attendance may not be allowed to appear for the university term and the respective monthly internal assessments.

RULES FOR EXAMINATION AND INTERNAL ASSESSMENT

1. Examination for the theory and practical courses will be conducted at the end of each respective semester or as continuous assessment as indicated in the syllabus.
2. The weightage allotted for internal assessment is 40%. Thus 40 marks out of 100 will be allotted for internal assessment which will be conducted throughout the semester in the form of tests/tutorials/seminars/oral presentations/assignments/debates, etc. as indicated in the syllabus. The university shall conduct an examination for 60 marks.
3. Internal assessment for the practical course is through continuous assessment. Each practical is evaluated for ten marks. Of this performance in the class is assessed for five

marks and timely journal submission (within a week of the practical being conducted) as per instructions given by the concerned teacher is assessed for five marks.

4. The general courses will be evaluated by the instructor on the basis of continuous assessment as indicated in the syllabus.

STANDARD OF PASSING

1. The 10-point scale Grades and Grade Points according to the following table.

Range of Marks (Out of 100)	Grade	Grade Point
$80 \leq \text{Marks} \leq 100$	O	10
$70 \leq \text{Marks} < 80$	A+	9
$60 \leq \text{Marks} < 70$	A	8
$55 \leq \text{Marks} < 60$	B+	7
$50 \leq \text{Marks} < 55$	B	6
$40 \leq \text{Marks} < 50$	C	5
Marks < 40	D	0

2. The performances at UE and IA will be combined to obtain the Grade Point Average (GPA) for the course. The weights for performance at UE and IA shall respectively be 60% and 40%.
3. GPA is calculated by adding the UE marks out of 60 and IA marks out of 40. The total marks out of 100 are converted to grade point, which will be the GPA.

Formula to calculate Grade Points (GP)

- a. Suppose that 'Max' is the maximum marks assigned for an examination or evaluation based on which GP will be computed. In order to determine the GP, Set $x = \text{Max} / 10$ (since we have adapted 10-point system). Then GP is calculated by the formulas shown as below:

a. Range of Marks at the evaluation	b. Formula for the Grade Point
$8x \leq \text{Marks} \leq 10x$	10
$5.5x \leq \text{Marks} < 8x$	Truncate (Marks / x) + 2
$4x \leq \text{Marks} < 5.5x$	Truncate (Marks / x) + 1

- b. Two kinds of performance indicators, namely, the Semester Grade Point Average (SGPA) and the Cumulative Grade Point Average (CGPA) shall be computed at the end of each term. The SGPA measures the cumulative performance of a learner in all the courses in a particular semester, while the CGPA measures the cumulative performance in all courses since his/her enrolment. The CGPA of learner when he/she completes the programme is the final result of the learner

c. The Formula to compute equivalent percentage marks for specified CGPA:

% Marks (CGPA) =	$10 \times \text{CGPA} - 10$	if $5.00 \leq \text{CGPA} \leq 6.00$
	$5 \times \text{CGPA} + 20$	if $6.00 \leq \text{CGPA} \leq 8.00$
	$10 \times \text{CGPA} - 20$	if $8.00 \leq \text{CGPA} \leq 9.00$
	$20 \times \text{CGPA} - 110$	if $9.00 \leq \text{CGPA} \leq 9.50$
	$40 \times \text{CGPA} - 300$	if $9.50 \leq \text{CGPA} \leq 10.00$

New guidelines for Standards of Passing

Standards of Passing

- For all courses, both UE and IE constitute separate heads-of-passing (HoP). In order to pass in such courses and to 'earn' the assigned credits
 - The learner must obtain a minimum grade point of 5.0 (40% marks) at UE and also a minimum grade point of 5.0 (40% marks) at IA;

OR

- b. If he / she fails in IA, the learner passes in the course provided he / she obtains a minimum of 25% in IA and GPA for the course is atleast 6.0 (50% in aggregate). The GPA for a course will be calculated only if the learner passes at the UE. The following examples illustrate this rule for passing in a course under.

Illustration of Passing Rule specified

Case No.	UE Marks Out of 60	IA Marks Out of 40	Total Marks Out of 100	GP of UE	GP of IA	GPA	Remarks
1	24	16	40	5.0	5.0	5.0	Pass
2	40	10	50	7.0	0	6.0	Pass
3	40	06	46	7.0	0	5.0	Fails at IA
4	20	40	--	0	10.0	0	Fails at UE
5	34	12	46	7.0	0	5.0	Fails at IA
6	20	15	--	0	0	0	Fails at both UE & IA

2. A student who fails at UE in a course has to reappear only at UE as a backlog candidate and clear the HoP. Similarly, A student who fails in a course at IA has to reappear only at IA as a backlog candidate and clear the HoP.
3. Subject to the Rules E1-E2, the ATKT and other rules may be framed by respective BOS and faculty.

Award of Honours

A student who has completed the minimum credits specified for the program shall be declared to have passed in the programme. The final result will be in terms of letter grade only and is based on the CGPA of all courses studied and passed. The criteria for the award of honours are given below.

Range of CGPA	Final Grade	Performance Descriptor	Equivalent Range of Marks (%)
$9.50 \leq \text{CGPA} \leq 10.00$	O	Outstanding	$80 \leq \text{Marks} \leq 100$
$9.00 \leq \text{CGPA} \leq 9.49$	A+	Excellent	$70 \leq \text{Marks} < 80$
$8.00 \leq \text{CGPA} \leq 8.99$	A	Very Good	$60 \leq \text{Marks} < 70$
$7.00 \leq \text{CGPA} \leq 7.99$	B+	Good	$55 \leq \text{Marks} < 60$
$6.00 \leq \text{CGPA} \leq 6.99$	B	Average	$50 \leq \text{Marks} < 55$
$5.00 \leq \text{CGPA} \leq 5.99$	C	Satisfactory	$40 \leq \text{Marks} < 50$
CGPA Below 5.00	F	Fail	Marks Below 40

IMPORTANT INSTRUCTIONS FOR STUDENTS

- Read carefully the entire Syllabus, making sure that all aspects of the course are clear to you, ie. Structure of the program, electives, details of assignments, internal and external examinations systems, marking systems, grading, attendance requirements as well as rules and regulations.
- Course coordinators are liable to change from those mentioned. Students will be informed about the change if any before the commencement of the semester.
- Familiarize yourself with the library and online resources for maximizing your learning experience.
- BVIEER faculty are always willing to accommodate interested and exceptional students in their on going research. If you are interested in volunteering your time on any of the projects to gain valuable work experience, do get in touch with them.
- Make sure that all assignments are submitted on time. Late submission of assignments may result in loss of a certain percentage of marks or rejection of your assignment.
- Every practical journal must be complete before the next practical to ensure it is assessed.
- **Academic Integrity**

Bharati Vidyapeeth University is committed to maintaining academic quality, excellence, and honesty. All faculty and students are expected to share the commitment to academic integrity, an essential component of a quality academic experience.

Students are expected to read and follow all policies, procedures, and program information guidelines contained in publications; pursue their learning goals with honesty and integrity; demonstrate that they are progressing satisfactorily and in a timely fashion by meeting course deadlines and following outlined procedures; observe a code of mutual respect in dealing with mentors, staff, and other students; behave in a

manner consistent with the standards and codes of the profession in which they are practicing; keep official records updated regarding changes in name, address, telephone number, or e-mail address; and meet financial obligations in a timely manner.

- **Academic Dishonesty**

All students are expected to approach their education with academic integrity. Academic dishonesty undermines this objective. Academic dishonesty can take the following forms:

- Cheating
- Gaining or providing unauthorized access to examinations or using unauthorized materials during exam administration
- Submitting credentials that are false or altered in any way
- Plagiarizing (including copying and pasting from the Internet without using quotation marks and without acknowledging sources)
- Forgery, fabricating information or citations, or falsifying documents
- Submitting the work of another person in whole or in part as your own (including work obtained through document sharing sites, tutoring schools, term paper companies, or other sources)
- Tampering with the academic work of other students

- **Plagiarism**

Plagiarism, which is defined as using the work and ideas of others without proper citation is strictly prohibited in all assignments and dissertation. Students indulging in plagiarism will find their work is not assessed.

Plagiarism defeats the purpose of education. If you plagiarize, you are not educating yourself, and you are wasting your time on courses meant to improve your skills.

SEMESTER WISE COURSE INFORMATION

Semester I

Course Number	Course Title	Credit Value	Hours per week	Weightage For EoTE/IA	EoTM
	Core Courses				
GEO101	Fundamentals of remote sensing	4	4	0.6/0.4	University
GEO 102	Fundamentals of Geoinformatics	4	4	0.6/0.4	University
GEO 103	Fundamentals of programming	4	4	0.6/0.4	University
EST 101	Ecosystem Studies	4	4	0.6/0.4	University
EST 305	Urban Environment Management	4	4	0.6/0.4	University
EST 111	Field techniques –I	2	3	0.6/0.4	University
GEO 111	Techniques in image interpretation and remote sensing	2	3	0.6/0.4	University
GEO 112	Techniques in GIS and GPS	2	3	0.6/0.4	University
	Pre-requisites				
EST 104	Statistical Methods	3	3	Continuous assessment	Institute
EST 105	Fundamentals of computing and database	3	3	Continuous assessment	Institute
	Total	32	35		

Total credits offered in Semester I : 32

Semester II

Course Number	Course Title	Credit Value	Hours per week	Weightage For EoTE/IA	EoTM
	Core Courses				
GEO 201	Geodatabase Management	4	4	0.6/0.4	University
GEO 202	Advanced Remote Sensing	4	4	0.6/0.4	University
GEO 203	Digital Image Processing	4	4	0.6/0.4	University
GEO 204	Fundamentals of WebGIS	4	4	0.6/0.4	University
EST 205	Research Methodology	2	2	Continuous assessment	Institute
GEO 211	Techniques in database management	2	3	0.6/0.4	University
EST 212	Techniques in digital image processing	2	3	0.6/0.4	University
GEO 213	Programming for GIS-I	2	3	0.6/0.4	University
	Electives (any two)				
EST 201	Biodiversity assessment and conservation	4	4	Continuous assessment	Institute
EST 206	Natural resource management	4	4	Continuous assessment	Institute
EST 207	Environment and Health	4	4	Continuous assessment	Institute
EST 402	Water management	4	4	Continuous assessment	Institute
EST 208	Climate change science and strategies	4	4	Continuous assessment	Institute
	General Courses (any one)				
GEN 201	General English	2	2	Continuous assessment	Institute
GEN 202	Project Management	2	2	Continuous assessment	Institute
	Total	34	37		

Total Credits offered in Semester II : 34

Semester III

Course Number	Course Title	Credit Value	No. of hours per week	Weightage For EoTE/IA	EoTM
	Core Courses				
GEO 301	Trends in geospatial technologies	4	4	0.6/0.4	University
GEO 302	Spatial analysis and modeling	4	4	0.6/0.4	University
GEO 311	Dissertation	14	16	0.6/0.4	University
GEO 312	Programming for GIS-II	2	3	0.6/0.4	University
GEO 313	Techniques in Spatial Statistics, Analysis and Modeling	2	3	0.6/0.4	University
	Electives (any two)				
EST 303	Environmental Modeling	4	4	Continuous assessment	Institute
GEO 303	Applications of geospatial technologies	4	4	Continuous assessment	Institute
GEO 304	Photogrammetry	4	4	Continuous assessment	Institute
EST 301	Integrated Impact Assessment	4	4	Continuous assessment	Institute
SD 101	Fundamentals of sustainable development	4	4	Continuous assessment	Institute
	General Courses (any one)				
GEN 301	Personality development	2	2	Continuous assessment	Institute
GEN 302	Communication	2	2	Continuous assessment	Institute
	Total	36	40		

Total Credits offered in Semester III : 36

Semester IV

Course Number	Course Title	Credit Value	Hours per week	Weightage For EoTE/IA	EoTM
	Core Courses				
GEO 411	Dissertation	14	16	0.6/0.4	University
GEO 412	Internship	14	16	0.6/0.4	University
	General Courses (any one)				
GEN 401	Entrepreneurship Development	2	2	Continuous assessment	Institute
	Total	30	34		

Total Credits offered in Semester IV : 30

Course No: GEO 101

Course Title: Fundamentals of remote sensing

Number of Credits: 4

No. of Lectures-Tutorial: 45-15

Course Coordinator/ Instructor: Dr. Pradyumn Joshi

Course Outline

The course deals with the fundamentals of remote sensing, introduction to various satellites and introduces the participant to the basic concepts and the operational skills necessary to acquire remote sensing data and extract geo-information from them.

Learning Outcomes

The student should develop:

- A firm understanding of the various remote sensing systems
- Understand the basic principles of remote sensing.

Pre-requisite

None

Evaluation Procedure : 0.6/0.4 University

Assignment	2	20%	Internal Assessment
Minor Test	3	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Introduction Definition and concept of remote sensing Components of remote sensing, natural remote sensing, artificial remote sensing, passive and active remote sensing Platforms of remote sensing-aircraft, satellites Applications of remote sensing in various fields such as forestry, mining, watershed, urban planning,	6	

	agriculture and advantages and limitations of remote sensing Indian scenario – Indian satellites – history and progression including present status Remote sensing data collection: The remote sensing process-statement of the problem, identification of in-situ and remote sensing data requirements, remote sensing data acquisition and analysis, reference data		
2	Physics of remote sensing Conduction, convection and radiation Electro radiation models (Wave model of electromagnetic energy, the Particle Model-Radiation from atomic structures) Energy-matter interactions in the atmosphere (Refraction, scattering and absorption, reflectance) Atmospheric windows and types of remote sensing systems Energy matter interactions with the terrain (hemispherical reflectance, absorptance and transmittance, spectral reflectance of vegetation, water body and soil spectral response patterns) Radiant Flux Density (Irradiance and exitance radiance) Energy-matter interactions at the sensor system (target and path radiance) An ideal remote sensing system, characteristics of real remote sensing system	4	
3	Fundamentals of aerial photography Classification of aerial photography on the basis of orientation of camera axis, types of cameras and films used, filter combination Scale of aerial photography, photographic resolution, Stereoscopic photography (flight planning, discrepancies-TIP, TILT, DRIFT, CRAB) Geometric characteristics of aerial photographs-	6	

	terms, symbols and definitions Comparison between aerial photography and topographic map (scale, relief, displacement, tilt, optical distortion, paper and film distortion) Types of films, pocket and mirror stereoscopes Measurement of scale and height on aerial photographs Photorecognition elements Digital elevation model, orthophotos		
	Assignment 1 Discussion and presentation of selected research paper in groups of two students.		4
	Minor Test 1		2
4	Elements of visual interpretation Factors governing the interpretability, elements of image interpretation with examples Methods of search: Use of collateral information, convergence of evidence, the multi concept	6	
5	Sensors and remote sensing data products Quality of image in optical systems, imaging mode, photographic cameras, television cameras, multi-spectral imaging sensors (optical-mechanical scanners and optical –electronic scanners, modular optoelectronic multispectral/stereo scanner, whisk broom, and push broom scanner, hyperspectral scanners) Operating principles of across and along track scanning with examples Geometric characteristics of across track and along track scanner imagery Data formats, ground segment organization, data product generation, referencing scheme, data products output medium (photo products and digital products)	8	

	Assignment 2 Seminar presentation by individual students on predecided topics.		5
	Minor Test 2		2
6	Multispectral Remote Sensing Details of Earth Resource Satellites operating in the optical spectrum with respect to their sensor characteristics with examples of applications: LANDSAT Series SPOT series IRS series Meteorological satellites Ocean monitoring satellite	8	
7	Thermal Infrared Remote Sensing Thermal infrared radiation properties Thermal infrared atmospheric windows Thermal radiation laws (Stefan-Boltzmann Law, Wien's Displacement Law, Emissivity, Kirchoff's law) Thermal properties of terrain Thermal infrared data collection-types of sensors Thermal infrared environmental considerations Applications of thermal remote sensing	6	
	Minor Test 3		2
	Total	42	18

Suggested Readings

1. Askne Jain, Sensors and Environmental Applications of Remote Sensing, A. A. Balkeme Publishers, 2005.
2. Ramasamy S. M., Remote Sensing in Water Resources, Rawat Publications, 2005.
3. Joseph George, Fundamentals of Remote Sensing, Universities Press (India) Private Limited, 2004.

4. Lillesand T. M., Kiefer R. W, Remote Sensing and Image interpretation, John Wiley & Sons Inc, 2000.
5. Campbell James, Introduction to Remote Sensing, Taylor & Francis London.
6. Agarwal C.S, Textbook on Remote Sensing, Wheeler A. H., 2000
7. Agarwal C.S., Garg, P. K., Remote Sensing, A. H. Wheeler and Co. Ltd., New Delhi, 2000.
8. Jensen, John R., Remote Sensing of the Environment: An Earth Resource Perspective, 2009, Prentice Hall

Course No: GEO 102

Course Title: Fundamentals of Geoinformatics

Number of Credits: 4

No. of Lectures-Tutorial: 45-15

Course Coordinator/Instructor: Dr. Shamita Kumar

Course Outline

The course provides a firm understanding of the conceptual and technical issues related to use of geospatial technologies and in various aspects of wildlife and natural resource management. It introduces the students to the fundamentals of GIS, GPS, data models, data sources, cartography as well as multi-criteria analysis.

Learning Outcomes

- Demonstrate a good understanding of the use of geospatial technologies in various sectors.
- Demonstrate an understanding of building geo-databases.
- Develop abilities to think about and implement geographic data management and analysis for research and a variety of planning and management applications.

Pre-requisite

None

Evaluation Procedure : 0.6/0.4 University

Assignment	2	20%	Internal Assessment
Minor Test	3	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Introduction to GIS Overall introduction to the concept of geoinformatics and its application	02	
2	Geographic data and data measurement Data types and scales of data measurement, sampling methods	08	

	Map basics History of cartography, basic characteristics of maps, categories of maps, map scale Typography and lettering the map, elements of generalization-classification, simplification and exaggeration, symbolization-point, line, area, volume Basic geographic concepts Basic geodesy: Spherical, ellipsoidal and geoidal earth, geographical co-ordinates, Co-ordinate systems: Plane co-ordinate system, Geographic co-ordinate system Map projections: Scale factor and transformation, distortions resulting from map transformations, properties of map projections, classification of map projections, aspects of map projections, some commonly used projections, selection of a particular projection, geo-referencing, relationship between co-ordinate systems and map projections Geodetic datum-concept and types Nature of geographic phenomena and measurement of geographical variables		
3	Data Models, data structures and data input Introduction: bits and bytes, binary system, ASCII system GIS data models: Raster data models-nature, characteristics of raster data, principles of raster data compression GIS data models: Vector and raster data models-nature, characteristics Concept of topology, topological relationships between spatial objects Data input (raster and vector), metadata, data sources for GIS, input of methods of data input, digitization, error identification, types and sources of errors, correction, data editing, topology building.	08	
	Assignment 1 Discussion and presentation of selected research paper in groups of two students.		4
	Minor test 1		2

4	Global Positioning Systems Global positioning systems: introduction, GPS segments, GPS satellite generations, current GPS satellite constellation working principle GPS working principle, GPS signal structure, types of GPS receivers, pseudorange measurements, carrier phase measurements, cycle slips GPS errors and biases Methods of GPS observations GPS applications	06	
4.	Database Management Introduction to database and database management systems, importance of databases in GIS Database structures Database data models: Hierarchical model, network model, relational database model, object oriented data model Database creation, linking spatial and attribute data, GIS database applications	04	
	Assignment 2 Seminar presentation by individual students on predecided topics.		5
	Minor test 2		2
5.	Data analysis Measurements Queries Buffering and neighbourhood functions Map overlay Spatial analysis Multicriteria analysis Network Analysis	15	
6.	Application of Geoinformatics	06	

	Applications in forestry and wildlife management Applications in mining Applications in urban planning Applications in disaster management Applications in health studies Business applications		
7.	GIS project design and management Introduction to GIS project design and management Problem identification, designing a data model, project management, project design including data sources, image analysis, GIS operations, spatial analysis, time management and implementation problems.	04	
	Minor test 3		
	Total	45	15

Suggested Readings

1. Burrough P. A., R. A MacDonneli, Principles of Geographical Information Systems, Oxford University Press, 2000.
2. Lo. C. P., A.W. Yeung, Concepts and Techniques of Geographical Information Systems, Prentice- Hall of India Pr. Ltd., 2002.
3. Heywood I., S. Cornelius, S. Carrer, An Introduction to Geographical Information Systems, Pearson Education Pvt. Ltd, 2002.
4. Kang-stung-Chang, Introduction to Geographical Information System, Tata McGraw Hill Pub. Comp, 2002.
5. Demers M.N, Fundamentals of Geographic Information Systems, John Wiley & Sons, 2000.
6. Roy P.S., Dwivedi R.S., Vijayan D., 2010 Remote Sensing Applications National Remote Sensing Centre, India
7. Reddy, M.A., 2008. Textbook of remote sensing and geographical information systems. BS publications.
8. El-Rabbany, A., 2002. Introduction to GPS: the global positioning system. Artech House.
9. Arthur Robinson, H., 1958. Elements of cartography, John Wiley and Sons Inc.

Course No: GEO 103

Course Title: Fundamental of Programming

Number of Credits: 4

No. of Lectures-Tutorial: 45-15

Course Coordinator/ Instructor: Mr. Anand Shinde

Course Outline

The course focuses on the essential concepts and skills related to computer programming. This includes understanding of various programming technique.

Learning Outcomes

- Basic understanding of the concepts of programming structure
- Understanding of correct and efficient ways of solving problems.
- Ability to write and execute programming in C++.

Pre-requisite

Students are encouraged to complete the following free online course:

<https://www.edx.org/course/programming-basics-iitbombayx-cs101-1x>

Evaluation Procedure

Assignment	2	20%	Internal Assessment
Minor Test	3	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Introduction to programming Structure of CPU Planning the computer program, Purpose Introduction to programming, Developing a Program, Exceptions and errors Basic features programming Language like Identifier, Keywords, Variable, data types, Operators and Expression.	6	
2	Algorithm	4	

	Key features of an Algorithm, What are variables Different ways of stating Algorithms		
3	Flowcharts Standards for flowcharts Symbols used for flowcharts Guidelines for drawing flowcharts. Advantages and Limitations of using flowcharts Understanding programming using flowcharts	4	
	Assignment 1 Students will be allotted case studies for building algorithms and flowcharts which will be presented in class.		3
	Minor test 1		2
4	Introduction to Query language DML DDL DCL	4	
5	Number systems Number Representation Decimal and Binary Numbering System– Number system conversions ASCII & Unicode Compiler and Interpreter, Assembler, Linker and Loader	4	
6	Control Structures Decision control structures Logical operators Conditional operator and relational operators Loop control structures-While, do-while, for loop, Break statement and Continue statement Switch-case control structure. Test Conditions, Conditional execution and selection, Iteration and Repetitive Executions, Nested loops.	3	

7	Arrays Introduction to contiguous data types. One dimensional arrays Multidimensional arrays Array as strings Multidimensional character arrays Operations on strings.	2	
8	Functions Built-in and user-defined Function declaration Definition and function call Parameter passing: call by value, call by reference, recursive functions	3	
9	Searching and Sorting Linear and Binary Search Bubble, Heap and Merge		
	Assignment 2 Hands on exercise on programming concepts and numbering system		3
	Minor test 2		2
10	Introduction to OOP Basic Concepts of OOP Applications of OOP. Introduction to C++ Introduction to C++ Declarations in C++, Creating New data types in C++, function Prototypes, Inline functions, Reference Parameters Dynamic memory allocation, default arguments	5	
11	Class, Objects and Constructors Introduction,	5	

	Comparing class with Structure, Class Scope, Accessing Members of a class, Constructor, Destructor, This pointer Data abstraction and Information hiding Container classes and Iterators		
12	Overloading & Inheritance Operator Overloading, Restrictions, Insertion and stream extraction operators, Introduction to Inheritance, multiple inheritance Protected members Overloading Base class members in a Derived class, Public, Protocols and Private inheritance, Direct base classes and Indirect Base Classes, Using Constructors and Destructors in Derived classes,	5	
	Minor test 3		2
	Total	45	15

Suggested Readings

- Stanley B. Lippman , C++ Primer Fourth Edition, 2007, Pearson Education
- H.M. Harwani, C++ for Beginners , 2009, Sharaff Publication
- Lndrey Ullman, C++ Programming, 2007, Person Education Pvt. Ltd.
- Madhusudan Mothe, C. For Beginners, 2009, B.P.B. Publication Navi Mumbai
- Balguruswami E., Programming in C++, 2010, Tata Mc Graw Hill
- Yeshavant Kanetkar Asang Dani, Let Us C++, 2010, B.P.Bpublication New Delhi
- Robert J Oberg , Introduction to c++ Using Net, 2002, Pearsun Education Singapur Ltd.
- Herbert Schildt, The complete reference C++ 4.0, 2010, Tata Mc Graw Hill
- Herbert Schildt A., Beginnss Guide C++ 3.0, Tata Mc Graw Hill
- Tom Archer Andrew, Inside C++ 2 , 2007, A.P. Publishing Pvt. Ltd.
- Rohan White, How computers work, 2002, Techmedia Publication
- Paul Wilton Johncolby, Beginning SQL, 2005, Wiley Publishing Inc. India Pvt Ltd.

Course No: EST 101

Course No: EST 101

Course Title: Ecosystem Studies

Number of Credits: 4

No. of Lectures-Tutorial: 45-15

Course Coordinator/Instructor: Dr. Kranti Yardi with inputs from Dr. Rahul Mungikar

Course Outline

Ecosystems provide a vast range of services, from food and medicines to a stable climate, clean water and storm protection. This course provides an introduction to the functioning of ecosystems underlying these services, in particular looking at how ecosystems are structured and how they function. The course has a practical ethos and involves fieldwork and analysis of real data. The course looks at the dynamic nature of ecosystems, which often behave as complex systems. The course provides students with the core ecosystem knowledge needed for management.

Learning Outcomes

Student will develop:

- An understanding of the fundamental principles of ecosystem ecology including how ecosystem structure relates to function and the dynamics of ecosystems.
- Appreciation of the diversity of ecosystem functions across time, space and biomes.
- Appreciation of how ecosystems respond to global change drivers including climate change, land use change and biodiversity loss.
- An understanding of ecosystem services, principles of ecosystem valuation and its importance

Pre-requisite

None

Evaluation Procedure: 0.6/0.4 University

Assignment	2	20%	Internal Assessment
Minor Test	3	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1.	Biogeography and evolution • Patterns of species distribution – evolutionary	04	

	relicts, climatic relicts, endemic organisms, environmental gradients, interaction of factors, species interactions • Natural selection, Darwin's theory • Plate tectonics and evolution of biodiversity • Species diversity in the tropics		
2.	Ecological Concepts and Ecosystem • Evolution of natural environment • Introduction: Biotic and abiotic factors • Ecosystem productivity • Food chains and food webs and trophic levels • Energy flows– pyramid of number, pyramid of energy and pyramid of biomass • Patterns and types of bio-geochemical cycles – oxygen, nitrogen, carbon, sulphur and phosphorus • Water cycle • Principles of limiting factors- Liebig's law of Minimum, Shelford's law of tolerance, Combining concepts of limiting factors, limiting factors in ecosystem context • Ecological indicators, Ecotones and concept of edge effect, successional patterns (grasslands to old growth) and response of wildlife	06	
3.	Biodiversity • Definition: species richness, species diversity, biological diversity • Levels of biodiversity: genes to landscapes • Values of biodiversity – direct and indirect • Biogeographic zones of India	02	
	Assignment 1 Discussion and presentation of selected research paper in groups of two students.		4
	Minor test 1		2
4.	Ecosystems • Forests – Biogeography of forests in India, vegetation structure and functions, food chain and food webs, plant-animal interaction, productivity and nutrient cycling, biological diversity of tropical forests, limiting factors, gap	10	

	theory, threats and conservation. • Grasslands – Biogeography of grasslands in India, structure and function, food chains and food webs, animal population dynamics, limiting factors, threats and conservation • Deserts – Biogeography of deserts in India, structure and function, limiting factors, environmental factors and plant-animal distributions, threats and conservation • Mountains – Tropical mountains, structure and function, plant and animal ecophysiology, threats and conservation • Mangroves – structure and function, ecological adaptations of mangroves, plant and animal diversity and interactions, mangrove productivity, food chains and food webs, threats and conservation • Marine ecosystems – structure and function, plant and animal diversity with reference to India, food chains and food webs, threats and conservation • Coral reefs – Distribution, structure and function, coral reef biology, coral reef communities, coral reef biodiversity, threats and conservation • Wetlands/Rivers - Biogeography, structure and function, stratification, food chains and food webs, catchment area concept, threats and conservation.		
5.	Taxonomy • Study of identification and classification characters / Concepts of Taxonomic characters • Morphological features • Overview of the classification systems for each group • Major Classification systems preferred for identification of cryptogams and phanerogams up to order level ▪ Alexopolus, Mims & Blackwell – For Fungi ▪ Natural classification system and APG III • Types of keys and use of floras or identification keys • Plant nomenclature - ICBN	12	

	Animal taxonomy - Brief classification of animals up to class level for invertebrates and up to order level for vertebrates - Use of Taxonomic Keys for Identification of the animal specimen		
	Assignment 2 Seminar presentation by individual students on predecided topics.		5
	Minor Test 2		2
6.	Ecosystem services and ecosystem dynamics Ecosystem services - Ecosystem functioning and ecosystem services provided by different ecosystems at present – provisioning services, regulating services, habitat or supporting services, cultural services - Species population and ecosystem services-the connections - Millennium Ecosystem Assessment, TEEB with case studies Ecosystem dynamics - Definition of ecosystem dynamics and its relevance - Changes in ecosystems over different time scales, drivers of ecosystem dynamics (natural and human induced), patterns and elements of ecosystem dynamics with examples	05	
7.	Valuation of Ecosystem Services - Overview of economic valuation of ecosystems - Key issues in valuation of economics of ecosystems-identifying key stakeholders, key development goals, assessing the status and trends of key ecosystems, engaging stakeholders - Valuation methods – preference based approaches, biophysical based approaches and their limitations - Selecting valuation method and indicators, developing an implementation plan, Capturing the value of ecosystem services, implementing and monitoring - Payments for ecosystem services - Case studies	06	

	Minor test 3		2
	Total	45	15

Suggested Readings

1. Groom M.J., Meffe G.K. and Carroll C.R. (2006) *Principles of Conservation Biology* (3rd edition), Sinauer Associates, Sunderland
2. Gopal, R., 2011. Fundamentals of Wildlife Management. Natraj Publishers, New Delhi.
3. Sawarkar, V.B., 2005. A guide to planning wildlife management in protected areas & managed landscapes. Natraj Publishers.
4. Primack R.B. (2006) *Essentials of Conservation Biology* (4th ed.), Sinauer Associates, Sunderland.
5. Carabias Julia and Kishore Rao, Capacity Needs to Manage Protected Areas, The Nature Conservancy, 2003.
6. Champion S., Seth S, (2005). Revised survey of forest types of India. Nataraj Publishers, New Delhi.
7. Estuaries of India, ENVIS, 2002.
8. Sustainable management of wetland, biodiversity and beyond. Jyoti Parikh & Hemant Date.
9. Mangroves of India, ENVIS, 2002.
10. Hunter Malcom. Jr, Maintaining Biodiversity in Forest Ecosystems, Cambridge University Press, 1999.
11. Townsend Colin. R, John. L. Harper and Michael Begon, Essentials of Ecology, Blackwell Science, 2000.
12. Owen Oliver. S, Daniel. D. Chiras and John. P. Reganold, Natural Resource Conservation, 7th Edition, 1998.
13. Keddy Paul. A, Wetland Ecology – Principles and Conservation, Cambridge University Press, 2000.
14. Botkin Daniel. B and Edward. A. Keller, Environment Science – Earth as a living Planet, John Wiley and Sons, 2005.
15. Nebel Bernard. J. and Richard. T. Wright, Environment Science, Pearson Custom Publishing, 8th Edition, 2003.
16. Alfred J. R.B, A.K.Das and A.K.Sanyal, Ecosystems of India, ZSI, 2001.
17. Puri, G.S., Gupta, R.K., Meher-Homji, V.M., Puri, S., others, 1989. Forest ecology. Volume 2. Plant form, diversity, communities and succession. Oxford & IBH Publishing Co. Pvt. Ltd.
18. Puri, G.S., Meher-Homji, V.M., Gupta, R.K., Puri, S., others, 1983. Forest ecology. Volume I. Phytogeography and forest conservation. Forest ecology. Volume I. Phytogeography and forest conservation.
19. Venkataraman K., 2012. Fauna of Maharashtra Part 1: Vertebrates Zoological Survey of India
20. Sahara V.B. (2001) *Wildlife in India*, Natraj Publishers, Dehra Dun.

21. Enger, E.D., Ross, F.C., Bailey, D.B., 2003. Concepts in biology. McGraw-Hill Science / Engineering/Math.
22. Grimmett R., Inskipp C. and Inskipp T. (2001) *Pocket Guide to the Birds of the Indian Subcontinent*, Oxford University Press, Oxford.
23. Menon, V., 2014. Indian mammals: a field guide. Hachette India.
24. Sharma, B.D., Karthikeyan, S., Singh, N.P., Flora of Maharashtra State. Botanical Survey of India.
25. Miller, G., Spoolman, S., 2007. Environmental Science: Problems, Connections and Solutions. Cengage Learning.

Journals (to be accessed through JGATE)

1. Ecology
2. Conservation Biology

Course No: EST 111

Course Title: Field techniques I

Number of Credits: 2

Course Coordinator/Instructor: Dr. Kranti Yardi

Course Outline

The course provides hand on expertise in identifying flora and fauna as well as in depth understanding of ecosystem structure and function through a combination of field visits and lab work.

Learning Outcomes

Students will:

- Develop skills in identifying birds, mammals and major plant species
- Develop an ability to analyze structure of ecosystems.
- Acquire competence in design and implementation of sampling techniques.

Pre-requisite

None

Evaluation Procedure : 0.6/0.4 University

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed Journal submitted timely (within 7 days): 5 marks	Internal Assessment
Major exam	60%		University Assessment

Details of course content

1. Sampling techniques for vegetation analysis using quadrats.
2. Sampling techniques for vegetation analysis using line and belt transects.
- 3A. Identification of birds
- 3B. Identification of birds
4. Identification of bird calls (30 calls)
5. Identification of insects (atleast 30)
- 6A. Identification of plants -visual identification (atleast 50)
- 6B. Identification of plants –visual identification
7. Study of identification of non-chordates and Chordates (20 specimens from

different Phyla)

8. Study of planktons.
9. Preparation for field work (Use of google earth and other sources for gathering information, planning methods)
10. Methods for assessment and evaluation of ecosystems (frequency, abundance, density, GBH, canopy cover and diversity index)
11. Field work in forest ecosystem – field work in Mulshi (assessment and evaluation)
12. Field work in grassland ecosystem – field work in Supe (assessment and evaluation)
13. Field work in wetland ecosystem – field work in Bhigwan (assessment and evaluation)

Field techniques for students who have opted for Urban Environment Management

14. Analysis of environmental problems in the urban fringe
15. Analysis of environmental problems related to informal housing
16. Analysis of problems related to water management in the urban areas
17. Analysis of problems related to urban green spaces

Course No: GEO 111

Course Title: Techniques in image interpretation and remote sensing

Number of Credits: 2

Course Coordinator/Instructor: Mr. Lakshmi KantaKumar

Course Outline

The course provides hand on expertise in satellite image interpretation and cartography.

Learning Outcomes

- Proficiency in identifying various features on the satellite images
- Ability to work with satellite images

Pre-requisite

None

Evaluation Procedure : 0.6/0.4 University

Continuous assessment during practical	40 %	Marking pattern for every practical: Performance during the practical and completion of practical in the lab itself : 5 marks Completed Journal submitted timely (within 7 days): 5 marks	Internal Assessment
Major exam	20%		University Assessment

Details of course content

1. Annotation of SOI topographical maps (with reference to numbering, scales, grid reference, signs and symbols, colour system)
2. Study and interpretation of SOI maps, study and interpretation of cadastral maps/thematic maps
3. Problems based on determination of scale using (i) ground distance (ii) toposheet
4. Preparation of landuse pattern maps using aerial photographs.
5. Visual interpretation of satellite images for landuse/landcover
6. Field identification of features using aerial photographs and satellite images.
7. Introduction to Erdas Imagine (displaying data from different satellites and using image visualization tools)

8. Reading IRS data (BIL/BSQ formats), downloading data (GLCF, Bhuvan) and stacking images
9. Introduction to SAGA
10. Registration of satellite images (Assignment using SAGA)
11. Image to image registration (Assignment using SAGA)
12. Mosaicking satellite images (Assignment using SAGA)
13. Subsetting satellite images (Assignment using SAGA)

Course No: GEO 112

Course Title: Techniques in GIS and GPS

Number of Credits: 2

Course Coordinator/Instructor: Dr. Shamita Kumar

Course Outline

The course provides hand on expertise with use of open source as well as commercial GIS software through a series of well designed practical's related to cartography, building geo databases, querying data, use of GPS and multicriteria analysis.

Learning Outcomes

- Proficiency in use of open source and commercial software for basic GIS operations.
- Ability to use GPS for data collection.
- Ability to build basic geo databases.
- Competence in querying and making GIS analysis.

Pre-requisite

None

Evaluation Procedure : 0.6/0.4 University

Continuous assessment during practical	40 %	Marking pattern for every practical: Performance during the practical and completion of practical in the lab itself : 5 marks Completed Journal submitted timely (within 7 days): 5 marks	Internal Assessment
Major exam	20%		University Assessment

Details of course content

1. Introduction to ArcGIS tools
2. Digital cartography
3. Defining co-ordinate systems and projecting data sets
4. Map registration
5. Introduction to QGIS (Assignment-self study with discussion)
6. On screen digitization (Assignment using QGIS)
7. Error identification, rectification

8. Working with tables (Assignment using QGIS)
9. Using the analysis tools in ArcGIS (Assignment using QGIS)
10. Data query in ArcGIS (Assignment using QGIS)
11. Performing multicriteria analysis
12. Use of GPS and input of GPS data
13. Introduction to Google Earth

Course No: EST 104

Course Title: Statistical Methods

Number of Credits: 4

No. of Lectures-Tutorial-Practical: 32-3-22

Course Coordinator/Instructor: Dr. Rahul Mungikar

Course Outline

The course has been designed to help biologists/environmental scientists answer questions of applications of statistics in their field of work. The course focuses on techniques for generating informative data, extraction information from data and to analyze data to get meaningful interpretations.

Learning Outcomes

After the course the student will be able to:

- Apply the appropriate technique for extraction of information from data
- Analyze data using appropriate statistical techniques and software

Pre-requisite

Students are encouraged to join and complete the free online course offered by Harvard University at : <https://www.coursera.org/learn/basic-statistics#syllabus>

Evaluation Procedure : Continuous assessment

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed home assignment submitted timely (within 7 days): 5 marks	Practicals must be in the prescribed journal format	Internal Assessment
Major exam	60%	Theory cum practical examination		Internal Assessment

Details of course content and allotted time

Unit	Topic	Time (Hours)		
		Lectures	T	P
1	Data in Ecology and Environment Sciences	4		

	• Samples and populations • Accuracy and precision • Variables • Derived variables • Frequency distribution • Types of sampling Statistical techniques • Data collection • Organization of data • Representation of data – tabular and graphic			
2	Basic elements and tools of statistical analysis • Measures of central tendency – arithmetic mean, geometric mean, harmonic mean, mode, median • Measures of dispersion – Standard deviation, • Coefficient of variation	2		
3.	Practical 1: Tabulation and graphical representation of the data, estimation of mean, mode, median of different data types using statistical formulae and by graphs			2
4.	Practical 2: Calculation of Standard deviation, coefficient of variation of different data types by different methods.			2
5.	Correlation of measurement • Estimated correlation coefficient • Significance tests for correlation coefficients	2		
6.	Practical 3: Correlation Coefficient and test of significance			2
7.	Concepts of probability • Basic laws – Examples from Ecology – Discrete probability distribution – expectation and variance	2		
8.	Practical 4: Calculation of Simple probabilities, Expected Probabilities & Variance, Binomial probability distribution			2
9.	Distribution • Binomial distribution	5		

	• Normal distribution • Poisson distribution • t – test • Chi square test			
10.	Practical 5: Problems based on Poisson and Normal probability distribution			2
11.	Non Parametric • Non parametric tests (Mann-Whitney, Kruskal Wallace, Wilcoxin signed ranks, Spearman etc.)	1		
12.	Contingency tables and χ^2 • Contingency tables • Special case of a table with only two rows • Special case of 2 X 2 tables, exact test for 2 X 2 tables	2		
14.	Practical 6: Problems based on t-test analysis and Chi-square test			2
15.	χ^2- test of goodness – of – fit and homogeneity • Testing the fit of a whole frequency distribution data • Test of homogeneity • Small samples for normal distribution • Binomial and Poisson distribution • Additive property of χ^2 • Normal approximation	3		
16.	Practical 7: Problem based on Test of goodness of fit			2
17.	Practical 8: Introduction to SPSS/R for calculation of various test of statistics			2
19.	Comparison of means • t-test, ANOVA	2		
20	Practical 9: Problems based on ANNOVA – One way, Two way			2

21.	Regression analysis • Regression coefficient • Standard errors and significance tests	4		
22.	Practical 10: Problems based on Regression analysis			2
23.	Introductory Multivariate Statistics and Partial correlation	5		
24.	Practical 11: Problems based on Regression coefficient, standard errors			2
	Final Assessment		3	
	Total	32		22

Suggested Readings

1. Clark, J. S. Models for Ecological Data: An Introduction. Princeton University Press Princeton, New Jersey, USA, 2007.
2. Legendre, P., and L. Legendre. Numerical Ecology. Vol. 20. Elsevier, 2012.
3. Ott, L., and M. Longnecker. An Introduction to Statistical Methods and Data Analysis. Duxbury press, 2010.
4. Sokal, R.R. and Rohlf, F.J. 1995. Biometry: the principles and practice of statistics in biological research. 3rd edition. New York.
5. Zar J.H. 1999. Biostatistical Analysis. Prentice Hall, New Jersey, 663 pp.

Course No: EST 105

Course Title: Fundamentals of computing and database

Number of Credits: 4

No. of Lectures-Tutorial-Practical: 26-10-24

Course Coordinator/Instructor: Mr. Anand Shinde

Course Outline

The course will introduce basic software programming and use of database software. It focuses on the fundamentals of computer science, database systems, programming languages, data types, etc.

Learning Outcomes

At the end of the course the student will:

- Have a understanding of databases and building databases
- Ability to write simple programs

Pre-requisite

Students are strongly encouraged to complete the following free online courses:

<http://www.studytonight.com/dbms/>

<https://www.learnstreet.com/lessons/study/javascript>

http://www.w3schools.com/js/js_intro.asp

Evaluation Procedure :Continuous

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed home assignment submitted timely (within 7 days): 5 marks	Practicals must be in the prescribed journal format	Internal Assessment
Major exam	60%	Theory cum practical examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	T	P
1	Hardware and Software	2		

	• Memory management and File associations • Computer languages • Overall functioning of operating system and other application software's			
2	Problem Solving techniques • Algorithms • Flowcharts	6		
	Practical 1 : Preparing flowcharts and algorithm based on specific problems			2
3	Database fundamentals • Properties of a database • Database models and objects • Components of DBMS, DBMS Functions • Advantages and disadvantages of DBMS • Data types • Introduction to Fields, Tables, Database, Understanding forms and its controls	6		
	Practical 2: Creating Database (table, records, fields and data types). Data sorting, Data filtration, pivot table, graphs and reports			2
	Practical 3: Create module and reports using tables			2
4	Relational Database Components • Logical/Physical database design components • Form based database queries – creating queries • Introduction to SQL – Data Query Language • Designing tables and constraints	6		
	Practical 4: Create database schema, append data, update data and schema, delete data and structure. Assigning constraints to table			2
5	Programming using macros in excel • Introduction to macro programming • Macros with worksheet, forms and controls	4		
	Practical 5: Developing and testing macros in VBE. Excel macro recorder			2

	Practical 6: Working with statements, functions, variables, events			2
	Practical 7: Working with forms, controls and events			2
6	Introduction to programming • Introduction to Javascript programming • Understanding structure of JavaScript code • Understanding types and objects • Control statements and functions • Understanding Object-Oriented Features, Class and Objects, Data Hiding and Encapsulation, Structures, Data members and Member functions. • Data Members and Member Functions, Constructors & Destructors, Roles and types of Constructors, Roles of Destructors	10		
	Practical 8: Study of javascriptstructure, types and objects			2
	Practical 9: Study of data members , functions, controls statements, Operators			2
	Practical 10: Study of object oriented concepts			2
	Minor Test 3		2	
	Total	34	6	20

Suggested Readings

1. Microsoft Excel 2010, 1 edition. ed, 2010. . Microsoft Press, Redmond, Wash.
2. Hunt Roger, Computer and Common senses, Prentice Hall of India, New Delhi, 1995.
3. Oka Milind M, Computer Fundamentals, Everest Publishing House, Pune, 2001.
4. Rajaraman V, Fundamentals of Computers, Prentice Hall of India Pvt.Ltd, New Delhi, 2000.
5. Jain V. K, Basic Computer Programming, Pustak Mahal, 1992.
6. Sinha Pradeep and Priti Sinha, Computer Fundamentals, BPB Publications, 2006.
7. Groff James and Paul Weinberg, The Complete Reference, Tata McGraw Hill Edition, 2003.
8. Paul Wilton & Jeremy McPeak, Beginning JavaScript (4th Edition), Wrox Press

9. David Flanagan, JavaScript - The Definitive Guide (6th Edition), O'Reilly
10. Roger Hunt & John Shelley, Computer and Commonsenses, Prentice Hall of India Pvt. Ltd
11. Dr.Milind M. Oka, Computer Fundamentals, Prentice Hall of India Pvt.Ltd.
12. Paul Wilton Johncolby, Beginning SQL, 2005, Wiley Publishing Inc. India Pvt Ltd.
13. James R. Groff and Paul N, Weinbery, The Complet Reference SQL,2002, Tata McGraw Hill New Delhi
14. Sumathi, S., 2008. Fundamentals of Relational Database Management Systems. Springer.

SEMESTER II

Course No: GEO 201

Course Title: Geodatabase management

Number of Credits: 4

No. of Lectures-Assignments-Tutorial/Exam: 45-10-03

Course Coordinator: Mr. Anand Shinde

Pre-requisite

None

Course Outline

Access to accurate data is a pre requisite for any geospatial project. This course along with GEO 211 trains students in creating, maintaining, and retrieving data from a spatially enabled database. The course covers relational database topics that are of relevance in both geographic and non-geographic contexts (e.g., Structured Query Language and database design). It then focuses on the special considerations involved in the management of a spatial database by demonstrating two broad approaches. The first utilizes open-source technologies (specifically, the Postgres database management system and its spatial extension PostGIS); the second utilizes technologies from commercial vendors.

Learning Outcomes

At the successful completion of this course and Course GEO 211, students should be able to:

- retrieve data from an existing database using SQL Select queries
- design a database schema from a set of requirements
- implement that design through the creation of related tables
- insert and update rows in a table
- create spatially enabled tables in Postgres/PostGIS
- work with PostGIS data using open-source desktop GIS software (QGIS)
- create an Esri file geodatabase
- model real-world entities through subtypes, domains, topology rules, and relationship classes
- discuss the suitability of an open-source or proprietary approach to various project scenarios

Evaluation Procedure : 0.6/0.4 University

Assignment	2	20%	Internal Assessment
Minor Test	3	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Introduction to Database System • Introduction and purpose of database, computer data organisation, level of database implementation • Database system architecture: Levels of architecture, client server architecture, centralised and distributed processing • Characteristics of Database System ➤ Concurrent Use ➤ Structured Data ➤ Data Security and Integrity constraints ➤ Transactions ➤ Keys ➤ Views ➤ Backup and Recovery • Normalisation of Data, Codd's Rules	07	
2	Database models and modelling • Introduction to database model: schema, instance • Types of data modelling: Conceptual, logical and physical • Principles and techniques of data modelling • Database relationships: logical, physical • Relational Database model • Entity relationship model • Object oriented model	10	
	Assignment 1		4
	Minor Test 1		2
3	Introduction to Oracle and MS-Access • Introduction to Oracle architecture, history of Oracle and Oracle database system • Data Definition language • Data manipulation language • Introduction to queries • Scheme object, literals, data types, nulls, comments • SQL command syntax	13	

	- SQL Functions, Joins and Sub Queries: Types of SQL functions: Character functions and Numeric Functions - Relational operation - Logical operation, condition based on pattern matching, order by clause and group by clause		
	Assignment 2: Linked to field work in Protected Area		4
	Minor Test 2		2
4	Spatial data and database systems - Spatial data structure and database models - Classification of spatial database systems - Characteristics of spatial database systems - ArcGIS databases - Spatial data processing; spatial data standards and standardisation - OGC spatial data standards WMS, WFS, WCS - Metadata, spatial metadata standards	7	
5	PostgreSQL and PostGIS - Introduction to PostgreSQL Database Management System - PostGIS Functions - Spatial Query - Spatial storage	08	
	Minor Test 3		03
	Total	45	15

Suggested Readings

- Koch Loney, Oracle 9i – The complete reference, Tata McGraw Hill, 2007
- Nanda Arup, Steven Feuerstein, Oracle PL/SQL for DBA, Shroff publishers and distributors pvt. Ltd., July 2008
- Feuerstein Steven, Pribyl, Oracle PL/SQL Programming, SPD publication, Fourth Edition, 2005
- Misbra Sanjay, Alan Beaulieu, Mastering Oracle SQL, SPD Publications, 2008
- Gennick Jonathan, Oracle SQL Plus - The Definitive Guide, SPD Publications, 2005
- Millsap Cary, Jatt Holt, Oracle Performance Optimizing, SPD Publications, 2003
- McLaughlin, Oracle Database 11g, Tata McGrawHill Publishing Company Ltd, 2008

- Bayross Ivan, Understanding oracle BPB Publications, 2004
- Bayross Ivan, Oracle Developer 2000, BPB Publications
- Loney Kevin, George Koch, Oracle 8i the complete reference, Tata Mcgraw Hill Edition, 2000
- Date C.J., An introduction to database systems, Pearson Education, 2007

Course No: GEO 202

Course Title: Advanced Remote Sensing

Number of Credits: 4

No. of Lectures-Tutorial: 45-10-03

Course Coordinator: Mr. Lakshmi KantaKumar N.

Course Outline

The course will provide opportunity to understand and work with latest developments in the Remote Sensing datasets.

Learning Outcomes

At the end of the course, student will :

- Acquire deeper knowledge about advanced remote sensing methods
- Be able to apply their knowledge of remote sensing to various applications.

Pre-requisite

GEO 101

Evaluation Procedure : 0.6/0.4 University

Assignment	2	20%	Internal Assessment
Minor Test	3	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Active and passive microwave remote sensing • Radar development, SLAR system operation, Spatial resolution of SLAR system, Geometric characteristics of SLAR Imagery, Interpretation of SLAR imagery • Transmission characteristics of radar signals, earth surface feature characteristics influencing radar returns (geometric characteristics, electrical characteristics, soil response, vegetation response, water and ice response) • Synthetic Aperture Radar Systems (SAR), SAR remote sensing from space (Seasat, Shuttle Imaging Radar SIR Series, RADARSAT, ERS-Series, JERS, Passive microwave sensing (elements, sensors and applications), Scatterometers	15	
	Minor Test 1		2

	Assignment 1: Research Paper discussion in groups of two students		4
2	LiDAR remote sensing • Introduction to LiDAR, Topographic, bathymetric and Multiple return LiDAR, Scanning Mechanism. • Working principal of LIDAR, Various range and time of travel (ToT) measurements. Geolocation of LiDAR measurements, LiDAR data characteristics (Zig-Zag, parallel line and elliptical patterns), Processing of LiDAR data. • Available LIDAR sensors (ALTM, ALS and Toposys etc.), LiDAR applications, Case studies of urban applications and biomass estimation.	15	
	Minor Test 2		2
3	Hyperspectral remote sensing • Introduction, Principles of spectroscopy, Spectrometers, Image cube, preprocessing of hyperspectral data (calibration, atmospheric corrections and geometric corrections), data characteristics and quality. Noise filtering with PCA and MNF • Spectral profiles, Spectral libraries, Image endmembers, Pixel purity index, Hyper spectral mapping techniques (Binary encoding, Spectral matching, Spectral mixing, Spectral angle mapping, spectral information divergence) • Hyperspectral sensors (HIS, Hyperion, AVIRIS and IMS) it applications with case studies.	15	
	Assignment 2: Research Paper discussion in groups of two students		5
	Minor Test 3		2
	Total	45	15

Suggested Readings

1. Borengasser M, Hungate WS, Watkins R (2007) Hyperspectral Remote Sensing: Principles and Applications. CRC Press
2. Campbell JB, Wynne RH (2011) Introduction to Remote Sensing, Fifth Edition. Guilford Press

3. Du Y, Chang C-I, Ren H, et al (2004) New hyperspectral discrimination measure for spectral characterization. *Opt Eng* 43:1777–1786. doi: DOI: 10.1117/1.1766301
4. Eismann MT (2012) *Hyperspectral Remote Sensing*. SPIE
5. Jensen JR (1996) *Introductory digital image processing: a remote sensing perspective*. Prentice Hall
6. Jensen JR (2007) *Remote sensing of the environment: an earth resource perspective*. Pearson Prentice Hall
7. Lillesand TM, Kiefer RW, Chipman JW (2008) *Remote sensing and image interpretation*. John Wiley & Sons
8. Meer F van der, Jong SM de (2002) *Imaging Spectrometry: Basic Principles and Prospective Applications*. Springer Science & Business Media
9. Ridgway JR, Minster JB, Williams N, et al (1997) Airborne laser altimeter survey of Long Valley, California. *Geophys J Int* 131:267–280.
10. Woodhouse IH (2005) *Introduction to Microwave Remote Sensing*. CRC Press

Course No: GEO 203

Course Title: Digital Image Processing

Number of Credits: 4

No. of Lectures-Tutorial: 45-10-03

Course Coordinator: Dr. Shamita Kumar

Course Outline

The course will provide an indepth knowledge of satellite image fundamentals and techniques for extraction information from satellite images including pre processing and post processing operations. This course assumes that students have prior knowledge in the basics of remote sensing, mapping, and GIS, and have experience with geospatial software. Through laboratory work, students will have opportunities to practice the concepts and techniques learnt in the lectures.

Learning Outcomes

On successful completion of this course and Course GEO 212, the students will :

- Develop a strong understanding of the tools and techniques used to display, process, and analyze remotely sensed data
- Critically assess the strengths and weaknesses of remote sensing instruments and platforms for a broad range of application scenarios and design a remote sensing program.
- Use acquired knowledge and critical thinking skills to solve a real-world problem with appropriate remote sensing data and processing methods.

Pre-requisite

GEO 101, GEO 202

Evaluation Procedure : 0.6/0.4 University

Assignment	2	20%	Internal Assessment
Minor Test	3	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	A	T/E
1	Introduction to digital image processing	02		

	• Overview of remote sensing data collection and analysis • Data collection: Insitu and remote sensing data collection-biophysical and hybrid variables, analog and digital image processing • Digital remote sensor data collection: multispectral imaging using discrete detectors, scanning mirrors, linear arrays, area arrays, digital frame cameras • Digital image data formats: BIL, BIP, BSQ			
2	Image Quality Assessment and Statistical Evaluation • Significance of the histogram in digital image processing • Univariate descriptive image statistics: measures of central tendency, measure of dispersion, skewness • Multivariate image statistics: covariance in multiple bands, correlation between multiple bands • Feature space plots	04		
	Assignment 1: Seminar presentation by individual students on pre decided topics as assigned by the teacher.		5	
3	Image rectification and restoration • Introduction • Radiometric correction: random bad pixels, line or column drop-outs, partial line or column dropouts, line start problems, n-line stripping • Atmospheric correction • Geometric correction: Internal and external geometric error, types of geometric correction- image to map rectification, image to image registration, hybrid approach to image rectification/registration • Intensity interpolation: nearest neighbour, bilinear	05		

	interpolation • Mosaicking			
	Minor Test 1			01
4	Image enhancement techniques • Image reduction and magnification • Contrast enhancement: linear contrast enhancement, maximum-minimum contrast stretch, percentage linear and standard deviation contrast stretching, piecewise linear contrast stretch, non-linear contrast enhancement • Band ratioing, spatial filtering: spatial convolution filtering, fourier transform • Edge enhancement: linear and non-linear edge enhancement • Principal Component Analysis • Vegetation indices: Dominant factors controlling leaf reflectance, NDVI, SAVI,	10		
5	Image classification • Introduction: Parametric and non-parametric method • Supervised classification: LULC classification levels, Classification stage-Minimum-Distance-to-Means Classifier, Parallelpiped Classifier, Maximum Likelihood Classifier, Nearest Neighbour; Training Stage • Unsupervised classification; Classification accuracy assessment, error matrix • Fuzzy classification • Classification based on object oriented image segmentation • Hybrid classification, incorporating ancillary data in the classification process • Knowledge based classification • Classification using neural networks	10		

	Assignment 2: Research paper discussion in groups of two students		05	
	Minor Test 2			01
6	Hyperspectral image analysis Hyperspectral image analysis: Atmospheric correction of hyperspectral images, hyperspectral image analysis techniques	07		
7	Digital change detection Steps required to perform change detection, change detection algorithms	07		
	Minor Test 3			1
	Total	45	10	03

Suggested Readings

1. Richards J. A, Jia Xiuping, Remote Sensing Digital Image, Springer Verlag Berlin Heidelberg My., 1999
2. Chanda B., D Datta, Majumdar, Digital Image Processing and Analysis, Prentice- Hall of India , 2001.
3. Prithvish Nag, M. Kudrat, Digital Remote Sensing, Concept Publishing Company, New Delhi, 1998
4. Lecture notes, module II, Image Analysis and Interpretation, IIRS
5. Jensen John: Introductory Digital Image Processing-A remote sensing perspective, Prentice Hall Series, 2005

Course No: GEO 204

Course Title: Fundamentals of WebGIS

Number of Credits: 4

No. of Lectures-Tutorial: 45-10-03

Course Coordinator: Mr. Dinesh Grover

Course Outline

Web GIS has immense applicability to e-government, e-business, e-science, and daily life. Government employees can utilize Web GIS to improve public services and enhance collaboration across agencies. Businesses can use Web GIS to enhance their existing business models and create new ones. Researchers can find new solutions to meet the challenges of the new frontiers. Web GIS has great practical value to our world today and into the future. The course provides in depth insight into the new field of Web GIS alongwith its principles and application.

Learning Outcomes

At the end of the course students will have:

- Critically assess the organizational benefits and challenges of developing Web GIS applications;
- Explain the difference between Web GIS, geospatial web services, mashups, mobile GIS solutions, geoportals, and how these are applicable to e-business and e-government;
- Evaluate current technologies or architectures that support Web GIS; and Design and implement an independent Web GIS application

Pre-requisite

None

Evaluation Procedure: 0.6/0.4 University

Assignment	2	20%	Internal Assessment
Minor Test	3	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	A	T/E
1.	Introduction • The Web and GIS • Origins and evolution • Web GIS concept • Web GIS applications • Introduction to HTML 5.0	07		

2	Technical basics WebGIS fundamentals • Web GIS basic architecture and components • Thin vs thick client architecture • Introduction to GML, geoRSS, XML, WKT (Well Known text) and preferred coordinate systems (GCS84) for web GIS apps. • Use of APIs in creating web enabled GIS websites (open layers API and google map API) • User experience design	10		
	Assignment 1: Hands on session (practical) – developing a simple Web GIS application using different APIs		05	
	Minor Test 1			01
3	Geospatial Web Services • From websites to web services • WMS, WFS and WCS; their roles in web GIS • Geospatial web service functions • Web service architecture • Introduction to Interoperability and geospatial web service standards • HTTP WebRequest • Introduction to PHP	07		
4.	Geospatial Mashups • Evolution and impact • Web contents, functions and interfaces • Mash up design and implementation • Challenges and prospects • Demonstration of mashups	07		
	Assignment 2: Developing a Web GIS application using HTML 5/Javascript by enforcing different OGC standards		05	
	Minor Test 2			01
5.	Web GIS applications in e-business • Introduction to e-business and geobusiness • Types of applications • Challenges and prospects	06		
6.	Web GIS applications in e-government • Introduction to e-government and geo	06		

	government • Types of applications • Challenges and prospects			
7.	Introduction to RDBMS support in creating interactive webGIS applications	02		
	Minor Test 3			01
	Total	45	10	03

Suggested Readings

- Web GIS: Principles and Applications Paperback – Import, 15 Mar 2011, by Pinde Fu (Author), Jiulin Sun (Author)
- GIS for Web Developers: Adding 'Where' to Your Web Applications Paperback – October 19, 2007, by Scott Davis (Author)

Course No: EST 205

Course Title: Research Methodology

Number of Credits: 2

No. of Lectures-Assignments: 20-50

Course Coordinator: Dr. Shamita Kumar

Course Outline

The course will provide students with a critical understanding of the research process and familiarize students with the main approaches, methods and techniques of qualitative and quantitative research. The course will enable students to undertake their own independent research and apply appropriate research methodologies in order to plan, conduct and evaluate basic research as part of their degree and provide a solid foundation for further advanced research.

Learning Outcomes

- Ability to identify various sources of information and write up a literature review
- Planning and conducting basic qualitative and quantitative research
- Ability to write an introduction and methodology

Evaluation Procedure: Continuous

Assignments	50%	1. Chapter on literature review of the individual students' thesis
	50%	2. Chapter on Methodology of the individual students' thesis

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	A
1.	Research Design: Overview • Understanding research • The qualitative/quantitative divide • Overview of different research traditions – action research, case studies, documentary analysis, ethnographic research, experiments, grounded theory, surveys	02	
2.	Planning the research • Selecting a topic • Topic to research question – problem definition, research question, hypothesis, research objectives • Research question to research design –developing the	02	

	design • Data gathering – primary and secondary		
3.	Literature Review • Introduction to literature review • Methodology of literature review • Literature sources – books and journals, electronic databases, government and industry, internet • Writing a literature review • Referencing – systems, referencing websites, citations, use of software	04	
5.	Qualitative Research • Qualitative data collection techniques: collecting secondary data - journals, existing documents and records, etc.; collecting primary data – sampling need and design, pilots, techniques- surveys, questionnaires and rating scales, checklists, observations, interviews-structures, semi structured and open • Analyzing data: quantitative analysis, qualitative analysis	06	
6.	Ethical Considerations • Ethics committee, ethical guidelines – voluntary participation, informed consent, confidentiality and anonymity, plagiarism, academic fraud and misinterpreting results, conflict of interests, observation, permissions, video/audio taping	02	
	Exercise 2: Designing/ formatting a questionnaire/interview for a given problem Conducting a semi structured interview and analyzing data (with the upcoming field work in March)		10
7.	Writing up the research • Grammar, punctuation and conventions of academic writing -Tense, gender neutral language, referencing, use of notes and footnotes, English and American spellings, abbreviations, consistency • Writing an introduction • Writing the methodology	04	
	Assignment 1: Writing the introduction chapter of the		10

	students own thesis		
	Assignment 2: Writing the literature review and methodology chapter of the students own thesis		20
	Total	20	50

Assignments

The separate assignments will result in a single document – the research proposal of the student.

Suggested Readings

1. Becker, H. S. Writing for Social Scientists: How to Start and Finish Your Thesis, Book, or Article. University of Chicago Press, 2007.
 2. Creswell, J. W., and V. L. P. Clark. Designing and Conducting Mixed Methods Research. Wiley Online Library, 2007.
 3. Denzin, N. K., and Y. S. Lincoln. The Sage Handbook of Qualitative Research. Sage Publications, Incorporated, 2005.
 4. The SAGE Handbook of Qualitative Research (3 Rd. Thousand Oaks, CA: Sage, 2005.
 5. Hart, C. Doing a Literature Review: Releasing the Social Science Research Imagination. Sage Publications Limited, 1999.
 6. Malmfors, B., P. Garnsworthy, and M. Grossman. Writing and Presenting Scientific Papers. Nottingham University Press UK, 2004.
 7. Morrison, M. L., B. Marcot, and W. Mannan. Wildlife-habitat Relationships: Concepts and Applications. Island Press, 2006.
 8. O'Connell, A. F., J. D. Nichols, and K. U. Karanth. Camera Traps in Animal Ecology: Methods and Analyses. Springer, 2010.
 9. O'Leary, Z. The Essential Guide to Doing Research. Sage Publications Limited, 2004.
 10. The Essential Guide to Doing Your Research Project. Sage Publications Limited, 2009.
 11. Peat, J. et al. Scientific Writing: Easy When You Know How. BMJ books, 2007.
 12. Ridley, D. The Literature Review: a Step-by-step Guide for Students. Sage Publications Limited, 2012.
 13. Silverman, D. Doing Qualitative Research. Sage Publications Limited, 2009.
- Torraco, R. J. "Writing Integrative Literature Reviews: Guidelines and Examples." Human Resource Development Review 4.3 (2005): 3

Course No: GEO 211

Course Title: Techniques in Database Management

Number of Credits: 2

Course Coordinator: Mr. Anand Shinde

Course Outline

The main aim of this course is designing, using, and implementing database systems and applications. Our course stresses the use of languages and facilities provided by database management systems, and system implementation techniques.

Learning Outcomes

- Proficiency in using database management system
- Ability to analyse and create spatial database
- Competence in using spatial queries in PostGIS

Pre-requisite

None

Evaluation Procedure : 0.6/0.4 University

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed Journal submitted timely (within 7 days): 5 marks	Internal Assessment
Major exam	60%		University Assessment

Details of course content

1. To create and load Data in database system
2. To perform append, updating, backup and recovery of database.
3. Design database schema after normalizing fields and tables by assigning constraints and keys.
4. To perform conversion of Entity Relationship Diagrams into a logical database structure and implement the database into database management system.
5. To perform creating ArcGIS geodatabase.
6. To store spatial data and create relationship between two spatial objects using ArcGIS.

7. Introduction to Oracle.
8. To display data from multiple tables by using different types of joins in Oracle
9. Problem solving through use of different types of Character functions and Numeric Functions in MS-Access
10. To perform Aggregating data using group Functions in MS-Access
11. Problem solving through use of sub queries, nested Queries in Oracle
12. Introduction to PostgreSQL and PostGIS
13. To build a spatial database by using PostGIS
14. To perform Importing and exporting of spatial data and use of various Spatial SQL Queries using PostGIS
15. To perform spatial joins use PostGIS
16. To produce maps from PostGIS using open-source desktop GIS software (QGIS)
17. To execute SQL Query using pgAdmin III

Suggested Readings

- Koch Loney, Oracle 9i – The complete reference, Tata McGraw Hill, 2007
- Nanda Arup, Steven Feuerstein, Oracle PL/SQL for DBA, Shroff publishers and distributors pvt. Ltd., July 2008
- Feuerstein Steven, Pribyl, Oracle PL/SQL Programming, SPD publication, Fourth Edition, 2005
- Misbra Sanjay, Alan Beaulieu, Mastering Oracle SQL, SPD Publications, 2008
- Gennick Jonathan, Oracle SQL Plus - The Definitive Guide, SPD Publications, 2005
- Millsap Cary, Jatt Holt, Oracle Performance Optimizing, SPD Publications, 2003
- McLaughlin, Oracle Database 11g, Tata McGrawHill Publishing Company Ltd, 2008
- Bayross Ivan, Understanding oracle BPB Publications, 2004
- Bayross Ivan, Oracle Developer 2000, BPB Publications
- Loney Kevin, George Koch, Oracle 8i the complete reference, Tata McGraw Hill Edition, 2000
- Date C.J., An introduction to database systems, Pearson Education, 2007

Course No: GEO 212

Course Title: Techniques in digital image processing

Number of Credits: 4

No. of hours: Lab-Student Practice: 51-60

Course Coordinator: Dr. Shamita Kumar

Course Outline

The course provides skill in analysis of digital images and extraction of information from satellite images using various software such as SAGA, ERDAS Imagine, IDRISI and ENVI.

Pre-requisite

GEO 111

Evaluation Procedure: 0.6/0.4 University

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed Journal submitted timely (within 7 days): 5 marks	Internal Assessment
Major exam	60%		University Assessment

Details of course content and allotted time

1. To download data from Earth Explorer.
2. To perform importing and sub setting of remotely sensed data.
3. Introduction to IDRISI.
4. Introduction to ENVI.
5. To perform pre-analysis of a satellite image using image statistics.
6. To perform radiometric correction.
7. To perform atmospheric correction.
8. To perform geometric correction.
9. Performing spatial and spectral enhancement.
10. To mosaic images.
11. To perform unsupervised classification using ISODATA method.
12. To perform supervised classification.

13. To perform knowledge based classification.
14. To perform hyperspectral classification.
15. To perform object oriented segmentation.
16. To use model maker in ERDAS.
17. To perform change detection using IDRISI.

Course No: GEO 213

Course Title: Programming for GIS

Number of Credits: 4

No. of Lectures-Tutorial: 50-10

Course Coordinator: Mr. Anand Shinde

Pre-requisite

None

Evaluation Procedure: 0.6/0.4 University

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed Journal submitted timely (within 7 days): 5 marks	Internal Assessment
Major exam	60%		University Assessment

Details of course content and allotted time

Theory	Practical
Introduction to Java • Features of Java, • OOPs concepts • Java virtual machine, • Data Types and Variables, and Arrays • Compiling vs interpreting source code • What is Java? • Writing programs in Java	1. To develop a Java application using different datatypes, Java Arrays and Multi-Dimensional Arrays.
• Basic data types • Declaring and using variables • Java Operators • Arithmetic • Comparison • Logical • Bitwise • Assignment • Operator Precedence	2. Problem solving through use of various arithmetic, conditional and logical operators in Java application.
Control structures in Java	3. Problem solving through use of Conditional Statements and Looping

• Making choices - if, else, switch • Looping - do, while, for	Statements and Branching Statements
Java Classes • Abstract classes, Static classes Packages, This	4. To create an application using Classes, Object reference variables
Writing methods / Functions • Designing methods • Parameters • pass by value • pass by reference • Returning values from methods	5. To create an application using Data members and Data functions
Classes, Objects and Methods, Constructor and destructor, method overloading.	6. To perform using Constructors and Destructors.
	7. To perform overloading of methods in Java application.
Using objects • encapsulation, inheritance, polymorphism, and abstraction • Method overriding, finalize methods.	8. To perform inheritance using super to call superclass constructions.
	9. To perform overriding of methods in Java application.
Abstract classes and methods Writing interfaces in Java Creating packages in Java	10. To create packages, access protection and importing packages in Java.
Exception handling What are exceptions? Kinds of exceptions Advantages for program design Java's exception, try blocks, catch	11. To perform exception handling in Java types of exceptions, using try and catch multiple catch, rested try and throws.
Basics of Servlet • Basics of Web • Servlet API • Servlet Interface • Servlet Life Cycle • Working with Apache Tomcat Server • Steps to create a servlet in Tomcat	12. To perform creating, compiling and building the web application using servlet

Basics of JSP • Life cycle of JSP • JSP API • JSP in Eclipse and other IDE's	13. Introduction to directives of JSP
Java applet basics • Applets vs applications • The Applet class and its parent classes • Your applet and the browser • Applet tag, Methods for Milestones - init() start() stop() destroy()	14. To build an application using applets and multithreading
Multithreading • Thread Life cycle • Thread synchronization	15. Introduction to multithreading

Course No: EST 201

Course Title: Biodiversity Assessment and Conservation

Number of Credits: 4

No. of Lectures-Assignments-Tutorial/Examination: 45-20-03

Course Coordinator: Dr. Kranti Yardi

Course Outline

The course focuses on the essential concepts and skills related to biodiversity conservation and assessment. This includes understanding threats to biodiversity, assessing biodiversity at various levels, concepts of landscape ecology and habitat management. It elucidates the perspectives of science and management of biodiversity in the context of current and future strategies needed for biodiversity conservation.

Learning Outcomes

Students will :

- Develop a deep understanding of the threats to biodiversity
- Develop skills of assessing biodiversity with different methodologies
- Develop a comprehensive understanding of issues in planning conservation areas and managing habitats.
- Acquire the ability to construct a conservation action plan for a species or site

Pre-requisite

EST 101

Evaluation Procedure : 0.6/0.4 University

Assignment	2	20%	Internal Assessment
Minor Test	3	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	A	T/E
1	Overview of biodiversity • Status of biodiversity • Biodiversity at regional and landscape levels • Biodiversity at ecosystem, community and population levels	05		
2	Threats to biodiversity			

	• Loss of biodiversity – past rates of extinction, human caused extinctions, extinction rates on islands, island biogeography and extinction rates, case studies • Vulnerability to extinction – Endemic species, case studies • Habitat destruction, fragmentation and degradation • Exotic species introductions and disease • Problems of small populations – loss of genetic variability, demographic variation, environmental variations	06		
	Minor Test 1			01
3	Assessment of biodiversity • Types of sampling – Qualitative and quantitative assessment techniques for mammals, birds, butterflies, plants. • Estimation of density, frequency and abundance of the species • Indices associated with species diversity, species similarity, temporal and spatial rate of change in species population • Alpha, Beta and Gamma diversity • Statistical approach to assessment of biodiversity • Software for biodiversity assessment	12		
	Minor Test 2			01
4	Planning Conservation Areas • Criteria for conservation – Conservation status, generalists and specialists; population size, sex and age classes, species restricted in distribution, isolated populations, habitat specialists and habitat obligates, species under illegal trade; key ecological functions of species; utility of the species • Approaches to conservation – species approach (featured species), management indicator species, species guild approach, flagship species approach, keystone species, ecosystem approach • Tools used for conservation – Population assessments, Gap analysis, habitat evaluation, GIS • Design criteria – habitat constituents, reserve design, reserve shape and size, population size, need for buffers, wildlife corridors, landscape connectivity, administrative, political and economic	12		

	considerations			
	Assignment 1 and 2: Field work in National Park followed by presentation		20	
5	Habitat Management • <i>Insitu</i> management – categories of biotic factors and their pressures- livestock grazing, fire wood collection, non wood forest produce collection, fires, encroachments, mining and quarrying, weeds and weed infestations (Invasive species), large scale monocultures, soil erosion, timber smuggling, poaching, development activities that are insensitive to ecological integrity, vandalism, unregulated tourism; • Eco-restoration- habitat restoration techniques and monitoring • Wildlife management plans.	10		
	Minor test 3			01
	Total	45	20	03

Suggested Readings

1. Alexander, M. Management Planning for Nature Conservation: a Theoretical Basis & Practical Guide. Springer, 2008.
2. Groves, C. Drafting a Conservation Blueprint: a Practitioner's Guide to Planning for Biodiversity. Island Press, 2003.
3. Margules, C., S. Sarkar, and C. R. Margules. Systematic Conservation Planning. Cambridge University Press, 2007.
4. McNeely, J. A. Expanding Partnerships in Conservation. Island press, 1995.
5. Postel, S. et al. Nature's Services: Societal Dependence on Natural Ecosystems. Island Press, 1997.
6. Smith, D. S., and P. C. Hellmund. Ecology of Greenways: Design and Function of Linear Conservation Areas. University of Minnesota Press, 1993.
7. Sutherland, W. J. Conservation Science and Action. Blackwell Science Ltd, 1998.
8. Sutherland, W. J., and D. A. Hill. Managing Habitats for Conservation. Cambridge University Press, 1995.
9. Sutherland, W. J., I. Newton, and R. E. Green. Bird Ecology and Conservation: a Handbook of Techniques. Oxford University Press, USA, 2004.

Course No: EST 206

Course Title: Natural Resource Management

Number of Credits: 4

No. of Lectures-Tutorial: 45-20-03

Course Coordinator: Dr. Kranti Yardi

Course Outline

The course is intended to impart knowledge and skills considered crucial for natural resource managers to manage effectively in the dynamic and intricate environment. It enhances the students' understanding at diverse levels by maintaining the equilibrium between the occupation obligations and enduring growth requirements. The fundamental thrust of the course is to assist the students to obtain theoretical and logical abilities in relation to the field situations, necessary for managing natural resources efficiently.

Learning Outcomes

The student will be able to:

- Contribute in managing the resource in a comprehensive way as professionals working in this sector
- Balance the needs of people and the economy with protecting the ability of ecosystems to support soil, water, forests, wildlife, fish, recreation, and other resources

Evaluation Procedure: Continuous

Assignments	40 % (3)	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment • Completed home assignment submitted timely and excellent written presentation	Assignments must be in the prescribed format. One journal may contain assignments of different elective courses separated by a separator. Index must reflect all the assignments duly signed by the concerned teacher. Marks for every assignment must reflect on the assignment itself.	Internal Assessment
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	A	T/E
1.	Fundamental of Natural Resources - Ecology and ecosystems: concept of sustainability - Earth and water resources - Environment, energy and technology - Natural resource governance and policy	8		
2.	Theoretical aspects of Natural Resource Management - Environmental Monitoring Assessment – basic, time, cost, resources, techniques, guidelines - Natural Resource Economics - Society, Ethics and Participatory Development - Environmental Impact Assessment (EIA) and Auditing - Livelihoods and Natural Resources	8		
	Assignment 1: Discussion and presentation of selected research paper in groups of two/three students.		05	
3.	Integrated watershed management - Definition of watershed - Watershed development strategy - Socio-economic and natural resource information through PRA's - Land surveys through land class determination for area, slope, depth of soil, texture, erodability; soil and water testing - Engineering surveys – topographical surveys, drainage line survey, contour survey - Ecological assessment of the area – A statement of significance; site description-significant habitat types, native species of wild plants and animals of conservation importance, significant corridors, biotic pressures and threats, significant ecological services. People and their relationship with natural areas (valid and invalid stakes). - Microplanning – microplanning process, difficulties faced during microplanning, advantages of microplanning - Principles of soil and water conservation	12		

	Assignment 2: Ecological assessment of a given area		05	
	Assignment 3: Collection of data using GIS compatible participatory rural appraisal technique		10	
4	Analytical aspects of Natural Resource Management • Remote sensing and GIS application in NRM • Statistical analysis in NRM • Vegetation inventory and rapid assessment • Financial analysis and project management in NRM	09		
5	Managerial aspects of Natural Resource Management • Wildlife conservation and management • Wetland management • Watershed management • Urban forestry, biodiversity and landscape • Climate change and carbon trading • Agro-ecosystems and Agro forestry • Environmental modeling • Eco-tourism and other environmental services • Bio-resources	18		
	Final Assessment			03
	Total	45	20	03

Suggested Readings

1. Francois Ramade 1984. Ecology of Natural Resources. John Wiley & Sons Ltd.
2. Coastal Ecology & Management, Mann, K.H. 2000. Ecology of Coastal Waters with Implications for Management (2nd Edition).Chap. 2-5, pp.18-78 & Chap. 16, pp.280-303.
3. Global Change and Natural Resource Management, Vitousek, P.M. 1994. Beyond global warming: Ecology and global change. Ecology 75, 1861-1876.
4. Agarwal, K.C., 2001. Environmental Biology, Nidhi Publication Ltd. Bikaner.
5. Cunningham, W.P. Cooper, T.H. Gorhani, E & Hepworth, M.T. 2001, Environmental Encyclopedia, Jaico Publishing House.
6. Heywood, V.H. & Watson, R.T. 1995. Global Biodiversity Assessment. Cambridge Univ. Press.
7. Miller T.G. Jr. Environmental Science, Wadsworth Publishing Co. (TB)
8. Townsend C., Harper J, and Michael Begon. Essentials of Ecology, Blackwell Science.
9. Barber, E. 1989. Economics: Natural Resources Scarcity and Development. Earthscan.
10. Harris, J.M. 2006. Environmental and Natural Resource Economics: A Contemporary Approach, 2nd edition. Houghton Mifflin.

Course No: EST 208

Course Title: Climate change science and strategies

Number of Credits: 4

No. of Lectures-Tutorial: 45-20-03

Course Coordinator: Arch. Aditi Lanke / Mr. Parag Khatavkar/ Dr. Girish Jathar

Course Outline

Global climate change is a planetary scale phenomenon that impacts upon all socioeconomic and natural systems. Despite the growing consensus about the fundamentals of climate warming, scientific understanding of the complex interactions of ocean, land, clouds, and atmosphere remains highly uncertain, particularly with respect to environmental, social, and economic disruptions affecting human societies. This course will provide students with the scientific literacy to understand the issue itself and consider existing solutions such as the Kyoto Protocol, voluntary measures, etc. The guiding principle will be to promote the understanding needed to evaluate, develop, and propose emerging and creative solutions at individual, campus, and local levels. This course will examine the dilemmas faced in climate science, politics, economics, management, and ethics – all with an eye to the implications for global and regional sustainability.

Learning Outcomes

The student will be able to:

- Think intelligently about the issue and to understand what processes are currently underway and what more can be undertaken.
- Understand the precarious feedbacks from the climate system that could create dramatic impacts.
- Understand, plan and propose creative solutions at temporal, spatial, political, scientific, and social scale.

Evaluation Procedure: 0.6/0.4 University

Assignments	40 % (3)	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment • Completed home assignment submitted timely and	Assignments must be in the prescribed format. One journal may contain assignments of different elective courses separated by a separator. Index must reflect all	Internal Assessment

		excellent written presentation	the assignments duly signed by the concerned teacher. Marks for every assignment must reflect on the assignment itself.	
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	A	T/E
1	Climate science and impacts • Introduction: overview of the topic • Climate change: cause and effect • Climate disruption • Impact analysis: freshwater sources and oceans • Impact analysis: food and forests • Economic impacts of climate change	10		
	Assignment 1: Discussion and presentation of selected research paper in groups of three students.		05	
2	Policies and market issues • International treaties • Carbon trade and taxation • Strategies for low cost carbon abatement • Climate policy: global scenario • Climate policy: Indian scenario • Green business initiatives	10		
	Assignment 2: Discussion and presentation of selected research paper in groups of three students.		05	
3	Climate solutions • Energy solutions: past and present • Transportation • Building and habitation • Industry and waste management • Land use, agriculture and forestry	15		

	- Adaptation and tropical forest sequestration - Geo-engineering of earth's atmosphere			
	Assignment 3 : Discussion and presentation of selected research paper in groups of three students.		10	
4	Future direction - Mobilizing the world to action - Trends and futures of food scarcity solutions - Trends and futures of green and clean energy supply and consumption - The negotiating challenges ahead	10		
	Final Assessment			03
	Total	45	20	03

Assignments

In the assignments the students will be expected to express their view on promise and limitations of sustainability ideas and practices for dealing with climate threats. They will also be expected to understand and illustrate the nature of climate controversies and the positions of various stakeholders. The assignments will also help to create an interdisciplinary understanding of climate interactions with human and natural systems.

Suggested Readings

1. Stephen Schneider, Armin Rosencranz, Michael Mastrandrea, eds., 2010. Climate change science and policy. Island Press.
2. Bert Metz, 2010. Controlling climate change, Cambridge University Press.
3. Lester Brown, 2009. Plan b 4.0: mobilizing to save civilization. W.W. Norton.
4. Kerry Emanuel, 2007. What We Know About Climate Change. Boston: Boston Review/MIT Press
5. Tim Flannery, 2006. The Weather Makers. New York: Atlantic Monthly Press
6. Bill McKibben, 2010. Earth. NY: Times Books,
7. David Blockstein and Leo Weigman 2010. The Climate Solution Consensus NCSE/Island Press.
8. Monty Hempel, 1996. Environmental Governance: The Global Challenge. Washington, DC: Island Press.
9. Arnold J. Bloom, 2009. Global climate change: convergence of disciplines. Sinauer Associates.

Course No. EST 207

Course Title: Environment and Health

Number of Credits: 4

No. of Lectures-Tutorial-Practical: 21-20-20

Course Coordinator: Dr. Thomas Krafft, University of Maastricht, Netherlands

Course Outline

The aim of this course is to provide the students with a comprehensive understanding and applicable knowledge of health geography as a scientific concept using tools like GIS for a holistic approach to public health that promotes the wellbeing of human populations through organizing data and understanding links between environment and health. The health of human population reflects the complex interplay between population characteristics and the environment. Genetic makeup can predispose certain populations to chronic or acute conditions. Cultural factors, such as stress, economic status, and access to health care, can play a significant part on disease onset. Students will learn how to assess environment and health related issues with different methodologies and they will be able to conduct a critical analysis on health and environment related research. The use of environmental health chain to study mechanism by which environmental hazards impacts health will be discussed as well as the aspect of the governance process to mitigate or eliminate environmental health hazards. Special focus will be laid on measuring health outcomes, mortality, incidence, prevalence etc.

Outcomes

Students will develop:

- Ability to apply the theoretical frameworks offered during the course to actual cases of environmental health problems.
- Ability to prioritize different interventions to manage environmental health risks.
- Ability to formulate simple research protocols for environmental measurements, exposure assessment or health effect assessment.
- Conduct simple analysis on health and environment using Geographic Information Systems and spatial cluster detection software.
- Discuss the suitability of various study designs and approaches in environmental and health research

Pre-requisite : None

Assessment

Assignments	40 %	Marking pattern for every assignment	Assignments must be in the prescribed I	Internal Assessment

	(3)	- Innovativeness and accuracy in completing the assignment - Completed home assignment submitted timely and excellent written presentation	format. One journal may contain assignments of different elective courses separated by a separator. Index must reflect all the assignments duly signed by the concerned teacher. Marks for every assignment must reflect on the assignment itself.	
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	T	P
1.	Outline of the course - Introduction to Health Geography and Environmental Health Introduction - Health Geography and Environmental Health Human Ecology Models - A theoretical approach to study the forces in a person's environment that affects and influences development and interaction between individuals. One Health Concept - The approach recognizes that health of humans, animals and ecosystems are interconnected. It involves applying a coordinated, collaborative, multidisciplinary and cross-sectoral approach to address potential or existing risks that originate at the animal-human-ecosystems interface.	3		2

	Emerging and Re-emerging diseases This topic focuses on formerly unknown diseases that are increasing in time and a specific location. They are considered to be emerging. Diseases that were eradicated or controlled and present themselves again in a specific location are considered re-emerging diseases. Task: background literature for reading till next session			
2.	PBL Case 1: Environmental Health Hazards		4	2
3.	Global Environment Change, Human Health and Public Health Environmental Health Chain - In environmental health, research is primarily concerned with the relationships between environment and human health. These relationships comprise a set of causes and effects and typically involve many of each. They may therefore be best studied as a causal chain, which shows the links between sources and impacts. Environmental Determinants of Health - Environmental determinants of health are typically considered as external factors such as access to safe water, air pollution, droughts and others that can be causally linked to a change of health status. Social Determinants of Health - Social determinants of health are the conditions, in which people were born, live, grow up and age. The social determinants of health are mostly responsible for health inequities - the differences in health status within and between countries. Task: Answering questions during a group discussion round, prepare for presenting the results during the next session.	2		1

4.	Urbanization and Health Impacts Urbanization and Migration - The ongoing rapid urbanization leads to an increased migration away from rural areas to urban areas. Although urbanization usually accompanies social and economic development, the rapid urbanization strains local and national governments to provide basic services such as safe water, electricity and sewerage. This in turn affects the health status of a large amount of today's population. Urban – Rural Health Divide - Although the majority of India's population lives in rural areas, most medical infrastructure is concentrated in urban areas. This, among other factors such as access to safe water, sanitation and hazardous working and living conditions leads to high prevalence of infectious diseases in rural areas as compared to urban areas. Urban Health Models - Urban health models address the challenge of communicating and modeling the complex relationships and interdependencies of various determinants of health in urban areas. Healthy City Concept - The approach seeks to put health high on the political and social agenda of cities and to build a strong movement for public health at the local level. It strongly emphasizes equity, participatory governance and solidarity, intersectoral collaboration and action to address the determinants of health. Health and Wellbeing in the Changing urban environment - ICSU approach - The approach of the International Council for Science (ICSU) is to establish a system analysis to study the causal chain and various complex interactions between different processes and factors that influence health and wellbeing in	2		1

	urban environments. Ambient Particulate Matter (PM) • Particulate matter in its various form has a profound impact on human health. Exposure may be higher in urban areas and industrial areas due to an increase in the number of sources. This topic will focus on the impact of PM on health. <u>Task:</u> Answering questions during a group discussion round, prepare for presenting the results during the next session.			
5.	PBL Case 2: Exposure to bad Air Quality		4	2
6.	Methodologies in the field of Health Geography and Environmental Health Health Impact Assessment • Economic sectors such as transport, agriculture and housing have profound impacts on health. Health Impact Assessment is a means of assessing the health impacts of policies, plans and projects in diverse economic sectors using quantitative, qualitative and participatory techniques. Geographic Field Work Methodologies • This topic will focus on a wide range of quantitative and qualitative methodologies applied in the field of health geography. Pressure and Release model • The pressure and relief model explains the interactions that lead to an increase of vulnerability within a society and its relation to hazards that may become a disaster through the progression of vulnerability. Introduction to Health GIS as a tool of health geography and environmental health research • This topic will present the application of GIS to monitor health related data and evaluate contributing environmental factors on human	4	2	

	health. <u>Task:</u> Paper (10 page) on one of the topics presented during the lectures or a topic of their own research interest. This paper needs to be handed before the symposium. The paper will be presented during the symposium via PowerPoint.			
7.	Vulnerability and Global Environmental Change Drivers of Change - Global environmental hazards to human health include climate change, stratospheric ozone depletion, changes in ecosystems due to loss of biodiversity and a wide range of other factors. Drivers of global environmental change and its interdependencies will be explored in this topic. Concept of Vulnerability and Resilience - Societal response, particularly the societal capacity to adapt to climate change impacts, determines both, the severity of impacts and the costs of adaptation. The focus of this topic is to give an understanding of the concepts that define vulnerability and resilience. Vulnerable populations - Understanding the wide variety of driving factors that contribute to the vulnerability of a specific population is essential to target areas for interventions. Risk Assessment - A risk assessment is a process to identify potential hazards, vulnerable populations and to measure the impact a potential hazard might have on the vulnerable populations. This topic will provide insight in the process of conducting risk assessments. Mitigation and Adaptation - Adaptation and mitigation refer to two different ways of adjusting to climate change. This topic will focus on the different ways to adapt to climate	2		2

	change that are comprised within these two terms. Exposure To fully understand the concept of vulnerability and resilience, it is necessary to study the exposure of populations to various hazards. <u>Task:</u> Practical Framing research question, design research and prepare a poster for presentation at the workshop			
8.	PBL Case 3: Exposed?		4	2
9.	Training Workshop on Health Geography and Environmental Health The training workshop will be designed including lectures on GIS application, spatial cluster detection using SaTScan, visualizing health data, design maps for health study and projection and using spatial data. The students have to present and discuss the findings of their practical tasks in a special session at the end of the training workshop. Students will learn how to address health-related challenges, from disease analysis to policy planning. During the training workshop the students will present their papers via Power Point. Further the students will present in a special session their research posters. The time duration for the training workshop will be 5 days.	8	6	8
	Total	21	20	20

Assignments

Reading: The students have to get a broad overview of the topic by reading assigned background literature.

PBL elements: Answering research questions on environment and health issues in a group discussion and presenting the results during the class based on problem-based learning (PBL).

Paper: The students will be asked to prepare a paper on one of the topics presented during the lecture or a topic of their own research interest. The paper will be a 10 page document which

will be need to be handed in up to a clear deadline and will be assessed by the teachers of the course.

Poster presentation: The students will be asked to prepare a poster on one of the topics presented during the lecture or a topic of their own research interest. This poster will be presented during the symposium. The students will have 10 minutes for presentation followed by a 5 minute open discussion. The goal of this exercise is to familiarize the students with poster presentation for conferences.

Research proposal exercise: The students will be divided in small groups, the groups will be asked to design a research proposal that address one of the research issues that were presented during the lectures. The results will be presented by the groups via PowerPoint during the symposium.

Methodologies: During the course there will be a focus on methodologies to assess Environment and Health related issues. During the symposium there will be an assignment for the students to carry out a cluster detection using SaTScan software. Further there will be a special session on Health GIS were students will learn basic application of GIS for health related research questions.

Suggested Readings

1. Brown T and Moon G. (2012) Commentary- Geography and global Health, *The Geographical Journal*, 178, 13-17.
2. McMichael A, Woodruff E, Hales S. (2006) Climate Change and human Health: present and future risks, *Lancet*, 367, 859-869
3. Haines A, Kovats R S, Campbell-Lendrum D, Corvalan C. (2005) Climate Change and human health: Impacts, vulnerability and public health, *Public Health*, 120, 585-596
4. Haines A, Kovats R S, Campbell-Lendrum D, Corvalan C. (2006) Climate change and human health: impacts, vulnerability, and mitigation, *Lancet*, 367, 2101-2109
5. Atul A, Khasnis, Nettleman M D. (2005) Global Warming and Infectious Disease, *Archives of Medical Research*, 36, 689-696
6. Patz J, Campbell-Lendrum D, Holloway T, Foley A. (2005) Impact of regional Climate Change and human health, *Nature*, 438, 310-317
7. Climate Change and Health: Research Challenges for Health in the Developing Countries, *Indian Journal of Occupational and Environmental Medicine*, 14,
8. Castello A et al. (2009) Managing the health effects of climate change, *The lancet Commissions*, 373, 1693-1733
9. Kovats S, Akhtar R (2008) Climate, Climate Change and Human Health in Asian Cities, *Environment and Urbanization*, 20, 165-175

10. Allen D E, Donham R S, Bernhardt S A (2011) Problem-Based Learning, *New Direction for Teaching and Learning*, 128, 21-29
11. Thomas I (2009) Critical Thinking, Transformative Learning, Sustainable Education, and Problem-based Learning in Universities, *Journal of transformative Education*, 7, 245
12. Pawson E, Fournier E, Haigh M, Muniz O, Trafford J, Vajocki S (2011) Problem-based Learning in Geography: Towards a critical Assessment of its Purposes, Benefits and Risks, *Journal of Geography in Higher Education*, 30:1, 103-116
13. Dummer T (2008) Health Geography: supporting public health policy and planning, *Canadian Medical Association Journal*, 178:9, 1177-1180.
14. Curtis S E, Owen K J (2011) Geographies of health and climate change, *Progress in Human Geography*, 36, 654-666.
15. Smyth F (2007) Medical geography: understanding health inequalities, *Progress in Human Geography*, 32, 119-127.
16. Bei X, Nath I, Capon A, Hasan N, Jaron D (2012) Health and wellbeing in the changing urban environment: complex challenges, scientific responses and the way forward, *Current opinion in Environmental Sustainability*, 4, 465-472.

Journals

1. Lancet
2. Environment and urbanization
3. Indian Journal of Occupational and Environmental Medicine
4. Nature
5. BMC Public Health
6. International Journal of Health Geographic (<http://www.ij-healthgeographics.com/>)
7. Progress in Human Geography

Course No: EST 402

Course Title: Water Management

Number of Credits: 4

No. of Lectures-Tutorial: 45

Course Coordinator:

Course Outline

The reasons for increased interest in protecting water concern over increased vulnerability to water-related stress are not difficult to discern. The users of water fall into three sectoral categories namely, agriculture, domestic and industrial sector. While agriculture sector demands a huge share of water for irrigation, the industrial and domestic sectors are mainly responsible for contaminating fresh water sources. Long term sustainability of fresh water resources cannot be guaranteed measured in terms of both availability and quality. Efficient water resources management and water conservation practices are a need of the time. This course will expose the students to (i) Introduction to water resources evaluation and assessment - SPAC, WUE, methods of assessment, sectoral water use and demand, assessment of water stress and need for water conservation and (ii) Water resources conservation and management including institutional and policy aspects such as rainwater harvesting, conjunctive water use, catchment planning, watershed management, irrigation use and efficiency, advanced treatment systems and zero discharge, participatory irrigation management including methods of minimizing evaporation losses, water pricing, river basin organizations, collective action and decentralization etc.

Pre-requisite

None

Assignments	40 % (3)	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment • Completed home assignment submitted timely and excellent written presentation	Assignments must be in the prescribed format. One journal may contain assignments of different elective courses separated by a separator. Index must reflect all the assignments duly signed by the concerned teacher. Marks for every assignment must reflect on the	Internal Assessment

			assignment itself.	
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	• Introduction to water conservation and assessment, Severity of water crisis, importance of conservation • Soil, Plant, Atmosphere Continuum (SPAC); Water use efficiency (WUE) • Methods of water resources assessment (hydrology cycle, surface flow assessment, groundwater recharge assessment) • Water stress: principles and indicators for assessing water stress • Water quality assessment: indicators for assessing water quality	10	
	Assignment 1		5
2	• Water resources conservation and management, Water conservation measures • Soil moisture retention and conservation (cover crop, mulching, etc) • Traditional systems and man-made structures (ponds, tanks, reservoirs, Minimizing evaporation loses • Rainwater harvesting and groundwater recharging • Irrigation: types, scheduling, efficiency and designing	10	
	Assignment 2		2
3	• Water auditing; Water treatment, recycling and reuse leading to water conservation, Industrial and urban water management leading to cleaner production, Institutional mechanisms for water management, programmes and policies for integrated water management	10	
	Assignment 3		4
	Total	45	15

Suggested Readings

1. Larry M. (2003) *Urban Storm Water Management Tools*, McGraw Hill Publication.
2. Michael A.M. (2008) *Irrigation Theory and Practices*, 2nd Edition, Vikas Publishing House Private Limited, Noida.
3. Suresh R. (2005) *Soil and Water Conservation Engineering*, 2nd edition, Standard Publishers Distributors.

Course No: GEN 202

Course Title: Project Management

Number of Credits: 2

No. of Lectures-Tutorial: 18-20

Course Coordinator: Mr. Parag Khataavkar

Course Outline

The course provides an overview of techniques of project management with an emphasis on project management, organizational structures, teams, functions, planning, scheduling, cost controls, trade-offs, risk management and other related topics. The course prepares students to conceptualize, implement, monitor and evaluate the project.

Learning Outcomes

The student should be able to:

- Construct, organize and explain project management.
- Devise, plan and compile work breakdown structures (WBS) and understand life cycle phases as quantitative tools in project management.
- Design, generate and explain scheduling techniques.

Pre-requisite

None

Evaluation Procedure: Continuous

Assignment	1	50%	Internal Assessment
Assignment	2	50%	Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	A
1	Introduction to project management • Definition and attributes of project and project management • Strategy in project management – establishing objectives, scoping the boundaries, priority setting, strategic development • Understanding project management and resistance to change • Project management life cycle • Critical success factors in project management • Best practices in project management	06	

	• Project monitoring		
	Assignment 1		05
2.	Project management methodologies • Modeling the project system – WBS, responsibility, communication plan • Estimations in projects – basic, time, cost, resources, techniques, guidelines • Developing project plans – Gantt charts, evaluating and constructing networks • Overcoming development and implementation barriers • Critical components of project management • Implementing a methodology • Strategic planning for project management	06	
3.	Issues in project management • Management Styles • Project Management Skills • Involvement of senior managers and stakeholders • Identification of projects • Project management information systems • Risk management • Change management • Role of culture in project management	06	
	Assignment 2		15
	Total	18	20

Assignments

In the assignments the students will be expected to design WBS, review of best practices in project management, role of change management, etc.

Suggested Readings

1. Baker, B. N., D. C. Murphy, and D. Fisher. "Factors Affecting Project Success." Project Management Handbook, Second Edition (2008): 902–919.
2. Dyball, R., and M. Keen. Social Learning in Environmental Management: Towards a Sustainable Future. Routledge, 2012.
3. Kerzner, H. Advanced Project Management: Best Practices on Implementation. Wiley, 2003.
4. Project Management: a Systems Approach to Planning, Scheduling, and Controlling. Wiley, 2009.
5. Meredith, J. R., and S. J. Mantel Jr. Project Management: a Managerial Approach. Wiley, 2011.

Course No: GEN 201

Course Title: General English

Number of Credits: 2

No. of Lectures-Tutorial: 24-8

Course Coordinator:

Learning Outcomes

The student should be able to:

- Construct sentences with correct grammar
- Write simple reports correctly

Evaluation Procedure: Continuous

Assignment	1	100%	Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Basic language skills: grammar and usage The ability to fill in blanks, correct errors, choose correct forms out of alternative choices, join clauses, rewrite sentences as directed, replace indicated sections with single words/opposites/synonyms, etc. Skills such as punctuation of passages, changing between direct and indirect speech, expanding points into complete sentences.	08	
	Comprehension This implies (a) an understanding of the passage in question and (b) a grasp of general language skills and issues with reference to words and usage within the passage and (c) the power of short independent composition based on themes and issues raised in the passage.	08	
	Composition: Paragraph-writing Formal training in composition and précis/summary writing through instruction, discussion and written work. Letter writing, Basic report writing	08	
	Assignment		4
	Total	24	8

SEMESTER III

Course No: GEO 301

Course Title: Trends in Geospatial Technologies

Number of Credits: 4

No. of Lectures-Tutorial: 45-15

Course Coordinator: Mr. Dinesh Grover

Course Outline

With the evolving scene in geospatial application, this course provides an overview of the recent trends in geospatial technologies and diverse applications.

Learning Outcomes

The student should have:

- A thorough knowledge of new trends in geospatial technologies
- Conceptualize and design new geospatial applications

Pre-requisite

All core courses of semester I and semester II

Evaluation Procedure : 0.6/0.4 University

Assignment	2	20%	Internal Assessment
Minor Test	3	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1.	3D GIS and Visualization • Introduction to 3D GIS and Data Visualization • Multi-scale and multi-representation • Multiple data sets and Hybrid data sets • 2D – one scale and one representation per view • 3D – multiple scales and multiple representations per view • 2D & 3D Landscape Models • 3D Multi-scale Representation Issues: Terrain Texture , Digital	06	

	Terrain Model • Integration of 3D Object Model into 2D GIS • Web-based 3D Terrain Visualization • Overview ArcGIS 3D Analyst - Interactive Navigation, Surface Creation and Analysis, Fly-Through Paths and Animations • Hands on session		
2	Object-Oriented GIS • Basics of Object-Oriented GIS and types of relationship • Introduction to Object and Class and types of relationship. • Database modeling with OOGIS • Relational database • Hands on session	05	
3	Mobile GIS • Introduction to Mobile GIS • Hardware and software used in Mobile GIS • Capturing of data • Real-World Applications of Mobile GIS: Positioning, location based services, personal and vehicle navigation • GIS/GPS applications in Automated mapping (AM) and Facility management (FM) • Case Studies	05	
	Assignment 1 Hands on session (practical) related to the above topics (to be given by the concerned faculty in groups of two students each).		4
	Minor Test 1		4
4	Spatial data warehousing and mining • Overview of Data warehousing: Introduction and definition	05	

	• Data Warehouse Stages • Need for data warehouse • Spatial data warehousing • Data mining: Introduction and definition • Data mining techniques • Spatial data mining		
5	Open GIS Consortium • Introduction: Objectives, Background, Mission, Benefits, architecture. • OpenGIS Standards • OGC and Interoperability: GML, WFS, WMS, WCS • Introduction to open source software's: GRASS, QGIS • Introduction to Google Earth • Hands on session	08	
	Assignment 2 Seminar presentation by individual students on pre decided topics as assigned by the teacher.		5
	Minor Test 2		2
6	Customization and automation in GIS • Introduction to programming in GIS • Customize the Interface • Overview ArcObjects, VBA, and COM • Custom interfaces • Introduction to ArcObjects • GIS Program using VBA Macros	08	
7	Trends in GIS • GIS Application Design and Development Support • GIS Project Financial Analysis and Business Case Preparation	05	

	• GIS Program Organizational Development • GIS Policies, Standards, and Best Practices Development • Support in GIS product/service procurements • GIS Database Design, Development, and Integration • GIS project and program management support		
	Minor Test 3		2
	Total	45	15

Suggested Readings

1. Cyber City Modeler. MapAsia 2002, Bangkok, August 2002
2. Ulm, K. 2003 Reality-based 3D city models with Cyber City-Modeler (CC-ModelerTM) and laser scanner data. Optical 3D Measurement Techniques, 22-25 September 2003, ETH Zürich.
3. Steidler, F., Beck, M. 2004. Cyber City-Modeler -Generation, Updating and Continuation of 3D-City models with on-line-Editing - Visualization with Terrain View 2.0. CORP 2004.
4. Pindu Fu, Juilin Sun. WebGIS Principles and Applications, ESRI Press 2010
5. Dunham MH, Data mining: Introductory and advanced topics, Pearson Education 2006 (pdf accessible from <http://www.general.nsysu.edu.tw/gena/gena02/dm/part2.pdf>)
6. Han J, Kamber M, Data Mining: South East Asia Edition, Concepts and Techniques, Elsevier 2006 (pdf accessible from <http://www.general.nsysu.edu.tw/gena/gena02/dm/part2.pdf>)

Course No: GEO 302

Course Title: Spatial analysis and modeling

Number of Credits: 4

No. of Lectures-Tutorial: 45-15

Course Coordinator: Mr. Parag Khatavkar/Dr. Shamita Kumar

Pre-requisite

All core courses of semester I and II

Evaluation Procedure : 0.6/0.4 University

Assignment	2	20%	Internal Assessment
Minor Test	3	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Introduction to Spatial analysis • Significance of spatial analysis • Overview of tools for analysis • Significance of modeling	3	
2	Vector Data Analysis • Buffering: Types and applications • Overlay: Methods and applications • Distance measurement • Pattern analysis: Nearest neighbour analysis, measuring spatial autocorrelation, measuring high/low clustering, applications of pattern analysis	6	
3	Raster Data Analysis • Local operations: Local operations with single raster, reclassification, local operations with multiple rasters, applications of local operations	6	

	• Neighbourhood operations and their applications • Zonal operations and their applications • Physical distance measure operations and their applications • Comparison of vector and raster based data analysis		
	Assignment 1 Discussion and presentation of selected research paper in groups of three students.		4
	Minor Test 1		2
4	Terrain mapping and analysis • Concept of DEM, TIN and data needed • Terrain mapping: Contouring, vertical profiling, hill shading, perspective view • Slope and Aspect (from raster and TIN), influencing factors • Raster vs TIN • Applications of terrain mapping and analysis	5	
5	Viewsheds and watersheds • Viewshed analysis: Parameters of viewshed analysis, applications of viewshed analysis • Watershed analysis: filled DEM, flow direction, flow accumulation, stream network, stream links, areawide watersheds, point based watersheds, factors influencing watershed analysis	6	
6	Spatial Interpolation • Elements of spatial interpolation, control points, types of spatial interpolation • Global methods: Trend surface models, regression models • Local methods: Thiessens polygons, Density estimation, inverse distance weighted interpolation, thin plate splines • Krigging: Semivariogram, ordinary krigging, universal	8	

	krigging		
	Assignment 2 Seminar presentation by individual students on predecided topics.		5
	Minor Test 2		2
7	Path Analysis • Concepts of source raster, cost raster, cost distance measures, least cost accumulative path • Applications of path analysis	4	
8	Modeling in GIS • Basic elements of GIS modeling: classification of GIS models, the modeling process, role of GIS in modeling • Types of models: Binary models, Index models, regression models	6	
	Minor Test 3		2
	Total	45	15

Suggested Readings

- Roy P. S, Geographical Information Science, Vol. I, IIRS, 2000.
- Demers M.N, Fundamentals of Geographic Information Systems, John Wiley & Sons, Second Edition, 2000.
- Burrough P. A., R. A MacDonneli, Principles of Geographical Information Systems, Oxford University Press, 2000.
- Makrewski Jacek, GIS and Multi-criteria Analysis, USA, 1999

Course No: GEO 311

Course Title: Dissertation

Number of Credits: 14

Evaluation Procedure: 0.6/0.4 University

Assessment 1 (February)	Internal	10%	<i>Presentation on introducing the topic and its feasibility (literature review and methodology to prove feasibility of the project)</i>
Assessment 2 (May)	Internal	15%	<i>Detailed literature review, methodology with data collection protocols,</i>
Assessment 2 (August-September)	Internal	15%	<i>Mid-course review. Presentation of results and preliminary analysis</i>
Major Exam (Phase 1) (November-December)	External	60%	University Assessment (Phase 1)

Guidelines for dissertation

Topic: Candidates will write a dissertation on issues related to environmental/geospatial issues under the guidance of their respective guides. Each student will work independently on the topic. The dissertation must consist of review of literature and produce a deep insight of the subject on the basis of personal research.

Initiation of work: Dissertation work will be initiated during the second semester during the course of the paper on Research Methodology. During the Research Methodology course in Semester II, students will be allotted guides (from within the faculty associated with the Institute) based on their area of interest. As part of their assignments in the Research Methodology course students will write their introduction and literature review.

Evaluation of thesis: The thesis will be evaluated in **two phases** over two semesters (third and fourth). **For the first phase** (in the third semester), 14 credits are allotted. The schedule for evaluation (internal and external) is given in the table above. For the University presentation the student is expected to submit one spiral bound copy of the thesis consisting of introduction, literature review, aims and objectives, methodology, data and preliminary analysis along with a content page and interim certificate signed by the guide. The dissertation should be typed on A4 size bond paper with 1.5 line spacing. Illustrations and photographs should be of high quality. Font to be used is Times New Roman or Arial with the text not less than 12 pt. Referencing must be done in Zotero or any other referencing software strictly in standard referencing style (Vancouver). The report should be flawless without any spelling mistakes and grammatical errors etc. If the dissertation contains such mistakes, the student will have to resubmit their dissertation after the necessary corrections.

Guidelines for presentation: For every presentation students will prepare a power point presentation highlighting the objectives, research question, methodology and key findings and defend the same. The presentation must not be texty. It should be aesthetically appealing and

contain relevant graphs and analysis. Wordy presentations are likely to get marked down. Students should be smartly dressed and speak in a clear voice. Do ensure that your presentations are loaded as per the given deadlines.

Guidelines for presentation: For every presentation students will prepare a power point presentation highlighting the objectives, research question, methodology and key findings and defend the same. The presentation must not be texty. It should be aesthetically appealing and contain relevant graphs and analysis. Wordy presentations are likely to get marked down. Students should be smartly dressed and speak in a clear voice. Do ensure that your presentations are loaded as per the given deadlines.

The student will be permitted to appear for the second phase of the thesis ONLY if he/she has cleared the first phase.

Course No: GEO 312

Course Title: Programming for GIS -II

Number of Credits: 4

No. of Lectures-Tutorial: 45-15

Course Coordinator: Mr. Anand Shinde

Pre-requisite

All core courses of semester I and II.

Evaluation Procedure: 0.6/0.4 University

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed Journal submitted timely (within 7 days): 5 marks	Internal Assessment
Major exam	60%		University Assessment

Details of course content and allotted time

1. To study of overview of C# programming structure.
2. To write an application that uses Literals, variables and data types.
3. To write a programme to understand the various Operators and expression, looping and branching.
4. To write a application to know how to work with Methods and Arrays and String.
5. To study of Implementing Object-Oriented Programming Techniques in C#.
6. To create an application of Programming with Forms and Controls.
7. To write a programme for creating and developing an ASP.NET Web Application
8. Study of understanding the execution model of Python.
9. Study of numeric object and understanding the advanced numeric programming.
10. Study of string objects and understanding string formatting, string methods and implement higher level operations such as splitting and joining, case conversions, content tests and substring searches.

11. Study of branching and looping by using if/else statement, while and for loops.
12. Study how to define and call functions. Study in detail about python scopes and argument passing.
13. Study of classes and their uses in object oriented programming

Suggested Readings

- Shapiro Jeffrey, The Complete Reference Visual Basic.NET, Tata McGrawHill, 2008
- Mitchell Scott, ASP.NET.2.0 in 24 hours, Pearson Education, 2006
- Shivprasad Koirala, Net.Interview Questions, BPB Publications, 2008
- Dan Liberty Jesse, Brain Macdonala, Learning ASP.Net 3.5, SPD Publications, 2008
- Wesley Addison, Understanding dot NET 2nd Edition
- Apress – Maximizing Dot NET Performance
- Martelli, Rarensicroff, David Ascher, Python Cookbook, SPD Publications, 2008
- Lutz Mark, Programming Python, SPD Publications, 2008
- Lutz Mark, Learning Python, SPD Publications, 2008

Course No: GEO 313

Course Title: Techniques in Spatial Statistics, Analysis and Modeling

Number of Credits: 4

No. of Lectures-Tutorial: 45-15

Course Coordinator: Mr. Parag Khataavkar

Pre-requisite

None

Evaluation Procedure : 0.6/0.4 University

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed Journal submitted timely (within 7 days): 5 marks	Internal Assessment
Major exam	60%		University Assessment

Details of course content and allotted time

1. Toolbox model development for process automation
2. Map algebra: Language components; Operators; Commands; Functions
3. To perform a local, neighbourhood, zonal and combined operations
4. Perform topographic analysis: Surface conversion, Contouring, derive slope, derive aspect, curvature, hillshade, visibility analysis;
5. Perform hydrologic modeling: Creating hydrologically correct topographic surfaces, processing flow, identifying and filling sinks, flow direction, stream networks, drainage basins, flow length, perform viewshed analysis, delineate areawide watersheds (2 practicals)
6. Perform spatial interpolation using trend surface models, IDW, ordinary krigging
7. Compute least accumulative cost distance and path distance, euclidean distance
8. To create 3D data, displaying 3D data, scene properties, layer properties, TIN symbology
9. To perform raster to vector and vector to raster conversions and use the raster calculator to change cell values
10. To build binary model
11. To build index model

Course No: GEO 303

Course Title: Applications of geospatial technologies

Number of Credits: 4

No. of Lectures-Tutorial: 45-15

Course Coordinator:

Pre-requisite

GEO 102

Evaluation Procedure : Continuous

Assignments	40 % (3)	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment • Completed home assignment submitted timely and excellent written presentation	Assignments must be in the prescribed format. One journal may contain assignments of different elective courses separated by a separator. Index must reflect all the assignments duly signed by the concerned teacher. Marks for every assignment must reflect on the assignment itself.	Internal Assessment
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Remote sensing and GIS applications in ecosystem, forest studies and conservation • Key concepts in ecosystem studies: ecosystem services,	8	

	threats to ecosystems, management of ecosystems, classification levels • Key concepts of forest types, distribution, forestry practices, forest management • Satellites commonly used in forest studies • Satellites commonly used in ecosystem studies: global, national, regional, local, micro levels • Vegetation Indices used- NDVI, SAVI, Tassel Capped Index • Agencies involved (ancillary data sources) Case studies • Biodiversity characterization • Monitoring ecosystems (forests, wetlands) • Landuse/landcover classification (state level) • Human - Wildlife conflicts • EIA using GIS & RS • Habitat evaluation, Corridor mapping • Eco-tourism using advanced techniques like PDA • Forest fire risk zone mapping • Forest / vegetation classification and mapping. • Forest inventory and sampling technique. • Forest carbon management/sequestration • Using LIDAR data in forestry management • Wildlife Habitat Suitability Analysis with respect to : Statement of problem, feasibility of RS and GIS, methodology (flow chart) for each case study, RS needs (satellite, resolution, seasons, method of classification, vegetation indices), field studies needed and methodology used for the same, GIS database building (layers-sources, methods), analysis tools (GIS, statistical).		
	Assignment 1 Hands on session with any one application (demo followed by an exercise and presentation)		2
2	Remote sensing and GIS applications in agricultural applications • Key concepts in agriculture: problems in agriculture, agricultural impact on the environment, sustainable	6	

	agriculture, global significance of agriculture • Satellites commonly used for agricultural studies • Vegetation Indices - NDVI, SAVI, Tassel Capped Index, remote sensing properties of soil • Agencies involved (ancillary data sources) Case studies • Crop yield estimation • Crop disease monitoring • Crop water requirement • Soil Mapping • WebGIS for agriculture • Precision farming with respect to : Statement of problem, feasibility of RS and GIS, methodology (flow chart) for each case study, RS needs (satellite, resolution, seasons, method of classification, vegetation indices), field studies needed and methodology used for the same, GIS database building (layers-sources, methods), analysis tools (GIS, statistical).		
	Assignment 2 Hands on session with any one application (demo followed by an exercise and presentation)		2
3	Remote sensing and GIS applications in urban application • Satellites commonly used for urban studies • Agencies involved (ancillary data sources) Case Studies • Urban Sprawl • Land Information Systems • Utilities management (water, sewage) • Fringe Area Development • Planning of facilities (green spaces, hospitals, etc) • Emerging Technologies • Urban heat islands with respect to : Statement of problem, feasibility of RS and GIS, methodology (flow chart) for each case study, RS needs (satellite, resolution,	8	

	seasons, method of classification, vegetation indices), field studies needed and methodology used for the same, GIS database building (layers-sources, methods), analysis tools (GIS, statistical).		
4	Remote sensing and GIS applications in water resources and related applications • Satellites used • Agencies involved (ancillary data sources) Case Studies • Groundwater modeling • Bathymetric mapping • Watershed development and management • Water Resource Assessment and Preparation of Management Planning Strategy • Water pollution monitoring/assessment • Vulnerability assessment of rivers/ waterbodies with respect to : Statement of problem, feasibility of RS and GIS, methodology (flow chart) for each case study, RS needs (satellite, resolution, seasons, method of classification, vegetation indices), field studies needed and methodology used for the same, GIS database building (layers-sources, methods), analysis tools (GIS, statistical).	8	
	Assignment 3 Hands on session with any one application (demo followed by an exercise and presentation)		2
5	Remote sensing and GIS applications in health studies 6. Key concepts: causes of epidemics, basic concepts of epidemiology-transmission of diseases, responsible environmental factors, challenges in disease / health management 7. Agencies involved (ancillary data sources) Case studies 8. Disease mapping (3 case studies from different parts of	8	

	the world) 9. WebGIS for human health issues 10. GIS as a tool for monitoring Health Management Information System Environment Mapping for Viral Disease Survey 11. Emergency Medical Systems 12. Access to health care with respect to : Statement of problem, feasibility of RS and GIS, methodology (flow chart) for each case study, RS needs (satellite, resolution, seasons, method of classification, vegetation indices), field studies needed and methodology used for the same, GIS database building (layers-sources, methods), analysis tools (GIS, statistical).		
	Remote sensing and GIS applications in Utilities • Key concepts of utilities-power, telecom, transport • Satellites commonly used in utilities • Agencies involved (ancillary data sources) Case studies • GIS in management of electricity distribution network • GIS for power plant site selection (hydro, thermal) • GIS in telecommunications • GIS in transportation design and management • Managing sewage/water supply systems through GIS • GIS in monitoring of infrastructure projects • GIS in business applications (2 case studies) with respect to : Statement of problem, feasibility of RS and GIS, methodology (flow chart) for each case study, RS needs (satellite, resolution, seasons, method of classification, vegetation indices), field studies needed and methodology used for the same, GIS database building (layers-sources, methods), analysis tools (GIS, statistical).	7	
6.	Remote sensing and GIS applications in Utilities • Key concepts of utilities-power, telecom, transport • Satellites commonly used in utilities • Agencies involved (ancillary data sources)	5	

	Case studies • GIS in management of electricity distribution network • GIS for power plant site selection (hydro, thermal) • GIS in telecommunications • GIS in transportation design and management • Managing sewage/water supply systems through GIS • GIS in monitoring of infrastructure projects • GIS in business applications (2 case studies) with respect to : Statement of problem, feasibility of RS and GIS, methodology (flow chart) for each case study, RS needs (satellite, resolution, seasons, method of classification, vegetation indices), field studies needed and methodology used for the same, GIS database building (layers-sources, methods), analysis tools (GIS, statistical).		
	Assignment 4 Hands on session with any one application (demo followed by an exercise and presentation)		2
	Total	50	8

Reference Books

- Subudhi A P, B. S. Sokhi, P. S. Roy, Remote Sensing and GIS Application in Urban and Regional Studies, IIRS, 2001
- Roy. P. S, Natural Disaster and their Mitigation, IIRS, 2000.
- Roy P S, Biodiversity Characteristics at Landscape Level in North East using satellite Remote And Geographical Information System, IIRs, 2002.
- Roy P S, Forest Cover Assessment in Asia, IIRS, 2002.
- Roy P S, Biodiversity and Environment, IIRS, 2000.
- Sudershana R, D Mitra, Mishra , P.S Roy., D.P Rao, Subtle Issues in Coastal Management, IIRS, 2000.
- Deekshatulu B. L., Description and use of Landuse/ Landcover, NRSA, 1990.
- Remote Sensing for Sustainable Development, Proceedings of National Symposium organized by ISRS and RSAC, ISRS, Nov 1992.
- Proceeding of National Symposium on RS for Agricultural Application held at New Delhi, ISRS/IARI, Dec 1990.

- Proceedings of ISPRS Commission VII Symposium Resource and Environmental Monitoring, Hyderabad, Dec 2002.
- Pre-Symposium Tutorial on Sustainable Agriculture (Volume of Lectures), Dec 2002, NRSA
- National Agricultural Drought Assessment and Monitoring System, India, Summary Report, Sept 2001.
- ISPRS Technical Commission VII Symposium on Resource and Environmental Monitoring and ISRS Annual Convention- ABSTRACTS, NRSA, Dec 2002.
- Spatial Technologies for Natural Hazards Management (Proceedings of ISRS National Symposium Nov 21-22,2000, IIT Kanpur)
- Application of RS and GIS in Disaster Management, Lectures notes by CSSTEAP, IIRS.
- Forest Resource Management, Lectures notes by CSSTEAP, IIRS.
- Application of RS and GIS in Marine Sciences, Lectures notes by CSSTEAP, IIRS.
- Application of RS and GIS in Urban Mapping, Lectures notes by CSSTEAP, IIRS.
- Application of RS and GIS in Geosciences, Lectures notes by CSSTEAP, IIRS.
- Application of RS and GIS in Water Resources, Lectures notes by CSSTEAP, IIRS.

Course No: EST 301

Course Title: Integrated Impact Assessment

Number of Credits: 4

No. of Lectures-Tutorial: 46-14

Course Coordinator: Mr. Mahesh Kulkarni

Course Outline

There is growing realization that the multi-dimensional nature of sustainable development targets requires the use of different disciplinary approaches, in an integrated framework, to the impact assessment of development projects/programmes. Integrated Impact Assessment (IIA) provides such a framework for a balanced consideration of the economic, environmental, social and health impacts of development interventions at the project, sector and economy levels. The course in Integrated Impact Assessment (IIA) is designed to build detailed knowledge, understanding and skills among students for conducting IIA, so that they are able to identify sustainable modes of environmental operation. The course starts with an overview of IIA—the different methodologies on which it draws the state of the art, current practices, constraints and future directions.

Pre-requisite

None

Evaluation Procedure : Continuous

Assignments	20 %	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment : 5 marks • Completed home assignment submitted timely and excellent written presentation (within 7 days): 5 marks	Assignments must be in the prescribed journal format. One journal may contain assignments of different elective courses separated by a separator. However each course must have a separate index duly signed by teacher. Marks for every assignment must reflect on the assignment itself.	Internal Assessment
Minor Tests	20%	3 minor tests will be conducted		
Major exam	60%	Theory examination		University Assessment

Details of course content and allotted time

Sr. No.	Topic	Time (Hours)	
		L	T
1.	Introduction and overview of Integrated Impact Assessment (IIA) Defining IIA; Sustainable Development challenges and need for IIA; Key Approaches of IIA: Environment, Social, Health and Economic; Current Practices, Changing Perspectives and Debate in IIA	2	
2	Assessing Environmental Impacts: The EIA Approach • Evolution of EIA, purpose of EIA, steps in EIA process, Environmental Impact Statement (EIS), impact indicators; • EIA in developed and developing countries, EIA notification. Environment clearance process; project screening, scoping, consideration of alternatives, establishing the environmental baseline, impact identification, prediction and evaluation; Mitigation: • Public Participation (PP): purpose, procedure, interested parties, PP in India, PP in decision making. • EIA methodologies - ad hoc, overlays, checklists, matrices, networks; strategies for selection of EIA methodologies, methodologies for prediction: judgmental approach, mathematical models, simulation, and physical models. • Environmental monitoring: purpose, scope, pre and post monitoring. • Preparing an EIA report: General requirements, Topical and generic outline: Executive Summary, Description of the Project, base line data, Anticipated Environmental Impacts and Mitigation Measures, Alternatives, Environmental Monitoring Program, Additional Studies, Environmental Management Plan, Summary and Conclusion, Annexes, review of EIA report. • EIA as a planning process: developmental plans, policies and strategies for developmental projects • Case studies of EIA for few Indian industries – eg: oil,	14	

	metallurgical, petrochemical, iron and steel, fertilizer, projects of roads / dams etc		
	Assignment 1 Impact assessment using the methods studied above of a given case study (individual assignment)		4
	Minor Test 1		1
3	Assessing Environmental Impacts: Biodiversity Inclusive Impact Assessment (BIA) • Role of BIA in the existing EIA process • Identification, prediction and evaluation of impacts on biodiversity • Techniques of biodiversity impact assessment and monitoring, threat reduction methods; Case study	8	-
4.	Strategic Environmental Assessment (SEA) • Defining an SEA and its importance • Comparing SEA and EIA • SEA arrangements and procedures • SEA aims, principles and elements of approach • Methodology of SEA with case studies of SEA	10	
	Minor Test 2		1
7.	Integrative Approaches to Impact Assessment and Planning • Introduction • Horizontal integration of impacts in EIA • Vertical integration of EIA and Environment Management Systems • Integration of wider sustainability issues • Integrative methods and tools	6	
8.	Monitoring and Evaluation Basic concepts of monitoring and evaluation, guidelines tool for M&E (logic model, monitoring plan, evaluation plan), measures and indicators, evaluation designs and its applications–case study	6	
	Assignment 4 Designing an integrated impact assessment strategy for any		4

	given problem. (assignment in groups of three students each).		
	Minor Test 3		1
	Major Test		2
	Total	46	14

Textbooks

1. Shukla and Shrivastav, Concepts in environmental impact analysis, Common wealth Publication, 2000.
2. Environmental Impact Assessment, Selected reading, Wildlife Institute of India, 1991.
3. Biswas A.K, Environmental Impact Assessment, Tycooly International, 1987.
4. SINAR MAS pulp and paper (India), Ltd. Engineering Projects Pvt, Ltd. February, 1997
5. Natarajan Banerjee, Environment impact assessment and control measures adopted in Neyvelli lignite project, N.L.C Printing Press, 1985.
6. Environmental Impact study for Bongaigain refinery and petrochemicals, Ltd, Engineers India Ltd.
7. Trivedi, Environmental Impact Assessment, A P H Publishing Corporation, 2004.
8. Kulkarni and Ramchandra, Environment Management, Capital Publishing Company, 2006.
9. Desh Bandhu, Environment management, Indian environment Society, 1981.
10. Baumgartner Ruedi, The search for sustainable livelihood system sage Publications, 2004.
11. Bathwal R.R. (1988) *Environmental Impact Assessment*, New Age, International Publishers.
12. Canter L.W. (1996) *Environmental Impact Assessment*, 2nd Edn. New York, McGraw Hill.
13. Dale R. (2004) *Evaluating Development Programme and Project*, Second Edition, Sage Publication.
14. Lee N. and Kirkpatrick C. (Eds) (2000) *Integrated Appraisal and Sustainable Development in a Developing World*, Cheltenham, Edward Elgar.
15. Vanclay F. and Bronstein D.A. (1995) *Environmental and Social Impact Assessment*, Wiley Publishers.

Course No.: SD 101

Course Title: Fundamentals of sustainable development

Number of Credits: 4

No. of Lectures-Tutorial-Assignment: 42:8:10

Course Coordinator: Dr. Shamita Kumar with inputs from Dr. Kranti Yardi, Mr. Shivam Trivedi

Course Outline

The course aims to build the students' understanding of the concepts of sustainable development in all its dimensions, i.e. social, economic and environment to help correlate these factors to development and understand the need for sustainable development. It also explores the role of education for sustainable development from just awareness creation to the need for more action and implementation. The course provides insights into integrating sustainability in development issues.

Learning Outcomes

Students will:

- Develop a good understanding of the basics of sustainable development.
- Demonstrate an understanding of challenges in sustainable development.
- Understand the role of education for sustainable development.
- Develop skills in systems thinking.

Additional courseware

Students are encouraged to register for the following free online course:

<https://www.coursera.org/learn/sustainable-development>

Evaluation Procedure : 0.6/0.4 University

Assignment	2	20%	Internal Assessment
Minor Test	3	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

Sr. No.	Topic	Time (Hours)	
		L	T
1.	Basic concepts of sustainable development • Understanding 'sustainability' and 'development'; different world views; the economic growth/GDP perspective. • Agenda 21 and sustainable development; Sustainable development goals	6	

	• Linkages between economic growth and quality of life; Causes and effects of unsustainable development-consumerism, globalization, urbanization, ecosystem degradation, war, terrorism, disasters, inequity • Pillars of sustainable development-economic, social, environmental, political (governance) • Timeline of sustainable development; Millennium development goals and sustainable development goals • The need for sustainable development across sectors		
2.	Challenges of Sustainable Development • Rapid population growth • Food security • Income inequality • Increasing urbanization; Energy transformation • Gaps in development-access to long term financing • Climate change • Environmental degradation • Increasing cultural differences • Globalization • Increasing gender disparity • Religious revival	8	
3.	Tools for achieving sustainable development • Inclusive development strategies • Technology innovation • Sustainable cities • Food and nutrition security • Energy transformation • Environmental policies and regulations • Financing sustainable development • Public private partnership • Sustainable consumption	12	
	Assignment 1 Presentation by students on a specified topic		4
	Assignment 2 Students will be allotted group work to be followed by		4

	discussions facilitated by the teacher		
	Minor test 1		2
4.	Introduction to ESD - History of Environment Education ,Indian Perspective - Emergence of the concepts of ESD - Inter linkages of ESD and sustainable development - ESD and Sustainability-multidisciplinary approach.	2	
5.	ESD and Social Learning - Introduction to social learning and how people learn - Transformative learning and change - Critical realism and learning - Indigenous knowledge - Traditional practices and sustainability	4	
6.	Systems thinking and Institutional approach - Introduction to systems thinking - Systems landscape - Whole institutional approach - Greening Curriculum –gap analysis	5	
7.	Leadership and Stakeholder Management - Introduction and importance of leadership for ESD - Leadership styles - Cooperation and stakeholders management - Negotiation in the context of ESD and negotiation styles ,next best alternative	6	
	Minor test 2		2
	Assignment 2 Seminar presentation by individual students on predecided topics.		5

8.	Change management Introduction to change management, the cycle of change and learning, resistance, reflection and withdrawal, risk assessment and management for a project cycle, roles and skills of change agents	6	
9.	Sustainability Research Project The student will take up research project in the beginning of the course and work on the concept and implementation strategies. The project selected should address sustainability and implementation in the selected location should ensure that even after the withdrawal the project is sustainable .Students will implement the project during the course and they can be simple action oriented sustainable projects that are doable in the given stipulated time .		4
	Minor test 3		2
	Total	42	18

Reference books

1. An Introduction to Sustainable Development-Peter P. Rogers, Kazi F. Jalal, and John A. Boyd
2. Understanding Sustainable Development-John Belwitt
3. Limits to Growth – The 30 year update by Donella Meadows, Dennis Meadows, Jorgen Randers
4. Cradle to Cradle Remaking the Way We Make Things by William McDonough and Michael Braungart North Point Press
5. Our Common Future -World Commission on Environment and Development Oxford Paperbacks
6. Education for Sustainable Development: Nature, School and Democracy Illustrated Paperback-by Klas Sandell, Johan Ohman and Leif Ostman
7. Sustainable Education: Revisioning Learning and Change (Schumacher Briefings) [Paperback] by David ORR and S.R.Sterling
8. Thinking in Systems: A Primer [Paperback] DonellaH.Meadows

Suggested Readings

1. Small is Beautiful- Economics as if people mattered by EF Schumacher
2. At the edge –Ann Dale UBC press

3. Collapse – How societies choose to fail or succeed by Jared Diamond Penguin publishers
4. Development as Freedom – Amartya Sen –Publisher Anchor
5. Resilience Thinking-Sustaining ecosystems and people in a changing world by Brian Walker and David Salt
6. Leadership for Sustainability –an action approach by Judi Marshall, Gill Coleman and Peter Reason

Journals

1. International Journal for Sustainable Development

Course No: EST 303

Course Title: Environmental Modeling

Number of Credits: 4

No. of Lectures-Tutorial: 45-15

Course Coordinator:

Course Outline

The environmental problems result from a complex interaction of physical, chemical and biological processes, involving land, water, air and energy resources that significantly affect human activities and attitudes. The complex and multidisciplinary nature of environmental problems requires that they are dealt in an objective and integrated manner. Quantitative tools provide the requisite objectivity in environmental decision-making. These tools help in investigating, understanding, representing the current and predicting the future state of environment and generating 'what-if' scenarios under alternative policy interventions. These are crucial for any integrated environmental assessment and management strategy. This course aims to provide introduction to the fundamental modeling concepts through use of geospatial technologies for application in various sectors.

Learning Outcomes

At the end of the course, students will:

- Be proficient in designing models
- Test the accuracy of their models, perform sensitivity and uncertainty analyses

Evaluation Procedure : Continuous

Assignments	40 %	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment : 5 marks • Completed home assignment submitted timely and excellent written presentation (within 7 days): 5 marks	Assignments must be in the prescribed journal format. One journal may contain assignments of different elective courses separated by a separator. However each course must have a separate index duly signed by teacher. Marks for every assignment must reflect on the assignment itself.	Internal Assessment
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

Sr. No.	Topic	Time (Hours)	
		L	T
1.	Introduction Modelling: scope and problem definition, goals and objectives, definition; modelling approaches—deterministic, stochastic and the physical approach; applications of environmental models; the model building process	02	
2	Ex. 1: Vector based modeling – Regression Analysis (Linear and Regression) (ArcGIS)	05	
4	Ex. 2: LULC Temporal-Spatial Change Analysis (IDRISI)	05	
5	Ex. 3: Connectivity Analysis /Corridor (ArcGIS)		
6	Ex. 4: Urban Modeling Cellular Automata	05	
7	Ex. 5: Hydrological Modeling (SWAT)	05	
8	Ex. 6: Species modeling (ENFA)	05	
9.	Ex.7: Habitat Suitability Analysis (HSI)	05	
10.	Ex. 8: SatSan	05	
	Total	36	10

Suggested Readings

All relevant material will be provided as handouts. Students can also refer to the following books.

1. Maguire, Batty, & Goodchild: GIS, Spatial Analysis, and Modeling. ESRI Press, 2005.
2. Clarke, K. et. al.: Geographic Information Systems and Environmental Modeling. Prentice Hall, 2001.
3. DeMers, M.: GIS Modeling in Raster. Wiley, 2002.
4. Goodchild et. al.: GIS and Environmental Modeling: Progress and Research Issues. GIS world, Inc., 1996.

Course No: GEO 304

Course Title: Photogrammetry

Number of Credits: 4

No. of Lectures-Tutorial: 45-15

Course Coordinator:

Pre-requisite

None

Evaluation Procedure : Continuous

Assignments	40 %	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment : 5 marks • Completed home assignment submitted timely and excellent written presentation (within 7 days): 5 marks	Assignments must be in the prescribed journal format. One journal may contain assignments of different elective courses separated by a separator. However each course must have a separate index duly signed by teacher. Marks for every assignment must reflect on the assignment itself.	Internal Assessment
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Introduction to photogrammetry • Types of photogrammetry: analog and digital photogrammetry • Elements of photogrammetry • Aerial photogrammetry • Satellite photogrammetry • Aerial vs satellite photogrammetry	10	
2	Practical Assignment 1	9	

2	Photogrammetric sensing systems • Types of aerial camera, scale • Basic geometric characteristics of aerial photographs • Scale and height measurement on serial photographs, stereoscopic measurement of object height • Aerial photo errors: classification of errors, least square adjustment • Image parallax and stereoscopy • Triangulation: Space resection, exterior orientation, interior orientation, bundle block adjustment • DEM, Orthophotos and planimetric features from soft copy photogrammetry: collection of data, image digitizing, DEMs, creation of digital orthoimages, extraction of thematic features of interest, area measurement • Dynamic terrain visualization, Flythrough	12	
4	Practical Assignment 2	9	
5	Applications of photogrammetry • Surveying • Monitoring Structures • Archeological documentation and cultural heritage conservation • UAV Photogrammetry	5	
6	Practical Assignment 3 and 4		2
	Total	45	15

Course No: GEN 301

Course Title: Personality Development

Number of Credits: 2

No. of Lectures: 30

Course Coordinator:

Evaluation Procedure : Continuous

Assignment	1	50%	Internal Assessment
Assignment	2	50%	Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Introduction to Personality a) Basic of Personality b) Human growth and Behavior c) Theories in Personality d) Motivation Communication skills and Personality Development a) Intra personal communication and Body Language b) Inter personal Communication and Relationships c) Leadership Skills d) Team Building and public speaking	07	
	Assignment 1		4
2	Techniques in Personality development I a) Self confidence b) Mnemonics c) Goal setting d) Time Management and effective planning	07	
3.	Techniques in Personality Development II a) Stress Management b) Meditation and concentration techniques c) Self hypnotism d) Self-acceptance	08	
	Assignment 2		4
	Total	22	8

Course No: GEN 302

Course Title: Communication

Number of Credits: 2

No. of Lectures-Tutorial: 24-8

Course Coordinator: Dr. Shamita Kumar

Course Outline

The course provides an outline of how to develop communication skills with an emphasis on scientific writing, proposal preparation and scientific but attractive way of presentation of research findings along with proper means of audio-visual documentation. The course prepares students to think, read and write scientific papers; conceptualize, frame and prepare complete project proposals and also will help them to realize the basics of audio-visual communication systems.

Learning Outcomes

The student will be able to:

- Think, read and prepare scientific manuscripts
- Conceptualize, frame and prepare project proposals
- Prepare oral presentations and posters
- Document, edit and publish findings in field and related topics

Pre-requisite

None

Evaluation Procedure

Assignment	1	50%	Internal Assessment
Assignment	2	50%	Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Technical writing Outlining content • Organizing content: Checklist for components of journal articles and research papers • Difference between Abstract and Executive Summary • Writing an Introduction and Conclusion • Using logic to present content: the building blocks of analytical writing	8	

	- Using graphics to represent data: making data more readable and using graphics to present analysis - Using keywords to enhance search: Effective use of keywords to enhance online reach of your articles Using language effectively - Using effective words and editing content: Using a tool kit for writing; what to avoid when writing - Creating flow of information: understanding the difference between listing or cataloguing details and analyzing and interpreting them for your reader Submitting papers - Understanding submission guidelines - Using appropriate resources - Handling manuscript rejections		
	Assignment 1		
2	Preparing project proposals - Mapping the donor needs to organisational needs - Structuring content - Specifying deliverables and timelines - Asking for commitment - Checklist for a complete proposal	6	
3	Oral and Poster Presentations - Designing the presentation and flow of content - Communicating with the audience: verbal and non-verbal soft skills - Using visuals effectively: basics of using graphics, illustrations and copyright issues	4	
	Assignment 2		
4	Visual Documentation - How to take a good picture - Videos - Video documentation and editing clips with movie maker - Using keywords for cataloguing and for online search engine optimization	6	

SEMESTER IV

Course No: GEO 411

Course Title: Dissertation

Number of Credits: 14

Evaluation Procedure: 0.6/0.4 University

Assessment by guide	40%	Internal Assessment
Major Exam	60%	University Assessment

This course is the second phase of the dissertation. A student cannot appear for the exam of this course unless he/she has cleared Phase I.

Evaluation of thesis: The second phase of the thesis will be evaluated for 14 credits. The internal and external assessment will be as indicated in the table above. Students have to appear for a final external viva to defend their thesis after submission of the thesis.

The dissertation will have to be submitted as per the dates indicated in Academic Calendar for appraisal and acceptance by the University. The students should submit their dissertation in the following format.

Cover Page

Inner Cover Page

Certificate duly signed by guide and head of institution

Acknowledgements

Contents

Chapter 1 – Introduction

A background with historical information and a review of existing material or data on the subject.

Chapter 2- Aims and Objectives

This chapter must contain the overall study design and aims and objectives of the study.

Chapter 3 – Literature Review

Detailed review of all existing literature related to the topic justifying the topic with a comprehensive bibliography generated using Zotero.

Chapter 3 –Methodology

Description of the issues, environmental setting and methodology adopted for the study etc.

Chapter 4 – Results

Presentation of results.

Chapter 5 – Discussion

Discussion on the data and results obtained and presentation of method suggested to solve the problem.

Chapter 5 – Summary and Conclusions

A summary of the dissertation and important conclusions drawn at the end of the investigation and a list of references cited in the text.

Chapter 6 - Bibliography

The dissertation should be typed on A4 size bond paper with 1.5 line spacing. Illustrations and photographs should be of high quality. Font to be used is Times New Roman or Arial with the text not less than in 12 pt. Referencing must be done in Zotero or any other referencing software in standard referencing style (Vancouver) for both intext citing and bibliography. The report should be flawless without any spelling mistakes and grammatical errors etc. If the dissertation contains such mistakes, the student will have to resubmit their dissertation after the necessary corrections. The dissertation should be bound in hard black mounted cover. Dissertations with spiral binding and paper cover will not be accepted.

The students are expected to prepare 3 copies (4 in case of a co-guide). If the guide gives a written consent that he/she does not need a hard copy a soft copy may be provided on a CD. The CD must contain a sticker with the cover page information. **The thesis will only be accepted after the relevant data used has been submitted to the faculty nominated and verified by them.** Students making special efforts to present their papers at conferences or publishing it will receive marks as below:

1.	Poster presented at a National level UGC recognized conference	5 marks
3.	Paper presented at a national level conference	10 marks
4.	Paper published in a SCOPUS/ WEB of SCIENCE indexed journal ONLY	25 marks

Guidelines for presentation: For every presentation students will prepare a power point presentation highlighting the objectives, research question, methodology and key findings and defend the same. The presentation must not be texty. It should be aesthetically appealing and contain relevant graphs and analysis. Wordy presentations are likely to get marked down. Students should be smartly dressed and speak in a clear voice. Do ensure that your presentations are loaded as per the given deadlines.

Guidelines for poster

For the final presentation students will prepare a poster as per the guidelines given below.

Poster size: 2ft (W) x 3ft (H)

Material: Vinyl (top quality)

Content: Aim, Objective, Method (in brief in a flow chart), findings (key graphs to be included), publications (if any), conclusion, suggestion

Name of the student and guide as well as institutional affiliation should be included.

Course No: GEO 412

Course Title: Internship

Number of Credits: 14

Course Coordinator: Dr. Shamita Kumar

Course Outline

The internship of six month ((minimum 5 months) duration to be completed in the fourth semester is an opportunity for students to develop research skills and/or gain professional expertise as well as academic knowledge. Students must plan for the internship towards the end of the second semester itself. While the Institute will facilitate the placement for internships, students are encouraged to find placements for internships and make initial contact with prospective organization as this builds skills of communication.

Learning Outcomes

- Plan, execute and present findings of tasks completed in the six month period.
- Write concisely and effectively in order to communicate concepts and ideas in a logical and coherent manner.
- Produce effective data presentations and use them to enhance the communication of quantitative information.
- Work effectively in a team.

Pre-requisites

The student must apply for the internship/scan internship opportunities atleast six to eight months in advance. Requisite correspondence with the concerned organization is the responsibility of the student. The Institute will support with a letter of intent. Throughout the internship, the student must maintain a work log that includes dates, time spent on site, and a summary of the work performed and its relevance. An updated copy of the log must be turned into the supervisor (at the place of work) and the faculty supervisor in the form of monthly reports. The student must meet with the supervisor (at the place of work) on a regular schedule (determined by the supervisors at their discretion). The supervisor must be willing to submit a written evaluation of the student at the conclusion of the internship.

Evaluation: Continous

Midterm report submitted with signature of the supervisor and a letter of appointment	Three month from time of commencement of internship	20%	Details of tasks assigned, tasks completed till date
End project report submitted with a report by the supervisor	Within seven days of completion of the internship (1 st August)	40%	
Presentation on internship	As per University schedule	40%	Detailed presentation of tasks completed

			with concrete outcomes and learnings.

Format of Internship Report

1. Cover page with title, your name and name of company
2. Certificate from the employer on employer letterhead stating tasks completed and level of achievement and

Name of the student

Place of internship

Supervisor

Duration of internship (Date of commencement of internship – date of completion)

3. Introduction
4. Objectives
5. Tasks done with methodology and date
6. Outputs
7. Learnings (to be added only for final report, not interim report)
 - A. Work experience
 - B. Academic and scientific and experience
 - C. Social and cultural experience

The internship report should be typed on A4 size bond paper with 1.5 line spacing. Illustrations and photographs should be of high quality. Font to be used is Times New Roman or Arial with the text not less than in 12 pt. Referencing must be done in Zotero or any other referencing software in standard referencing style (Vancouver) for both intext citing and bibliography. The report should be flawless without any spelling mistakes and grammatical errors etc. If the report contains such mistakes, the student will have to resubmit their dissertation after the necessary corrections. The report should be ‘perfect bound ’ / ‘book bound’. Reports with spiral binding will not be accepted.

The students are expected to prepare 3 copies.

Course No. GEN 401

Course Title: Entrepreneurship Development

Number of Credits: 2

No. of Lectures-Tutorial-Practical: 15-15

Course Coordinator:

Course Description

This course is designed to help students evaluate the business skills and commitment necessary to successfully operate an entrepreneurial venture and review the challenges and rewards of entrepreneurship. Students will learn about themselves, their decisions, and their goals to determine how entrepreneurship can play a role in their lives. Students will also be introduced to entrepreneurship from an economic perspective and the concepts of environmentally sustainable practices and social entrepreneurship.

Learning Outcomes

On completion of this course, the student will:

- Develop an understanding of personal attributes and skills that characterize the 'successful' entrepreneur.
- Be able to assess and compare their personal characteristics and interests to that of the 'successful' entrepreneur.
- Be able to identify and assess sources of support for small businesses and entrepreneurs. Be able to research and explain issues relevant to entrepreneurs such as 'green' business practices, environmental sustainability.
- Be able to identify the financial, marketing, legal, human resource, operations, and general management skills that are necessary to successfully launch and operate a successful new venture.

Evaluation Procedure: Continuous

Assignment	1	100 %	Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	• Entrepreneurship-Enterprise: Conceptual issues. Entrepreneurship vs. Management. Roles and functions in relation to the enterprise and in	05	

	relation to the economy. Small business as seedbed of Entrepreneurship.		
2	• Opportunity scouting and idea generation: role of creativity and innovation and business research. Sources of business ideas. • Entrepreneur opportunities in contemporary business environment, for example opportunities in net-work marketing, franchising, business process outsourcing in the early 21 century. • The process of setting up a small business: Preliminary screening and aspects of the detailed study of the feasibility of the business idea and financing/non-financing support agencies to familiarize themselves with the policies/programs and procedures and the available schemes. • Preparation of Project Report and Report on Experiential Learning of successful and unsuccessful entrepreneurs.	05	
	Assignment 1		08
3.	• Issues in small business marketing. The concept and application of product life cycle, advertising and publicity, sales and distribution management. • The idea of consortium marketing, competitive bidding/tender marketing, negotiating with principal customers. • The contemporary perspectives on Infrastructure development, Product and Procurement Reservation, Marketing Assistance, Subsidies and other Fiscal and Monetary Incentives. National state level and grass-root level financial and non-financial institutions in support of small business development.	05	
	Assignment 1		07
	Total	15	15

BHARATI VIDYAPEETH UNIVERSITY, PUNE

FACULTY OF SCIENCE

MASTER OF ENVIRONMENT SCIENCE AND TECHNOLOGY

COURSE STRUCTURE AND DETAILED SYLLABUS

OF

SEMESTERS I, II, III and IV

(UNDER CREDIT SYSTEM)

EFFECTIVE FROM 2013-2014

BHARATI VIDYAPEETH UNIVERSITY, PUNE
FACULTY OF SCIENCE

Course Structure of
Master of Environment Science and Technology
(Under Credit System)
effective from 2013-2014

INTRODUCTION

The course has a multidisciplinary approach that integrates the science of environmental studies with technical and social issues and includes courses on ecosystem studies, biodiversity conservation, natural resource management, geoinformatics, water and waste water engineering, green technology, environmental lab techniques, sustainable development, urban sustainability and environment and health. The course builds on a candidate's knowledge of chemistry, biology, statistics, computers, engineering, sociology and economics to develop a deeper understanding of applications in the environmental sector. It includes the cognitive aspects and technological skills necessary to further sustainable form of development and rational resource-use management. It trains the candidate in advanced laboratory skills required for pollution monitoring and abatement, to undertake environmental impact assessment(EIA), ecodevelopment, ecorestoration, implement green technology, assess biodiversity, etc. The program addresses environment management from the technical, social as well as the policy aspect to counter the effects of degradation of the ecosystem.

OBJECTIVES

- To facilitate knowledge construction on various aspects of environment management.
- To foster inter-disciplinary approach by building scientific, technological, legal, economic, social and policy perspectives.
- To develop relevant analytical and field skills in assessing the state of the ecosystem as well as in communication and research.

SCOPE

Contrary to the popular belief that 'green jobs' exist in specific sectors, green jobs today are found in all sectors as a large number of industries and organizations have today committed or make commitments to sustainability. These jobs are beginning to emerge in favor of greener, cleaner and more sustainable occupations. The UNEP Report on green jobs shows that for the first time at global level green jobs are being generated in some sectors and economies largely resulting from the need to meet emission reduction targets. This has led to changing patterns of investment flows. Employment opportunities exist in diverse fields such as in government agencies, industries, manufacturing, energy, food, recycling, agriculture, business, policy, construction, forestry and conservation sectors all of which offer immense opportunities to environmental professionals.

The pace of green job creation is likely to accelerate in the years ahead. A global transition to a low-carbon and sustainable economy has already created a large numbers of green jobs across many sectors of the economy, and has indeed become an engine of development.

Climate deals are also supporting payments to countries for managing forests for their carbon absorption potential opening up new opportunities for green jobs in the forestry sector of the tropics. An agreement by 2010 under the Convention on Biological Diversity on Access and Benefit Sharing of Genetic Resources has triggered similar North-South funding flows with job implications in conservation and natural resource management.

The job profiles in green careers are as diverse as the problems they address. A degree in Environment Sciences definitely sets the pace in building a green career. One can be a researcher, a designer, a planner, an operator of pollution control facilities, a professor, a government regulatory agency official, a manager of programs, or be involved in professional society work. Potential employers can be private consulting engineering firms, universities, private research firms, testing laboratories, government agencies at different levels, or all types of major corporations and private businesses.

ELIGIBILITY FOR ADMISSION TO THE COURSE

- a. The candidate should have obtained the Bachelorsdegree in any Science subject such as Botany, Zoology, Chemistry, Physics, Statistics, Geography, Geology, Geography, Life Sciences, Environment Sciences, Microbiology, Biotechnology, Fisheries, Marine Biology, Horticulture, Agriculture, Computer Science, Veterinary Science or any branch of engineering or any relevant Social Science subject.
- b. The candidate should have secured at least 50% in the aggregate at undergraduate level and 45% for SC /ST / OBC candidates.

DURATION OF THE COURSE

The duration of this course is two years consisting of four semesters. The medium of instructions and examination will be only English.

RULES AND REGULATIONS

1. **Commencement and Conclusion:** The dates for the commencement and conclusion of each semester shall be determined by the University authorities. The terms can be kept by only duly admitted students. Each semester is of 15 weeks duration. Students must check the academic calendar for exact dates of commencement and conclusion.
2. **Credits:** The entire Course is of 128 credits and will be executed in 4 semesters.
3. One credit is equivalent to 15 hours of interaction of student with facilitator for theory, while one credit for practical is equivalent to 20 hours of practical work or 30 hours of field work.
4. 32 credits each are offered in each of the four semesters.
5. **Dissertation:** The student will undertake dissertation in Semester III and continue the same in Semester IV for which 28 credits have been allotted. The topic for the research must be finalized by the send of Semester II after thorough literature review.
6. **Field Visits:** The field / industrial / academic Institute visits will be organized for demonstration of advance experimental techniques wherever necessary along with the

courses. Attendance for these are mandatory and will form part of internal assessment as indicated in the syllabus.

7. **Internship:** Internship will be carried out by the student in the semester break between the second and the third semester.
8. **Attendance:** A student must have minimum 80% attendance in theory and 100% attendance in the practical courses to fulfill the term. A student who does not have the required attendance may not be allowed to appear for the university term and the respective monthly internal assessments.

RULES FOR EXAMINATION AND INTERNAL ASSESSMENT

1. Examination for the theory and practical courses will be conducted at the end of each respective semester or as continuous assessment as indicated in the syllabus.
2. The weightage allotted for internal assessment is 40%. Thus 40 marks out of 100 will be allotted for internal assessment which will be conducted throughout the semester in the form of tests/tutorials/seminars/oral presentations/assignments/debates, etc. as indicated in the syllabus. The university shall conduct an examination for 60 marks.
3. Internal assessment for the practical course is through continuous assessment. Each practical is evaluated for ten marks. Of this performance in the class is assessed for five marks and timely journal submission (within a week of the practical being conducted) as per instructions given by the concerned teacher is assessed for five marks.
4. The general courses will be evaluated by the instructor on the basis of continuous assessment as indicated in the syllabus.

STANDARD OF PASSING

- a. The 10-point scale Grades and Grade Points according to the following table.

Range of Marks (Out of 100)	Grade	Grade Point
$80 \leq \text{Marks} \leq 100$	O	10
$70 \leq \text{Marks} < 80$	A+	9
$60 \leq \text{Marks} < 70$	A	8

$55 \leq \text{Marks} < 60$	B+	7
$50 \leq \text{Marks} < 55$	B	6
$40 \leq \text{Marks} < 50$	C	5
Marks < 40	D	0

- b. The performances at UE and IA will be combined to obtain the Grade Point Average (GPA) for the course. The weights for performance at UE and IA shall respectively be 60% and 40%.
- c. GPA is calculated by adding the UE marks out of 60 and IA marks out of 40. The total marks out of 100 are converted to grade point, which will be the GPA.

Formula to calculate Grade Points (GP)

- a. Suppose that 'Max' is the maximum marks assigned for an examination or evaluation based on which GP will be computed. In order to determine the GP, Set $x = \text{Max} / 10$ (since we have adapted 10-point system). Then GP is calculated by the formulas shown as below.

Range of Marks at the evaluation	Formula for the Grade Point
$8x \leq \text{Marks} \leq 10x$	10
$5.5x \leq \text{Marks} < 8x$	Truncate (Marks / x) + 2
$4x \leq \text{Marks} < 5.5x$	Truncate (Marks / x) + 1

- b. Two kinds of performance indicators, namely, the Semester Grade Point Average (SGPA) and the Cumulative Grade Point Average (CGPA) shall be computed at the end of each term. The SGPA measures the cumulative performance of a learner in all the courses in a particular semester, while the CGPA measures the cumulative performance in all courses since his/her enrolment. The CGPA of learner when he/she completes the programme is the final result of the learner

The Formula to compute equivalent percentage marks for specified CGPA:

% Marks (CGPA) =	$10 \times \text{CGPA} - 10$	if $5.00 \leq \text{CGPA} \leq 6.00$
	$5 \times \text{CGPA} + 20$	if $6.00 \leq \text{CGPA} \leq 8.00$
	$10 \times \text{CGPA} - 20$	if $8.00 \leq \text{CGPA} \leq 9.00$
	$20 \times \text{CGPA} - 110$	if $9.00 \leq \text{CGPA} \leq 9.50$
	$40 \times \text{CGPA} - 300$	if $9.50 \leq \text{CGPA} \leq 10.00$

New guidelines for Standards of Passing**Standards of Passing**

1. For all courses, both UE and IE constitute separate heads-of-passing (HoP). In order to pass in such courses and to 'earn' the assigned credits
 - a. The learner must obtain a minimum grade point of 5.0 (40% marks) at UE and also a minimum grade point of 5.0 (40% marks) at IA;
 - OR**
 - b. If he / she fails in IA, the learner passes in the course provided he / she obtains a minimum of 25% in IA and GPA for the course is atleast 6.0 (50% in aggregate). The GPA for a course will be calculated only if the learner passes at the UE. The following examples illustrate this rule for passing in a course under.

Illustration of Passing Rule specified

Case No.	UE Marks Out of 60	IA Marks Out of 40	Total Marks Out of 100	GP of UE	GP of IA	GPA	Remarks
1	24	16	40	5.0	5.0	5.0	Pass
2	40	10	50	7.0	0	6.0	Pass
3	40	06	46	7.0	0	5.0	Fails at IA
4	20	40	--	0	10.0	0	Fails at UE
5	34	12	46	7.0	0	5.0	Fails at IA
6	20	15	--	0	0	0	Fails at both UE & IA

2. A student who fails at UE in a course has to reappear only at UE as a backlog candidate and clear the HoP. Similarly, A student who fails in a course at IA has to reappear only at IA as a backlog candidate and clear the HoP.
3. Subject to the Rules E1-E2, the ATKT and other rules may be framed by respective BOS and faculty.

Award of Honours

A student who has completed the minimum credits specified for the program shall be declared to have passed in the programme. The final result will be in terms of letter grade only and is based on the CGPA of all courses studied and passed. The criteria for the award of honours are given below.

Range of CGPA	Final Grade	Performance Descriptor	Equivalent Range of Marks (%)
$9.50 \leq \text{CGPA} \leq 10.00$	O	Outstanding	$80 \leq \text{Marks} \leq 100$
$9.00 \leq \text{CGPA} \leq 9.49$	A+	Excellent	$70 \leq \text{Marks} < 80$
$8.00 \leq \text{CGPA} \leq 8.99$	A	Very Good	$60 \leq \text{Marks} < 70$
$7.00 \leq \text{CGPA} \leq 7.99$	B+	Good	$55 \leq \text{Marks} < 60$
$6.00 \leq \text{CGPA} \leq 6.99$	B	Average	$50 \leq \text{Marks} < 55$
$5.00 \leq \text{CGPA} \leq 5.99$	C	Satisfactory	$40 \leq \text{Marks} < 50$
CGPA Below 5.00	F	Fail	Marks Below 40

IMPORTANT INSTRUCTIONS FOR STUDENTS

- Read carefully the entire Syllabus, making sure that all aspects of the course are clear to you, ie. Structure of the program, electives, details of assignments, internal and external examinations systems, marking systems, grading, attendance requirements as well as rules and regulations.
- Course coordinators are liable to change from those mentioned. Students will be informed about the change if any before the commencement of the semester.
- Familiarize yourself with the library and online resources for maximizing your learning experience.
- BVIEER faculty are always willing to accommodate interested and exceptional students in their on going research. If you are interested in volunteering your time on any of the projects to gain valuable work experience, do get in touch with them.
- Make sure that all assignments are submitted on time. Late submission of assignments may result in loss of a certain percentage of marks or rejection of your assignment.
- Every practical journal must be complete before the next practical to ensure it is assessed.

- **Academic Integrity**

Bharati Vidyapeeth University is committed to maintaining academic quality, excellence, and honesty. All faculty and students are expected to share the commitment to academic integrity, an essential component of a quality academic experience.

Students are expected to read and follow all policies, procedures, and program information guidelines contained in publications; pursue their learning goals with honesty and integrity; demonstrate that they are progressing satisfactorily and in a timely fashion by meeting course deadlines and following outlined procedures; observe a code of mutual respect in dealing with mentors, staff, and other students; behave in a manner consistent with the standards and codes of the profession in which they are practicing; keep official records updated regarding

changes in name, address, telephone number, or e-mail address; and meet financial obligations in a timely manner.

- **Academic Dishonesty**

All students are expected to approach their education with academic integrity. Academic dishonesty undermines this objective. Academic dishonesty can take the following forms:

- Cheating
- Gaining or providing unauthorized access to examinations or using unauthorized materials during exam administration
- Submitting credentials that are false or altered in any way
- Plagiarizing (including copying and pasting from the Internet without using quotation marks and without acknowledging sources)
- Forgery, fabricating information or citations, or falsifying documents
- Submitting the work of another person in whole or in part as your own (including work obtained through document sharing sites, tutoring schools, term paper companies, or other sources)
- Tampering with the academic work of other students

- **Plagiarism**

Plagiarism, which is defined as using the work and ideas of others without proper citation is strictly prohibited in all assignments and dissertation. Students indulging in plagiarism will find their work is not assessed.

Plagiarism defeats the purpose of education. If you plagiarize, you are not educating yourself, and you are wasting your time on courses meant to improve your skills.

SEMESTER WISE COURSE INFORMATION

Semester I

Course Number	Course Title	Credit Value	Hours per week	Weightage For EoTE/IA	EoTM
	Core Courses				
EST 101	Ecosystem Studies	4	4	0.6/0.4	University
EST 102	Environmental Chemistry	4	4	0.6/0.4	University
EST 103	Environmental Microbiology	4	4	0.6/0.4	University
GEO 102	Fundamentals of Geoinformatics	4	4	0.6/0.4	University
SD 101	Fundamentals of sustainable development	4	4	0.6/0.4	University
EST 111	Field techniques –I	2	3	0.6/0.4	University
EST 112	Lab Analytical techniques –I	2	3	0.6/0.4	University
GEO 112	Techniques in GIS and GPS	2	3	0.6/0.4	University
	Pre-requisites				
EST 104	Statistical Methods	3	3	Continuous assessment	Institute
EST 105	Fundamentals of computing and database	3	3	Continuous assessment	Institute
	Total	32	35		

Total credits offered in Semester I : 32

Semester II

Course Number	Course Title	Credit Value	Hours per week	Weightage For EoTE/IA	EoTM
	Core Courses				
EST 201	Biodiversity Assessment and Conservation	4	4	0.6/0.4	University
EST 202	Engineered Systems for Water and Waste Water	4	4	0.6/0.4	University
EST 203	Solid and Hazardous Waste Management	4	4	0.6/0.4	University
EST 204	Air and Noise Pollution Management	4	4	0.6/0.4	University
EST 205	Research Methodology	2	2	Continuous assessment	Institute
EST 211	Field Techniques - II	2	3	0.6/0.4	University
EST 212	Lab Analytical techniques –II	2	3	0.6/0.4	University
	Electives (any two)				
EST 206	Natural Resource Management	4	4	Continuous assessment	Institute
CA 201	Wildlife health, rescue and rehab	4	4	Continuous assessment	Institute
EST 207	Environment and Health	4	4	Continuous assessment	Institute
EST 208	Climate Change Science and Strategies	4	4	Continuous assessment	Institute
EST 209	Environmental biotechnology	4	4	Continuous assessment	Institute
EST 2010	Instrumentation and Lab Management for environmental analysis	4	4	Continuous assessment	Institute
	General Courses (any one)				
GEN 201	General English	2	2	Continuous assessment	Institute
GEN 202	Project Management	2	2	Continuous assessment	Institute
	Total	32	34		

Total Credits offered in Semester II : 32

Semester III

Course Number	Course Title	Credit Value	No. of hours per week	Weightage For EoTE/IA	EoTM
	Core Courses				
EST 301	Integrated Impact Assessment	4	4	0.6/0.4	University
EST 302	Environmental Law and Policies	4	4	0.6/0.4	University
EST 311	Dissertation	14	16	0.6/0.4	University
	Electives (any two)				
CA 101	Human Ecology	4	4	Continuous assessment	Institute
EST 303	Environmental Modeling	4	4	Continuous assessment	Institute
EST 304	Internship	4	4	Continuous assessment	Institute
GEO 303	Applications of geospatial technologies	4	4	Continuous assessment	Institute
EST 305	Urban Environment Management	4	4	Continuous assessment	Institute
EST 306	Environment Management Techniques	4	4	Continuous assessment	Institute
EST 307	Advanced Pollution Control Technology	4	4	Continuous assessment	Institute
	General Courses (any one)				
GEN 301	Personality development	2	2	Continuous assessment	Institute
GEN 302	Communication	2	2	Continuous assessment	Institute
	Total	32	34		

Total Credits offered in Semester III : 32

Semester IV

Course Number	Course Title	Credit Value	Hours per week	Weightage For EoTE/IA	EoTM
	Core Courses				
EST 411	Dissertation	14	16	0.6/0.4	University
	Electives (any four)				
EST 401	Ecorestoration, Ecodevelopment and Ecotourism	4	4	Continuous assessment	Institute
EST 402	Water Management	4	4	Continuous assessment	Institute
EST 403	Corporate Social Responsibility	4	4	Continuous assessment	Institute
EST 404	Comparative Environmental Law	4	4	Continuous assessment	Institute
EST 405	Urban Sustainability	4	4	Continuous assessment	Institute
EST 406	Industrial Safety and Occupational Health	4	4	Continuous assessment	Institute
EST 407	Green technology and Management	4	4	Continuous assessment	Institute
	General Courses (any one)				
GEN 401	Entrepreneurship Development	2	2	Continuous assessment	Institute
	Total	32	34		

Total Credits offered in Semester IV : 32

Course No: EST 101

Course Title: Ecosystem Studies

Number of Credits: 4

No. of Lectures-Tutorial: 45-15

Course Coordinator/Instructor: Dr. Kranti Yardi with inputs from Dr. Rahul Mungikar

Course Outline

Ecosystems provide a vast range of services, from food and medicines to a stable climate, clean water and storm protection. This course provides an introduction to the functioning of ecosystems underlying these services, in particular looking at how ecosystems are structured and how they function. The course has a practical ethos and involves fieldwork and analysis of real data. The course looks at the dynamic nature of ecosystems, which often behave as complex systems. The course provides students with the core ecosystem knowledge needed for management.

Learning Outcomes

Student will develop:

- An understanding of the fundamental principles of ecosystem ecology including how ecosystem structure relates to function and the dynamics of ecosystems.
- Appreciation of the diversity of ecosystem functions across time, space and biomes.
- Appreciation of how ecosystems respond to global change drivers including climate change, land use change and biodiversity loss.
- An understanding of ecosystem services, principles of ecosystem valuation and its importance

Pre-requisite

None

Evaluation Procedure: 0.6/0.4 University

Assignment	2	20%	Internal Assessment
Minor Test	2	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1.	Biogeography and evolution • Patterns of species distribution – evolutionary relicts, climatic relicts, endemic organisms, environmental gradients, interaction of factors, species interactions	04	

	• Natural selection, Darwin's theory • Plate tectonics and evolution of biodiversity • Species diversity in the tropics		
2.	Ecological Concepts and Ecosystem • Evolution of natural environment • Introduction: Biotic and abiotic factors • Ecosystem productivity • Food chains and food webs and trophic levels • Energy flows– pyramid of number, pyramid of energy and pyramid of biomass • Patterns and types of bio-geochemical cycles – oxygen, nitrogen, carbon, sulphur and phosphorus • Water cycle • Principles of limiting factors- Liebig's law of Minimum, Shelford's law of tolerance, Combining concepts of limiting factors, limiting factors in ecosystem context • Ecological indicators, Ecotones and concept of edge effect, successional patterns (grasslands to old growth) and response of wildlife	06	
3.	Biodiversity • Definition: species richness, species diversity, biological diversity • Levels of biodiversity: genes to landscapes • Values of biodiversity – direct and indirect • Biogeographic zones of India	02	
	Assignment 1 Discussion and presentation of selected research paper in groups of two students.		4
4.	Ecosystems • Forests – Biogeography of forests in India, vegetation structure and functions, food chain and food webs, plant-animal interaction, productivity and nutrient cycling, biological diversity of tropical forests, limiting factors, gap theory, threats and conservation. • Grasslands – Biogeography of grasslands in India, structure and function, food chains and food webs, animal population dynamics, limiting factors, threats and conservation • Deserts – Biogeography of deserts in India, structure and function, limiting factors, environmental factors	10	

	and plant-animal distributions, threats and conservation • Mountains – Tropical mountains, structure and function, plant and animal ecophysiology, threats and conservation • Mangroves – structure and function, ecological adaptations of mangroves, plant and animal diversity and interactions, mangrove productivity, food chains and food webs, threats and conservation • Marine ecosystems – structure and function, plant and animal diversity with reference to India, food chains and food webs, threats and conservation • Coral reefs – Distribution, structure and function, coral reef biology, coral reef communities, coral reef biodiversity, threats and conservation • Wetlands/Rivers - Biogeography, structure and function, stratification, food chains and food webs, catchment area concept, threats and conservation.		
	Minor test 1		2
5.	Taxonomy • Study of identification and classification characters / Concepts of Taxonomic characters • Morphological features • Overview of the classification systems for each group • Major Classification systems preferred for identification of cryptogams and phanerogams up to order level ▪ Alexopolus, Mims & Blackwell – For Fungi ▪ Natural classification system and APG III • Types of keys and use of floras or identification keys • Plant nomenclature - ICBN Animal taxonomy • Brief classification of animals up to class level for invertebrates and up to order level for vertebrates • Use of Taxonomic Keys for Identification of the animal specimen	12	
	Assignment 2 Seminar presentation by individual students on predecided topics.		5
6.	Ecosystem services and ecosystem dynamics Ecosystem services	05	

	• Ecosystem functioning and ecosystem services provided by different ecosystems at present – provisioning services, regulating services, habitat or supporting services, cultural services • Species population and ecosystem services-the connections • Millennium Ecosystem Assessment, TEEB with case studies Ecosystem dynamics • Definition of ecosystem dynamics and its relevance • Changes in ecosystems over different time scales, drivers of ecosystem dynamics (natural and human induced), patterns and elements of ecosystem dynamics with examples		
7.	Valuation of Ecosystem Services • Overview of economic valuation of ecosystems • Key issues in valuation of economics of ecosystems-identifying key stakeholders, key development goals, assessing the status and trends of key ecosystems, engaging stakeholders • Valuation methods – preference based approaches, biophysical based approaches and their limitations • Selecting valuation method and indicators, developing an implementation plan, Capturing the value of ecosystem services, implementing and monitoring • Payments for ecosystem services • Case studies	06	
	Minor test 2		2
	Total	45	15

Suggested Readings

1. Groom M.J., MeffeG.K. and Carroll C.R. (2006) *Principles of Conservation Biology* (3rd edition), Sinauer Associates, Sunderland
2. Gopal, R., 2011. Fundamentals of Wildlife Management. Natraj Publishers, New Delhi.
3. Sawarkar, V.B., 2005. A guide to planning wildlife management in protected areas & managed landscapes. Natraj Publishers.
4. Primack R.B. (2006) *Essentials of Conservation Biology* (4th ed.), Sinauer Associates, Sunderland.
5. Carabias Julia and Kishore Rao, Capacity Needs to Manage Protected Areas, The Nature Conservancy, 2003.

6. Champion S., Seth S, (2005). Revised survey of forest types of India. Nataraj Publishers, New Delhi.
7. Estuaries of India, ENVIS, 2002.
8. Sustainable management of wetland, biodiversity and beyond. Jyoti Parikh & Hemant Date.
9. Mangroves of India, ENVIS, 2002.
10. Hunter Malcom. Jr, Maintaining Biodiversity in Forest Ecosystems, Cambridge University Press, 1999.
11. Townsend Colin. R, John. L. Harper and Michael Begon, Essentials of Ecology, Blackwell Science, 2000.
12. Owen Oliver. S, Daniel. D. Chiras and John. P. Reganold, Natural Resource Conservation, 7th Edition, 1998.
13. Keddy Paul. A, Wetland Ecology – Principles and Conservation, Cambridge University Press, 2000.
14. Botkin Daniel. B and Edward. A. Keller, Environment Science – Earth as a living Planet, John Wiley and Sons, 2005.
15. Nebel Bernard. J. and Richard. T. Wright, Environment Science, Pearson Custom Publishing, 8th Edition, 2003.
16. Alfred J. R.B, A.K.Das and A.K.Sanyal, Ecosystems of India, ZSI, 2001.
17. Puri, G.S., Gupta, R.K., Meher-Homji, V.M., Puri, S., others, 1989. Forest ecology. Volume 2. Plant form, diversity, communities and succession. Oxford & IBH Publishing Co. Pvt. Ltd.
18. Puri, G.S., Meher-Homji, V.M., Gupta, R.K., Puri, S., others, 1983. Forest ecology. Volume I. Phytogeography and forest conservation. Forest ecology. Volume I. Phytogeography and forest conservation.
19. Venkataraman K., 2012. Fauna of Maharashtra Part 1: Vertebrates Zoological Survey of India
20. Sahara V.B. (2001) *Wildlife in India*, Natraj Publishers, Dehra Dun.
21. Enger, E.D., Ross, F.C., Bailey, D.B., 2003. Concepts in biology. McGraw-Hill Science / Engineering/Math.
22. Grimmett R., Inskipp C. and Inskipp T. (2001) *Pocket Guide to the Birds of the Indian Subcontinent*, Oxford University Press, Oxford.
23. Menon, V., 2014. Indian mammals: a field guide. Hachette India.
24. Sharma, B.D., Karthikeyan, S., Singh, N.P., Flora of Maharashtra State. Botanical Survey of India.
25. Miller, G., Spoolman, S., 2007. Environmental Science: Problems, Connections and Solutions. Cengage Learning.

Journals (to be accessed through JGATE)

1. Ecology
2. Conservation Biology

Course No: EST 102

Course Title: Environmental Chemistry

Number of Credits: 4

No. of Lectures-Tutorial: 45-15

Course Coordinator/Instructor: Ms. Archana Kalyani

Course Outline

The course provides a detailed understanding of various aspects of chemistry, with reference to environmental applications and lays the foundation for understanding in specialized areas of environment management and practices.

Learning Outcomes

Student will develop:

- An understanding of the fundamental principles of chemistry that is applicable to various aspects of environment management.
- A deep understanding of analytical techniques and environmental standards.
- Analytical and conceptual skills required for research in the field of environmental chemistry.

Pre-requisite

None

Evaluation Procedure: 0.6/0.4 University

Assignment	2	20%	Internal Assessment
Minor Test	2	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1.	Introduction • General chemistry: classification of elements, theory of valence, gas laws • Basic concepts from quantitative chemistry: buffers, colorimetry-Lamberts law, Beers law, colorimeters, spectrophotometers	6	
2.	Physical chemistry • Oxidation reduction reaction, Electrochemistry (seminars)	6	

	Organic chemistry - Reaction mechanism of selected organic compounds, pharma, alcohol, dye. Biochemistry - Composition cell, biochemistry of proteins, fats and oils, anaerobic biochemistry		
3.	Chemistry of the atmosphere - Basic principles involved in the analysis of various constituents present in the environment - Chemical composition of atmosphere- particles, ions and radicals; formation of particulate matter; photochemical and chemical reactions in the atmosphere; chemistry of greenhouse gases and ozone layer depletion; gaseous transformations in the atmosphere and removal mechanisms; nuclear winter; chemistry of particulate and gaseous pollutants in air, fog and smog formation.	6	
	Assignment 1 Discussion and presentation of selected research paper in groups of two students.		4
4.	Chemistry of the Lithosphere - Chemical composition of lithosphere, water and air in soil; inorganic and organic components in soil - Acid, base and ion-exchange reaction in the soil; soil acidity, salinity and sodicity - Effects of ecological factors on the toxicity of soil	6	
	Minor test 1		2
5.	Chemistry of water - Basic concept of colloidal and quantitative chemistry. Oxidation-reduction reactions and equations; gas laws, equilibrium and Lechatelier's principle, activity and coefficients, variations in equilibrium relationships, shifting chemical equilibrium, amphoteric hydroxides, buffers and buffer index; solubility of salts, complex formation - Water structure and anomalous behaviour of water; concept of dissolved oxygen, biological oxygen demand, chemical oxygen demand - Chemistry involved in water treatment procedures	8	

	like coagulation, disinfection, softening, fluoridation, defluoridation, iron and manganese removal , demineralization, corrosion and its control. • Various chemical constituents present in air and water, standards for quality of air and water.		
	Assignment 2 Seminar presentation by individual students on predecided topics.		5
6.	Composition and characterization of sewage and sewage sludge and gas analysis	3	
7.	Analytical techniques • Neutron Activation Analysis • Atomic Absorption Spectroscopy • Gas Chromatography • Polarography • Ion exchange electrodes • Inductively Coupled Plasma Atomic Emission Spectroscopy • Ion Chromatography • HPLC • Potentiometry • Conductometry - Viscosity	10	
	Minor test 2		2
	Total	45	15

Reference Books

1. Sharma B.K, Industrial Chemistry, Goel Publishing House, 1985.
2. De A. K, Environmental Chemistry, New Age International Limited Publishers, 4th edition, 2000.
3. Ladd Mark, Introduction to Physical Chemistry, CambridgeUniversity Press, 3rd Edition, 1988.
4. Christian Gary, Analytical Chemistry, John Wiley and Sons, 2001.
5. Spiro G and William M. Stigliani, Chemistry of the Environment, Thomas, Hall of India Pvt. Ltd, , 2nd edition, 2002.
6. Solomon's Graham and Craig Fryhle, Organic Chemistry, John Wiley and Sons, 7th edition, 2002.
7. Chang Raymond, Chemistry, McGraw Hill, 5th Edition, 1994.
8. Anil Kumar De, Environmental Chemistry, New Age International Limited Publishers, 5th edition, 2003.

9. Yadav L., Singh J., Srivastava J., Advanced practical's of chemistry (2014) Pragati Prakashan
10. Atkins, P., 2010. Shriver and Atkins' inorganic chemistry. Oxford University Press. (free pdf available at <http://ondobook.com/dl/shriver-and-atkins-inorganic-chemistry-5th-edition-free-download.pdf>)
11. Philip Kuchel, Simon Easterbrook-Smith, Vanessa Gysbers, J. Mitchell Guss, Dale P. Hancock, Jill M. Johnston, Alan Jones, and Jacqui M. Matthews. *Schaum's Outline of Biochemistry, Third Edition*. US: McGraw-Hill, 2011.
12. Khopkar, S.M., 1998. Basic concepts of analytical chemistry. New Age International.

Course No: EST 103

Course Title: Environmental Microbiology

Number of Credits: 4

No. of Lectures-Tutorial: 45-15

Course Coordinator/Instructor: Dr. Bipin Raj

Course Outline

The course provides detail understating of various aspects of microbiology, with reference to environmental applications and lays the foundation for understanding in specialized areas of environment management and practices.

Learning Outcomes

Student will develop:

- An understanding of the fundamental principles of microbiology that is applicable to various aspects of environment management.
- A deep understanding of analytical techniques and applications in pollution control using microbiology.
- Analytical and conceptual skills required for research in the field of environmental microbiology.

Pre-requisite

None

Evaluation Procedure : 0.6/0.4 University

Assignment	2	20%	Internal Assessment
Minor Test	2	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Natural history of microorganisms • Diversity of microbial forms • Mode of living • Microbial classification	2	
2	Population dynamics of micro – organisms • Exponential growth • Logistic growth • Tremostat model • Competition and prey – predator dynamics • Methods of monitoring populations	10	

	- Counting methods - Biomass estimation - Measurement of microbial diversity and productivity - Environmental factors affecting growth relationship of growth rate with nutrient concentration- temperature, pH, salinity and other factors - Extremophiles		
3	Handling micro – organisms - Methods of sterilization - Methods of disinfection - culturing micro organisms - pure culture isolation and maintenance	6	
	Assignment 1 Discussion and presentation of selected research paper in groups of two students.		4
4	Microbiology of water - Microbial analysis of potable and recreational water - Indicator organisms - Domestic, rural and urban treatment of water	6	
	Minor test 1		2
5	Wastewater microbiology - Microbial flora involved in wastewater treatment – aerobic and anaerobic degraders - Micro organism in trickling filters, activated sludge process, oxidation ponds, anaerobic digestion - Use of enrichment culture technique for improvement of biological treatment of waste	8	
6	Solid waste degradation - Composting – types of composting, micro organisms in composting - Vermicomposting	3	
	Assignment 2 Seminar presentation by individual students on predecided topics.		5

7	Other environmental applications of micro organisms • Biogas production • Microbial leaching • Metal removal • Bio fertilizers • Bio control of pests and disease	5	
8	Environmental aspects of infectious disease • Epidemiological investigation • Public health and hygiene • Epidemiological modeling and predictions	5	
	Minor test 2		2
	Total	45	15

Reference books

1. Powar and Dagainawala, General Microbiology Volume – I, Himalaya Publishing House, 2nd Edition, 1986.
2. Powar and Dagainawals, General Microbiology Volume II, Himalaya Publishing House, 8th Edition, 1992.
3. Stanier Roger Y, John, L.Ingraham, Mark. L.Wheelis, Page R. Painter, General Microbiology, Macmillan Press Ltd, 5th edition, 1987
4. Sullia S.B and S. Santharam, General Microbiology (revised), Oxford and IBH Publishing Co. Private Ltd, 1998.
5. Burlage Robert, Ronald Atlas, David Stahl, Gill Geesey, Techniques in Microbial Ecology, OxfordUniversity Press, New York.
6. Pelczar H.J, Jr., E.C.S. Chan, Noel. R. Krieg; Microbiology, Tata Mc.Graw – Hill 5th edition, 2002.
7. Lynch J.M. and J.E. Hobbie, Micro-organism in action – Concepts and Applications in Microbial Ecology, Blackwell Scientific Publications, 1979.
8. Deoray B.M. and A.E. Desai, Concepts in Molecular Biology, NiraliPrakashan, 1999.
9. Singh P. R, Microbiology, Kalyani Publishers, 2004.

Course No: GEO 102

Course Title: Fundamentals of Geoinformatics

Number of Credits: 4

No. of Lectures-Tutorial: 45-15

Course Coordinator/Instructor: Dr. Shamita Kumar

Course Outline

The course provides a firm understanding of the conceptual and technical issues of geospatial technologies and an overview of applications in various aspects of wildlife, natural resource management, environment management, etc. It introduces the students to the fundamentals of geographic information systems, navigation systems, data models, data sources, cartography as well as multi-criteria analysis.

Learning Outcomes

Students will:

- Demonstrate a good understanding of the use of geospatial technologies in various sectors.
- Demonstrate an understanding of building geo-databases.
- Develop abilities to think about and implement geographic data management and analysis for research and a variety of planning and management applications.

Pre-requisite

None

Evaluation Procedure : 0.6/0.4 University

Assignment	2	20%	Internal Assessment
Minor Test	2	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Introduction to GIS • Overall introduction to the concept of geoinformatics and its application	02	
2	Geographic data and data measurement 1. Data types and scales of data measurement, sampling methods Map basics • History of cartography, basic characteristics of maps,	08	

	categories of maps, map scale • Typography and lettering the map, elements of generalization-classification, simplification and exaggeration, symbolization-point, line, area, volume Basic geographic concepts Basic geodesy: Spherical, ellipsoidal and geoidal earth, geographical co-ordinates, Co-ordinate systems: Plane co-ordinate system, Geographic co-ordinate system • Map projections: Scale factor and transformation, distortions resulting from map transformations, properties of map projections, classification of map projections, aspects of map projections, some commonly used projections, selection of a particular projection, geo-referencing, relationship between co-ordinate systems and map projections • Geodetic datum-concept and types • Nature of geographic phenomena and measurement of geographical variables		
3	Data Models, data structures and data input • GIS data models: Raster data models-nature, characteristics of raster data, principles of raster data compression • GIS data models: Vector and raster data models-nature, characteristics • Concept of topology, topological relationships between spatial objects • Data input (raster and vector), metadata, data sources for GIS, input of methods of data input, digitization, error identification, types and sources of errors, correction, data editing, topology building.	08	
	Assignment 1 Discussion and presentation of selected research paper in groups of two students.		4
4	Satellite Navigation Systems (SNS) • Global positioning systems: introduction, GPS segments, GPS satellite generations, current GPS satellite constellation working principle • GPS working principle, GPS signal structure, types of GPS receivers, pseudorange measurements, carrier phase measurements, cycle slips	06	

	• SNS erros and biases • Methods of SNS observations • SNS applications		
	Minor test 1		2
4.	Database Management • Introduction to database and database management systems, importance of databases in GIS • Database structures • Database data models: Hierarchical model, network model, relational database model, object oriented data model • Database creation, linking spatial and attribute data, GIS database applications	04	
	Assignment 2 Seminar presentation by individual students on predecided topics.		5
5.	Data analysis • Measurements • Queries • Buffering and neighbourhood functions • Map overlay • Spatial analysis • Multicriteria analysis • Network Analysis	15	
6.	Application of Geoinformatics • Applications in forestry and wildlife management • Applications in mining • Applications in urban planning • Applications in disaster management • Applications in health studies • Business applications	06	
7.	GIS project design and management • Introduction to GIS project design and management • Problem identification, designing a data model, project	04	

	management, project design including data sources, image analysis, GIS operations, spatial analysis, time management and implementation problems.		
	Minor test 2		
	Total	45	15

Suggested Readings

1. Burrough P. A., R. A MacDonneli, Principles of Geographical Information Systems, Oxford University Press, 2000.
2. Lo. C. P., A.W. Yeung, Concepts and Techniques of Geographical Information Systems, Prentice- Hall of India Pr. Ltd., 2002.
3. Heywood I., S. Cornelius, S. Carrer, An Introduction to Geographical Information Systems, Pearson Education Pvt. Ltd, 2002.
4. Kang-stung-Chang, Introduction to Geographical Information System, Tata McGraw Hill Pub. Comp, 2002.
5. Demers M.N, Fundamentals of Geographic Information Systems, John Wiley & Sons, 2000.
6. Roy P.S., Dwivedi R.S., Vijayan D., 2010 Remote Sensing Applications National Remote Sensing Centre, India
7. Reddy, M.A., 2008. Textbook of remote sensing and geographical information systems. BS publications.
8. El-Rabbany, A., 2002. Introduction to GPS: the global positioning system. Artech House.
9. Arthur Robinson, H., 1958. Elements of cartography, John Wiley and Sons Inc.

Course No.: SD 101

Course Title: Fundamentals of sustainable development

Number of Credits: 4

No. of Lectures-Tutorial-Assignment: 42:8:10

Course Coordinator: Dr. Shamita Kumar with inputs from Dr. Kranti Yardi, Mr. Shivam Trivedi

Course Outline

The course aims to build the students' understanding of the concepts of sustainable development in all its dimensions, i.e. social, economic and environment to help correlate these factors to development and understand the need for sustainable development. It also explores the role of education for sustainable development from just awareness creation to the need for more action and implementation. The course provides insights into integrating sustainability in development issues.

Learning Outcomes

Students will:

- Develop a good understanding of the basics of sustainable development.
- Demonstrate an understanding of challenges in sustainable development.
- Understand the role of education for sustainable development.
- Develop skills in systems thinking.

Additional courseware

Students are encouraged to register for the following free online course:

<https://www.coursera.org/learn/sustainable-development>

Evaluation Procedure : 0.6/0.4 University

Assignment	2	20%	Internal Assessment
Minor Test	2	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

Sr. No.	Topic	Time (Hours)	
		L	T
1.	Basic concepts of sustainable development • Understanding 'sustainability' and 'development'; different world views; the economic growth/GDP perspective. • Agenda 21 and sustainable development; Sustainable development goals • Linkages between economic growth and quality of life;	6	

	Causes and effects of unsustainable development-consumerism, globalization, urbanization, ecosystem degradation, war, terrorism, disasters, inequity • Pillars of sustainable development-economic, social, environmental, political (governance) • Timeline of sustainable development; Millennium development goals and sustainable development goals • The need for sustainable development across sectors		
2.	Challenges of Sustainable Development • Rapid population growth • Food security • Income inequality • Increasing urbanization; Energy transformation • Gaps in development-access to long term financing • Climate change • Environmental degradation • Increasing cultural differences • Globalization • Increasing gender disparity • Religious revival	8	
3.	Tools for achieving sustainable development • Inclusive development strategies • Technology innovation • Sustainable cities • Food and nutrition security • Energy transformation • Environmental policies and regulations • Financing sustainable development • Public private partnership • Sustainable consumption	12	
	Assignment 1 Presentation by students on a specified topic		4
	Assignment 2 Students will be allotted group work to be followed by discussions facilitated by the teacher		4
	Minor test 1		2

4.	Introduction to ESD - History of Environment Education ,Indian Perspective - Emergence of the concepts of ESD - Inter linkages of ESD and sustainable development - ESD and Sustainability-multidisciplinary approach.	2	
5.	ESD and Social Learning - Introduction to social learning and how people learn - Transformative learning and change - Critical realism and learning - Indigenous knowledge - Traditional practices and sustainability	4	
6.	Systems thinking and Institutional approach - Introduction to systems thinking - Systems landscape - Whole institutional approach - Greening Curriculum –gap analysis	5	
7.	Leadership and Stakeholder Management - Introduction and importance of leadership for ESD - Leadership styles - Cooperation and stakeholders management - Negotiation in the context of ESD and negotiation styles ,next best alternative	6	
	Assignment 2 Seminar presentation by individual students on predecided topics.		5
8.	Change management Introduction to change management, the cycle of change and learning, resistance, reflection and withdrawal, risk assessment and management for a project cycle, roles and skills of change agents	6	
9.	Sustainability Research Project The student will take up research project in the beginning of the course and work on the concept and implementation strategies. The project selected should address sustainability and implementation in the selected		4

	location should ensure that even after the withdrawal the project is sustainable .Students will implement the project during the course and they can be simple action oriented sustainable projects that are doable in the given stipulated time .		
	Minor test 2		2
	Total	42	18

Reference books

1. An Introduction to Sustainable Development-Peter P. Rogers, Kazi F. Jalal, and John A. Boyd
2. Understanding Sustainable Development-John Belwitt
3. Limits to Growth – The 30 year update by Donella Meadows, Dennis Meadows, Jorgen Randers
4. Cradle to Cradle Remaking the Way We Make Things by William McDonough and Michael Braungart North Point Press
5. Our Common Future -World Commission on Environment and Development Oxford Paperbacks
6. Education for Sustainable Development: Nature, School and Democracy Illustrated Paperback-by KlasSandell,JohanOhman and Leif Ostman
7. Sustainable Education: Revisioning Learning and Change (Schumacher Briefings) [Paperback] by David ORR and S.R.Sterling
8. Thinking in Systems: A Primer [Paperback] DonellaH.Meadows

Suggested Readings

1. Small is Beautiful- Economics as if people mattered by EF Schumacher
2. At the edge –Ann Dale UBC press
3. Collapse – How societies choose to fail or succeed by Jared Diamond Penguin publishers
4. Development as Freedom – AmartyaSen –Publisher Anchor
5. Resilience Thinking-Sustaining ecosystems and people in a changing world by Brain Walker and David Salt
6. Leadership for Sustainability –an action approach by Judi Marshall, Gill Coleman and Peter Reason

Journals

1. International Journal for Sustainable Development

Course No: EST 111

Course Title: Field techniques I

Number of Credits: 2

Course Coordinator/Instructor: Dr. Kranti Yardi

Course Outline

The course provides hand on expertise in identifying flora and fauna as well as in depth understanding of ecosystem structure and function through a combination of field visits and lab work.

Learning Outcomes

Students will:

- Develop skills in identifying birds, mammals and major plant species
- Develop an ability to analyze structure of ecosystems.
- Acquire competence in design and implementation of sampling techniques.

Pre-requisite

None

Evaluation Procedure : 0.6/0.4 University

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed Journal submitted timely (within 7 days): 5 marks	Internal Assessment
Major exam	60%		University Assessment

Details of course content

1. Sampling techniques for vegetation analysis using quadrats.
2. Sampling techniques for vegetation analysis using line and belt transects.
- 3A. Identification of birds
- 3B. Identification of birds
4. Identification of bird calls (30 calls)
5. Identification of insects (atleast30)
- 6A. Identification of plants -visual identification (atleast50)
- 6B. Identification of plants –visual identification
7. Study of identification of non-chordates and Chordates (20 specimens from

different Phyla)

8. Study of planktons.
9. Preparation for field work (Use of google earth and other sources for gathering information, planning methods)
10. Methods for assessment and evaluation of ecosystems (frequency, abundance, density, GBH, canopy cover and diversity index)
11. Field work in forest ecosystem – field work in Mulshi(assessment and evaluation)
12. Field work in grassland ecosystem – field work in Supe (assessment and evaluation)
13. Field work in wetland ecosystem – field work in Bhigwan(assessment and evaluation)

Course No: EST 112

Course Title: Lab Analytical Techniques I

Number of Credits: 2

Course Coordinator/Instructor: Ms. Pradnya Kelkar

Course Outline

The course provides sound understanding of lab analytical techniques in environmental chemistry and microbiology and sets the foundation for application of these techniques in projects as well as further research.

Learning Outcomes

- Proficiency in use of analytical instruments.
- Ability to analyze samples using specific techniques
- Competency in interpretation of results.

Pre-requisite

None

Evaluation Procedure : 0.6/0.4 University

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed Journal submitted timely (within 7 days): 5 marks	Internal Assessment
Major exam	20%		University Assessment

Details of course content

1. Study the heat of solution of CaCl_2 and to determine the rate of corrosion.
2. Study the water quality parameters such as dissolved oxygen, hardness, conductivity.
3. Determination of Chemical Oxygen Demand of water.
4. Determination of iron from soil and water.
5. Determination of manganese from water.
6. Determination of nitrate from water.
7. Determination of cobalt by colorimetric method.
8. Study of composition and characterization of sewage and sludge.

9. Study the morphology of the organisms by monochrome/negative/gram staining.
10. Study of preparation of nutrient agar and study its composition.
11. Enumeration of coliform bacteria in water by Most Probable Number (MPN) method.
12. Study of isolation of bacteria by Streak plate/Spread Plate/ Pour Plate method.
13. Determination of bioload of microbial flora of air.
14. Study of soil flora.
15. Epidemiological survey of different parts of Pune city

Course No: GEO 112

Course Title: Techniques in GIS and GPS

Number of Credits: 2

Course Coordinator/Instructor: Dr. Shamita Kumar

Course Outline

The course provides hand on expertise with use of open source as well as commercial GIS software through a series of well designed practical's related to cartography, building geo databases, querying data, use of GPS and multicriteria analysis.

Learning Outcomes

- Proficiency in use of open source and commercial software for basic GIS operations.
- Ability to use GPS for data collection.
- Ability to build basic geo databases.
- Competence in querying and making GIS analysis.

Pre-requisite

None

Evaluation Procedure : 0.6/0.4 University

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed Journal submitted timely (within 7 days): 5 marks	Internal Assessment
Major exam	20%		University Assessment

Details of course content

1. Introduction to ArcGIS tools
2. Introduction to QGIS (Assignment-self study with discussion)
3. Digital cartography
4. Defining co-ordinate systems and projecting data sets
5. Map registration
6. On screen digitization (Assignment using QGIS)
7. Error identification, rectification
8. Working with tables (Assignment using QGIS)

9. Using the analysis tools in ArcGIS (Assignment using QGIS)
10. Use of GPS and input of GPS data
11. Introduction to Google Earth
12. Data query in ArcGIS (Assignment using QGIS)
13. Performing multicriteria analysis

Course No: EST 104

Course Title: Statistical Methods

Number of Credits: 4

No. of Lectures-Tutorial-Practical: 32-3-22

Course Coordinator/Instructor: Dr. Rahul Mungikar

Course Outline

The course has been designed to help biologists/environmental scientists answer questions of applications of statistics in their field of work. The course focuses on techniques for generating informative data, extraction information from data and to analyze data to get meaningful interpretations.

Learning Outcomes

After the course the student will be able to:

- Apply the appropriate technique for extraction of information from data
- Analyze data using appropriate statistical techniques and software

Pre-requisite

Students are encouraged to join and complete the free online course offered by Harvard University at : <https://www.coursera.org/learn/basic-statistics#syllabus>

Evaluation Procedure : Continuous assessment

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed home assignment submitted timely (within 7 days): 5 marks	Practicals must be in the prescribed journal format	Internal Assessment
Major exam	60%	Theory cum practical examination		Internal Assessment

Details of course content and allotted time

Unit	Topic	Time (Hours)		
		Lectures	T	P
1	Data in Ecology and Environment Sciences	4		

	• Samples and populations • Accuracy and precision • Variables • Derived variables • Frequency distribution • Types of sampling Statistical techniques • Data collection • Organization of data • Representation of data – tabular and graphic			
2	Basic elements and tools of statistical analysis • Measures of central tendency – arithmetic mean, geometric mean, harmonic mean, mode, median • Measures of dispersion – Standard deviation, • Coefficient of variation	2		
3.	Practical 1: Tabulation and graphical representation of the data, estimation of mean, mode, median of different data types using statistical formulae and by graphs			2
4.	Practical 2: Calculation of Standard deviation, coefficient of variation of different data types by different methods.			2
5.	Correlation of measurement • Estimated correlation coefficient • Significance tests for correlation coefficients	2		
6.	Practical 3: Correlation Coefficient and test of significance			2
7.	Concepts of probability • Basic laws – Examples from Ecology – Discrete probability distribution – expectation and variance	2		
8.	Practical 4: Calculation of Simple probabilities, Expected Probabilities & Variance, Binomial probability distribution			2
9.	Distribution • Binomial distribution	5		

	• Normal distribution • Poisson distribution • t – test • Chi square test			
10.	Practical 5: Problems based on Poisson and Normal probability distribution			2
11.	Non Parametric • Non parametric tests (Mann-Whitney, Kruskal Wallace, Wilcoxin signed ranks, Spearman etc.)	1		
12.	Contingency tables and χ^2 • Contingency tables • Special case of a table with only two rows • Special case of 2 X 2 tables, exact test for 2 X 2 tables	2		
14.	Practical 6: Problems based on t-test analysis and Chi-square test			2
15.	χ^2- test of goodness – of – fit and homogeneity • Testing the fit of a whole frequency distribution data • Test of homogeneity • Small samples for normal distribution • Binomial and Poisson distribution • Additive property of χ^2 • Normal approximation	3		
16.	Practical 7: Problem based on Test of goodness of fit			2
17.	Practical 8: Introduction to SPSS/R for calculation of various test of statistics			2
19.	Comparison of means • t-test, ANOVA	2		
20	Practical 9: Problems based on ANNOVA – One way, Two way			2

21.	Regression analysis • Regression coefficient • Standard errors and significance tests	4		
22.	Practical 10: Problems based on Regression analysis			2
23.	Introductory Multivariate Statistics and Partial correlation	5		
24.	Practical 11: Problems based on Regression coefficient, standard errors			2
	Final Assessment		3	
	Total	32		22

Suggested Readings

1. Clark, J. S. Models for Ecological Data: An Introduction. Princeton University Press Princeton, New Jersey, USA, 2007.
2. Legendre, P., and L. Legendre. Numerical Ecology. Vol. 20. Elsevier, 2012.
3. Ott, L., and M. Longnecker. An Introduction to Statistical Methods and Data Analysis. Duxbury press, 2010.
4. Sokal, R.R. and Rohlf, F.J. 1995. Biometry: the principles and practice of statistics in biological research. 3rd edition. New York.
5. Zar J.H. 1999. Biostatistical Analysis. Prentice Hall, New Jersey, 663 pp.

Course No: EST 105

Course Title: Fundamentals of computing and database

Number of Credits: 4

No. of Lectures-Tutorial-Practical: 26-10-24

Course Coordinator/Instructor: Mr. AnandShinde

Course Outline

The course will introduce basic software programming and use of database software. It focuses on the fundamentals of computer science, database systems, programming languages, data types, etc.

Learning Outcomes

At the end of the course the student will:

- Have a understanding of databases and building databases
- Ability to write simple programs

Pre-requisite

Students are strongly encouraged to complete the following free online courses:

<http://www.studytonight.com/dbms/>

<https://www.learnstreet.com/lessons/study/javascript>

http://www.w3schools.com/js/js_intro.asp

Evaluation Procedure :Continuous

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed home assignment submitted timely (within 7 days): 5 marks	Practicals must be in the prescribed journal format	Internal Assessment
Major exam	60%	Theory cum practical examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	T	P
1	Hardware and Software	2		

	• Memory management and File associations • Computer languages • Overall functioning of operating system and other application software's			
2	Problem Solving techniques • Algorithms • Flowcharts	6		
	Practical 1 : Preparing flowcharts and algorithm based on specific problems			2
3	Database fundamentals • Properties of a database • Database models and objects • Components of DBMS, DBMS Functions • Advantages and disadvantages of DBMS • Data types • Introduction to Fields, Tables, Database, Understanding forms and its controls	6		
	Practical 2: Creating Database (table, records, fields and data types). Data sorting, Data filtration, pivot table, graphs and reports			2
	Practical 3: Create module and reports using tables			2
4	Relational Database Components • Logical/Physical database design components • Form based database queries – creating queries • Introduction to SQL – Data Query Language • Designing tables and constraints	6		
	Practical 4: Create database schema, append data, update data and schema, delete data and structure. Assigning constraints to table			2
5	Programming using macros in excel • Introduction to macro programming • Macros with worksheet, forms and controls	4		
	Practical 5: Developing and testing macros in VBE. Excel macro recorder			2

	Practical 6: Working with statements, functions, variables, events			2
	Practical 7: Working with forms, controls and events			2
6	Introduction to programming • Introduction to Javascript programming • Understanding structure of JavaScript code • Understanding types and objects • Control statements and functions • Understanding Object-Oriented Features, Class and Objects, Data Hiding and Encapsulation, Structures, Data members and Member functions. • Data Members and Member Functions, Constructors & Destructors, Roles and types of Constructors, Roles of Destructors	10		
	Practical 8: Study of javascriptstructure, types and objects			2
	Practical 9: Study of data members , functions, controls statements, Operators			2
	Practical 10: Study of object oriented concepts			2
	Major Test 3		2	
	Total	34	6	20

Suggested Readings

1. Microsoft Excel 2010, 1 edition. ed, 2010. . Microsoft Press, Redmond, Wash.
2. Hunt Roger, Computer and Commonsenses, Prentice Hall of India, New Delhi, 1995.
3. OkaMilind M, Computer Fundamentals, Everest Publishing House, Pune, 2001.
4. Rajaraman V, Fundamentals of Computers, Prentice Hall of India Pvt.Ltd, New Delhi, 2000.
5. Jain V. K, Basic Computer Programming, PustakMahal, 1992.
6. Sinha Pradeep and Priti Sinha, Computer Fundamentals, BPB Publications, 2006.
7. Groff James and Paul Weinberg, The Complete Reference, Tata McGraw Hill Edition, 2003.
8. Paul Wilton & Jeremy McPeak, Beginning JavaScript (4th Edition), Wrox Press

9. David Flanagan, JavaScript - The Definitive Guide (6th Edition), O'Reilly
10. Roger Hunt & John Shelley, Computer and Commonsenses, Prentice Hall of India Pvt. Ltd
11. Dr.Milind M. Oka, Computer Fundamentals, Prentice Hall of India Pvt.Ltd.
12. Paul Wilton Johncolby, Beginning SQL, 2005, Wiley Publishing Inc. India Pvt Ltd.
13. James R. Groff and Paul N, Weinbery, The Complet Reference SQL,2002, Tata McGraw Hill New Delhi
14. Sumathi, S., 2008. Fundamentals of Relational Database Management Systems. Springer.

SEMESTER II

Course No: EST 201

Course Title: Biodiversity Assessment and Conservation

Number of Credits: 4

No. of Lectures-Assignments-Tutorial/Examination: 45-20-03

Course Coordinator: Dr. Kranti Yardi

Course Outline

The course focuses on the essential concepts and skills related to biodiversity conservation and assessment. This includes understanding threats to biodiversity, assessing biodiversity at various levels, concepts of landscape ecology and habitat management. It elucidates the perspectives of science and management of biodiversity in the context of current and future strategies needed for biodiversity conservation.

Learning Outcomes

Students will :

- Develop a deep understanding of the threats to biodiversity
- Develop skills of assessing biodiversity with different methodologies
- Develop a comprehensive understanding of issues in planning conservation areas and managing habitats.
- Acquire the ability to construct a conservation action plan for a species or site

Pre-requisite

EST 101

Evaluation Procedure : 0.6/0.4 University

Assignment	2	20%	Internal Assessment
Minor Test	3	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	A	T/E
1	Overview of biodiversity • Status of biodiversity • Biodiversity at regional and landscape levels • Biodiversity at ecosystem, community and population levels	05		
2	Threats to biodiversity			

	• Loss of biodiversity – past rates of extinction, human caused extinctions, extinction rates on islands, island biogeography and extinction rates, case studies • Vulnerability to extinction – Endemic species, case studies • Habitat destruction, fragmentation and degradation • Exotic species introductions and disease • Problems of small populations – loss of genetic variability, demographic variation, environmental variations	06		
3	Assessment of biodiversity • Types of sampling – Qualitative and quantitative assessment techniques for mammals, birds, butterflies, plants. • Estimation of density, frequency and abundance of the species • Indices associated with species diversity, species similarity, temporal and spatial rate of change in species population • Alpha, Beta and Gamma diversity • Statistical approach to assessment of biodiversity • Software for biodiversity assessment	12		
	Minor Test 1			01
4	Planning Conservation Areas • Criteria for conservation – Conservation status, generalists and specialists; population size, sex and age classes, species restricted in distribution, isolated populations, habitat specialists and habitat obligates, species under illegal trade; key ecological functions of species; utility of the species • Approaches to conservation – species approach (featured species), management indicator species, species guild approach, flagship species approach, keystone species, ecosystem approach • Tools used for conservation – Population assessments, Gap analysis, habitat evaluation, GIS • Design criteria – habitat constituents, reserve design, reserve shape and size, population size, need for buffers, wildlife corridors, landscape connectivity, administrative, political and economic considerations	12		

	Assignment 1 and 2: Field work in National Park followed by presentation		20	
5	Habitat Management • <i>Insitu</i> management – categories of biotic factors and their pressures- livestock grazing, fire wood collection, non wood forest produce collection, fires, encroachments, mining and quarrying, weeds and weed infestations (Invasive species), large scale monocultures, soil erosion, timber smuggling, poaching, development activities that are insensitive to ecological integrity, vandalism, unregulated tourism; • Eco-restoration- habitat restoration techniques and monitoring • Wildlife management plans.	10		
	Minor test 2			01
	Total	45	20	03

Suggested Readings

1. Alexander, M. Management Planning for Nature Conservation: a Theoretical Basis & Practical Guide. Springer, 2008.
2. Groves, C. Drafting a Conservation Blueprint: a Practitioner's Guide to Planning for Biodiversity. Island Press, 2003.
3. Margules, C., S. Sarkar, and C. R. Margules. Systematic Conservation Planning. Cambridge University Press, 2007.
4. McNeely, J. A. Expanding Partnerships in Conservation. Island press, 1995.
5. Postel, S. et al. Nature's Services: Societal Dependence on Natural Ecosystems. Island Press, 1997.
6. Smith, D. S., and P. C. Hellmund. Ecology of Greenways: Design and Function of Linear Conservation Areas. University of Minnesota Press, 1993.
7. Sutherland, W. J. Conservation Science and Action. Blackwell Science Ltd, 1998.
8. Sutherland, W. J., and D. A. Hill. Managing Habitats for Conservation. Cambridge University Press, 1995.
9. Sutherland, W. J., I. Newton, and R. E. Green. Bird Ecology and Conservation: a Handbook of Techniques. Oxford University Press, USA, 2004.

Course No: EST 202

Course Title: Engineered Systems for water and waste water

Number of Credits: 4

No. of Lectures-Tutorial: 45-10-03

Course Coordinator: Ms. Nayna Chavan / Dr. Milind Gidde

Course Outline

The course focuses on the essential concepts and skills related to water and waste water assessment. This includes understanding of various technique involved in treating of water and waste water.

Learning Outcomes

At the end of the course students will develop:

- Basic understanding of the concepts involved in water and waste water management
- Understanding of design parameters in various units of water and waste water treatment.
- Comprehensive understanding of issues water and waste water management.
- Ability to read and make basic engineering drawings.

Pre-requisite

EST 102, EST 103

Evaluation Procedure : 0.6/0.4 University

Assignment	2	20%	Internal Assessment
Minor Test	2	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	A	T/E
1	Introduction • Water availability, water distribution, Sources of water supply, general considerations for water supply schemes • Water usage, water demand from various sectors of society • Methods for population forecasting: Arithmetic,	5		

	geometric, Incremental, graphical methods			
2	Water treatment - Objectives; Physical, chemical and biological properties of water drinking water; Quality standards - Aeration: Theory of gas transfer, Henry's law, factors affecting aeration; Types of aeration systems: Cascade, spray, tray tower, diffused aeration - Sedimentation: Theory of plain sedimentation, Stokes law; Types of sedimentation tank; design considerations -design of circular and rectangular sedimentation tank - Coagulation and flocculation: Objectives, types of coagulants and flocculants; Advantages and disadvantages of aluminum and ferrous coagulants, chemical dosing, jar test; Design - Filtration: Objectives, mechanism, types of filters(Gravity, pressure, high rate, low rate, sand filter, dual media filter etc); Components of filter: Enclosure tank, Filtering media, under drainage system; Process of filtration, backwashing, Comparative study of slow and rapid sand filters; Design of rapid sand filter - Disinfection: Necessary, theory of disinfection, Minor methods of disinfection: boiling, excess lime treatment, ozonation, silver treatment, UV treatment - Chlorination: mechanisms of chlorination, application of chlorine, Methods of chlorination: plain chlorination, pre and post chlorination, break point chlorination, super chlorination, dechlorination, advantages and disadvantages - Softening: Purpose, removal of temporary and permanent hardness, lime soda process, zeolite process, Demineralization, Desalination - Miscellaneous methods: Taste, colour and odour removal methods - Aeration, activated carbon method, iron and manganese removal, fluoridation and defluoridation	16		

	Minor test 1			01
	Assignment 1: Discussion and presentation of selected research paper in groups of three students.		05	
3	Wastewater treatment • Wastewater engineering: Terminology, Necessity, collection and conveyance of wastewater , Flow rates, flow measurement devices • Classification of treatment processes: Physical, chemical and biological processes, primary, secondary, tertiary treatment, advanced waste water treatment • Unit operations and unit processes for wastewater treatment: Screening, objectives, types of screens, disposal of screenings, design of screen chamber • Grit chamber: Purpose, functioning, design of grit chamber • Sedimentation tank: Purpose, mechanism, Types of sedimentation tanks, design of primary sedimentation tank • Oil and grease removal: skimming method, vacuum floatation • Secondary Treatment (Biological treatments): Purpose, theory, classification of the processes, attached growth and suspended growth processes, comparison of biological processes • Activated sludge process: Conventional process and modifications, oxygen requirement aeration systems, Trickling filters, components, mechanism principle and working of rotating biological contractor • Low cost treatment processes and design criteria: Septic tanks, ponds and lagoons, design of pond and lagoon, root zone technology • Natural methods of wastewater disposal: Self-purification of streams, disposal by dilution, disposal by land treatment, dilution into sea, standards for land disposal, for irrigation, effluent	16		

	and stream standards			
	Assignment 2: Discussion and presentation of selected research paper in groups of three students.		05	
4	Sludge treatment and disposal - Objectives, Sludge thickening (Gravity thickening, Air flotation, Centrifugation), - Sludge digestion (anaerobic digestion, Types of digester), Sludge conditioning, sludge dewatering (Sludge drying bed, vacuum filtration) - Disposal methods for sludge.	08		
	Minor test 2			01
	Total	45	10	03

Reference Books

1. Metcalf and Eddy, Wastewater engineering treatment and reuse, Tata Mc-Grawhill Publishing Company Ltd, 4th edition, 2003.
2. Trivedi R.K and P.K.Goel, Chemical and biological methods for water pollution studies, Environmental Publications,1986.
3. Cormack D, Response to oil and chemical pollution, Applied science Publishers,1983.
4. Mathur R, Asha Mathur and Sanjay Sharma, Latest advances in environmental conservation, Scientific Publishers, 1998.
5. Shukla S.K and P.K.Shrivastav, Waste management and control, Common Wealth Publishers, 1992
6. Bhatiya S.C, Hand book of industrial pollution and control. Volume I and II , CBS Publishers & Distributers, 2002.
7. Noyer Robert, Unit operations in environment engineering, JAICO publishing House, 2005.
8. Upadhyay, Rai and Mishra, Recent advances in waste management, BIS publication.
9. Abbasi S.A. and E.Ramasami, Biotechnical methods of pollution control, Universities Press, 1999.
10. B.S.N Raju, Water supply and waste water engineering, Tata Mc Graw Hill Publishing Company Ltd, 1995.
11. Kshirsagar S.R, Water supply engineering, Roorkee Publishing House, 1966.

12. Pandey G.N and G.C. Carney, Environmental engineering , Tata Mc Graw Hill Publishing Company Ltd, 1994.
13. Metcalf and Eddy, Wastewater engineering: Treatment, disposal and reuse, Tata Mc Graw Hill Publishing Company Ltd, 3rd edition, 1991.
14. Rangawala S.C., Water supply and sanitary engineering Charotar Publishing House, 2005.
15. Gaikwad, R.S. Sapkal Environmental Engineering Denett & Co. 2006.
16. Punmia B.C. and Ashok Jain, Wastewater engineering, Laxmi Publications, 2005.
17. Sawyer, McCarty and Parkin, Chemistry for environment Forth edition, Tata Mc Graw Hill Publishing Company Ltd, 1994.
18. Paevy , Rowe and Tschobanoglous, Environmental Engineering , Tata Mc Graw Hill Publishing Company Ltd, 1995.
19. Sharma B.K, Environmental Chemistry, Goel Publishing House, 2004.

Course No: EST 203

Course Title: Solid and hazardous waste management

Number of Credits: 4

No. of Lectures-Assignment-Tutorial/Examination: 45-10-03

Course Coordinator: Ms. Anushka Kajbaje

Course Outline

This course builds a deep understanding of technical and social issues involved solid and hazardous waste management alongwith highlighting best practices and strategies that meet the public health and environmental concerns. It also focuses on financial and legal aspects of solid waste management through the evaluation of appropriate case studies.

Learning Outcomes

Students will develop:

- A deep understanding of the fundamental principles of solid waste management.
- Build capacity to evaluate the environmental, financial and legal concerns of solid waste management.
- Acquire skills to facilitate establishment of effective management system for solid waste.

Evaluation Procedure: 0.6/0.4 University

Assignment	2	20%	Internal Assessment
Minor Test	2	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

Unit	Topic	Time (Hours)		
		L	T	P
1	Introduction to Solid Waste • Sources, quantities and composition of solid wastes; Physical characteristics (specific weight, moisture content, particle size and distribution, field capacity) Chemical characteristics (proximate analysis (volatile combustible matter, fixed carbon, ash), fusing point, ultimate analysis, energy content) and Biological characteristics (biodegradability of organic waste component, odour production)	4		

	Causes of generation of solid waste, consumerism and consumption patterns, health and environmental impacts of improper handling of solid waste, social aspects related to solid waste management			
2	Waste generation, collection, storage and transport Waste stream assessment, collection components, storage (containers, storage bins, collection vehicles), collection operation (movement of collection crew, collection vehicle routing) transfer station (types, capacity, viability).	04		
3	Source reduction and recycling - Purpose, implementation, monitoring, evaluation, - Significance of recycling, planning for recycling programme - Recycling programme elements: source separation, drop-off/buy-back, curbside programmes, storage and collection of recyclables, processing equipment's for recycling, Material recovery facilities (MRFs) - Commonly recycled materials and processes: paper and cardboard, glass, metals, plastics, batteries and tyres.	06		
	Assignment 1: Discussion and presentation of selected research paper in groups of three students.		05	
4	Composting and Biogasification Theory of composting, types of composting, factors governing composting, design of mechanical composting plant Biogasification: anaerobic processing, types of digesters, biogas plants in India	5		
	Minor Test 1			01
5	Incineration and energy recovery Combustion of waste material, incineration objectives, planning an incineration facility, types of incinerators, energy recovery, air emission and its control (gaseous pollutants, gas cleaning	5		

	equipment's), pyrolysis and its products, environmental concerns.			
6	Sanitary Landfill • Principle, landfill processes, methods of landfilling, • Landfill gas generation: Composition and properties, hazards, migration, control • Leachate formation: Composition and properties, leachate migration, control and treatment • Environmental effects of landfill • Landfill operation issues: Design and construction, operation, monitoring	6		
	Assignment 2: Submission of 2-3 page paper on pre decided topics (individual assignments)		05	
7	Integrated solid waste management (ISWM) • Characteristics of ISWM, planning for ISWM, implementation and benefits of ISWM, waste management modelling, Life Cycle Assessment (LCA); benefits, phases and stages of LCA • Cost economics of solid waste management	5		
8	Management and Treatment of Hazardous waste • Identification and classification of hazardous waste, hazardous waste management: generation, storage and collection, transfer and transport, processing, disposal. • Hazardous waste treatment: physical and chemical treatment, thermal treatment, and biological treatment • Hazardous waste management in India	5		
9	E- Waste management Inventory management, production process modification, volume reduction, recovery and reuse, sustainable product design, responsibilities of government, industries, citizens	3		
	Minor Test 2			01
	Total	45	10	03

Reference Books

1. Noyes Robert, Unit Operations in Environmental Engineering, Jaico Publishing House, 2005.
2. Rao C.S, Environmental Pollution Control Engineering, New Age International (P) Ltd, 1991.
3. Trivedi P. R and Gurdeep Raj, Solid Waste Pollution;, Akashdeep Publishing House.
4. Agrawal K.C, Environmental Pollution – Causes, effects and control, Nidhi Publishers, 2001.
5. Sinha Rajiv K and Sunil Heart; Industrial Wastes – Health impacts and management plans, Pointer Publishers, 2004.
6. Lund Herbert F, The McGraw – Hill Recycling Handbook, McGraw- Hill Inc., 1993.
7. Frank Kreith, Handbook of Solid Waste Management, McGraw-Hill, Inc.
8. Pandey G.N and G.C. Carney, Environmental engineering, Tata McGraw- Hill Publishing company.
9. Dhamija Urvashi, Sustainable Solid waste Management – Issues, policies and structures, Academic Foundation, 2006.
10. Modak Prasad, Waste Minimization – A Practical Guide to Cleaner Production and Enhanced Profitability, Centre for Environment Education.
11. Nazaroff William W and Lisa Alvarez Cohen, Environmental Engineering Science, John Wiley & Sons Inc, 2001.
12. Nathanson Jerry A, Basic Environmental Technologies - Water supply, waste management and pollution control; Prentice Hall Inc., 4th edition, 2003.
13. Lal Banwari and M .P Reddy, Wealth from waste, TERI, 2nd edition, 2005.
14. Bhatia S. C, Handbook of Industrial Pollution and Control, Volume 1, CBS Publishers & Distributors.
15. Bhatia S. C, Handbook of Industrial Pollution and Control, Volume 2, CBS Publishers & Distributors.
16. Hosetti B. B, Prospects and Perspectives of Solid Waste Management, New Age International Publishers, 2006.
17. Mhaskar A. K, Matter Hazardous, Enviro Media Publications.
18. Plastics for Environment & Sustainable Development; Indian Centre for Plastics in the Environment, Central Institute of Plastics Engineering and Technology.
19. Ramchandra T.V, Management of Municipal Solid Waste, Capital Publishing Company, 2006.

Course No: EST 204

Course Title: Air and Noise Pollution Management

Number of Credits: 4

No. of Lectures-Tutorial: 45-10-03

Course Coordinator: Ms. Archana Kalyani

Course Outline

The course focuses on the essential concepts and skills related to air and noise assessment. This includes understanding of various techniques involved in assessing air and noise as well as techniques for their control.

Learning Outcomes

At the end of the course, students should have:

- Basic understanding of the concepts involved in air and noise management
- Understanding of various assessment mechanisms of air and noise.
- Develop skills in management of air and noise pollution.

Evaluation Procedure : 0.6/0.4 University

Assignment	2	20%	Internal Assessment
Minor Test	2	20%	Internal Assessment
Major Exam	1	60%	University Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	A	T/E
1	Introduction • Origin of the atmosphere, Structure, upper and lower atmosphere, temperature & pressure profile , chemistry of atmosphere, significance of troposphere, stratosphere, mesosphere, and thermosphere • Definition of pollution, difference between pollutant and contaminant, composition of air, history of air pollution, • Types of pollutants: Particulate matter, gaseous pollutants, aerosols, primary and secondary pollutants, chemistry of pollutants	10		

	- Sources of air pollution: natural and anthropogenic sources, domestic, industrial and automobile emissions point, line, area source - Effects of air pollutants on human health, vegetation and material with case studies and fact sheets , air pollution episodes, Occupational health hazards, personal protective equipments - Exhaust emissions, (CO, CO₂, Sox, Nox, HC, Smoke), status of vehicular pollution in Indian metro cities, control of vehicular emissions (catalytic converter, fuel change, lead phase out program, PUC, monitoring of vehicular emissions, air fuel ratio, awareness)			
2	Meteorology and air pollution dispersion - Motion of air: Planetary and Synoptic, mesoscale, microscale Land and sea breezes , hill and valley winds, Heat Island, measurement of wind speed and wind direction, representation and interpretation of wind data, wind rose - Concept of lapse rate, ambient, and adiabatic lapse rate, lapse rate and atmospheric stability, conditions Influence of meteorological factors on air quality: Plume behavior, mixing height, pressure and dispersion, wind and dispersion - Mathematical models for dispersion, estimation of ground level concentrations of pollutants, Gaussian dispersion model, design of stack, effect of air pollution on meteorological conditions - Environmental issues : Causes ,effects of climate change, green house effect, global warming, ozone depletion, acid rain preventive methods - Numerical excluding design	10		
	Minor test 1			01
	Assignment 1 Discussion and presentation of selected research paper in groups of three students. (Write up and ppt to be submitted for records)		05	
3	Air pollution control	09		

	- Air pollution control equipments - For particulate matter: Gravity settlers, Cyclones, fabric filters, Inertial separators, ESP, wet scrubber, Control equipments for gaseous pollutants: Combustion (after burner, flares, catalytic combustion) Absorption by scrubber, adsorption, close collection and recovery system, masking - Preventive techniques - Raw material and fuel substitution, process modification, alteration of equipment. good operating practices, Shifting of source Air pollution control at source: Proper disposal of effluents			
	Assignment 2 Discussion and presentation of selected research paper in groups of three students. (Write up and ppt to be submitted for records)		05	
3	Air quality monitoring and measurement - Objectives , Sampling principles, Sampling methods and procedures, - Sampling of Dust (Dust jar), SPM (High Volume Sampler) RPM(Respirable dust sampler) SO₂, Nox, CO, CO₂ (Impinger method) and lead (acid digestion), smoke monitoring (by Rengleman scale), handling and storage of samples, sampling precautions - Air quality monitoring: Ambient air monitoring, Stack monitoring, bio monitoring, air quality monitoring program in India - Air pollution status :Comparison of world and Indian situation, status of vehicular pollution in metro-cities of India Clean Development - Air quality management: Air quality criteria, air quality standards, air quality indices air quality management in India, Criteria sitting of industries and green belts, zoning, Bio remediation for air pollution control - Air pollution legislations	08		
4.	Noise pollution - Introduction - Definition of noise, Characteristics of sound,	05		

	difference between noise and sound, measurement of sound pressure and intensity level, noise monitoring national and international standards (permissible limits) for noise, zoning based on noise levels • Sources of noise - industrial noise, transport noise, neighborhood noise, Noise during festivals • Structure of ear, acute and chronic effects of noise on human health, physical and psychological effects, Temporary and permanent threshold shift, noise induced hearing loss, audiometric test • Noise control measures: Control at source, control of transmission, protection of recipient			
5	Minor test 2			01
	Total	45	10	03

Reference Books

1. Rao M.N and H. V. N. Rao, Air Pollution, Tata Mc-Grawhill Publishing Company Ltd, 1989.
2. Trivedi R.K and P.K.Goel, Introduction to air pollution, ABD Publishers, 2003.
3. Trivedi P.R. and Gurdeep Raj, Nuclear and thermal pollution, Akashdeep Publishing House, 1997.
4. Shukla S.K. and P.K.Shrivastav, Environmental noise impact analysis, Common Wealth Publishers, 1992.
5. Kamboj N.S., Control of noise pollution, Deep & Deepa Publications, 1993.
6. Brown Paul, Global warming, Universities Press, 1996.
7. Christainson Galee, Green house, Universities Press, 1999.
8. Trivedi R.K and P.K. Goel, Introduction to air pollution, Technoscience Publications, 1995.
9. Sharma B.K, Environmental Chemistry, Goel Publishing House, 2004.
10. Paevy, Rowe and Tschobanoglous, Environmental Engineering, Tata Mc Graw Hill Publishing Company Ltd.
11. Gaikwad and R.S. Sapkal, Environmental Engineering, Denett & Co, 2006.

Course No: EST 205

Course Title: Research Methodology

Number of Credits: 2

No. of Lectures-Assignments: 20-50

Course Coordinator: Dr. Shamita Kumar

Course Outline

The course will provide students with a critical understanding of the research process and familiarize students with the main approaches, methods and techniques of qualitative and quantitative research. The course will enable students to undertake their own independent research and apply appropriate research methodologies in order to plan, conduct and evaluate basic research as part of their degree and provide a solid foundation for further advanced research.

Learning Outcomes

- Ability to identify various sources of information and write up a literature review
- Planning and conducting basic qualitative and quantitative research
- Ability to write an introduction and methodology

Evaluation Procedure: Continuous

Assignments	1. Chapter on literature review of the individual students' thesis 2. Chapter on Methodology of the individual students' thesis

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	A
1.	Research Design: Overview • Understanding research • The qualitative/quantitative divide • Overview of different research traditions – action research, case studies, documentary analysis, ethnographic research, experiments, grounded theory, surveys	02	
2.	Planning the research • Selecting a topic • Topic to research question – problem definition, research question, hypothesis, research objectives • Research question to research design –developing the design • Data gathering – primary and secondary	02	

3.	Literature Review • Introduction to literature review • Methodology of literature review • Literature sources – books and journals, electronic databases, government and industry, internet • Writing a literature review • Referencing – systems, referencing websites, citations, use of software	04	
5.	Qualitative Research • Qualitative data collection techniques: collecting secondary data - journals, existing documents and records, etc.; collecting primary data – sampling need and design, pilots, techniques- surveys, questionnaires and rating scales, checklists, observations, interviews-structures, semi structured and open • Analyzing data: quantitative analysis, qualitative analysis	06	
6.	Ethical Considerations • Ethics committee, ethical guidelines – voluntary participation, informed consent, confidentiality and anonymity, plagiarism, academic fraud and misinterpreting results, conflict of interests, observation, permissions, video/audio taping	02	
	Exercise2: Designing/formatting a questionnaire/interview for a given problem Conducting a semi structured interview and analyzing data (with the upcoming field work in March)		10
7.	Writing up the research • Grammar, punctuation and conventions of academic writing -Tense, gender neutral language, referencing, use of notes and footnotes, English and American spellings, abbreviations, consistency • Writing an introduction • Writing the methodology	04	
	Assignment 1: Writing the introduction chapter of the students own thesis		10
	Assignment 2: Writing the literature review and		20

	methodology chapter of the students own thesis		
	Total	20	50

Assignments

The separate assignments will result in a single document – the research proposal of the student.

Suggested Readings

1. Becker, H. S. Writing for Social Scientists: How to Start and Finish Your Thesis, Book, or Article. University of Chicago Press, 2007.
 2. Creswell, J. W., and V. L. P. Clark. Designing and Conducting Mixed Methods Research. Wiley Online Library, 2007.
 3. Denzin, N. K., and Y. S. Lincoln. The Sage Handbook of Qualitative Research. Sage Publications, Incorporated, 2005.
 4. The SAGE Handbook of Qualitative Research (3 Rd. Thousand Oaks, CA: Sage, 2005.
 5. Hart, C. Doing a Literature Review: Releasing the Social Science Research Imagination. Sage Publications Limited, 1999.
 6. Malmfors, B., P. Garnsworthy, and M. Grossman. Writing and Presenting Scientific Papers. Nottingham University Press UK, 2004.
 7. Morrison, M. L., B. Marcot, and W. Mannan. Wildlife-habitat Relationships: Concepts and Applications. Island Press, 2006.
 8. O'Connell, A. F., J. D. Nichols, and K. U. Karanth. Camera Traps in Animal Ecology: Methods and Analyses. Springer, 2010.
 9. O'Leary, Z. The Essential Guide to Doing Research. Sage Publications Limited, 2004.
 10. The Essential Guide to Doing Your Research Project. Sage Publications Limited, 2009.
 11. Peat, J. et al. Scientific Writing: Easy When You Know How. BMJ books, 2007.
 12. Ridley, D. The Literature Review: a Step-by-step Guide for Students. Sage Publications Limited, 2012.
 13. Silverman, D. Doing Qualitative Research. Sage Publications Limited, 2009.
- Torraco, R. J. "Writing Integrative Literature Reviews: Guidelines and Examples." Human Resource Development Review 4.3 (2005): 3

Course No: EST 206

Course Title: Natural Resource Management

Number of Credits: 4

No. of Lectures-Tutorial: 45-20-03

Course Coordinator: Dr. Kranti Yardi

Course Outline

The course is intended to impart knowledge and skills considered crucial for natural resource managers to manage effectively in the dynamic and intricate environment. It enhances the students' understanding at diverse levels by maintaining the equilibrium between the occupation obligations and enduring growth requirements. The fundamental thrust of the course is to assist the students to obtain theoretical and logical abilities in relation to the field situations, necessary for managing natural resources efficiently.

Learning Outcomes

The student will be able to:

- Contribute in managing the resource in a comprehensive way as professionals working in this sector
- Balance the needs of people and the economy with protecting the ability of ecosystems to support soil, water, forests, wildlife, fish, recreation, and other resources

Evaluation Procedure: Continuous

Assignments	40 % (3)	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment • Completed home assignment submitted timely and excellent written presentation	Assignments must be in the prescribed format. One journal may contain assignments of different elective courses separated by a separator. Index must reflect all the assignments duly signed by the concerned teacher. Marks for every assignment must reflect on the assignment itself.	Internal Assessment
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	A	T/E
1.	Fundamental of Natural Resources - Ecology and ecosystems: concept of sustainability - Earth and water resources - Environment, energy and technology - Natural resource governance and policy	8		
2.	Theoretical aspects of Natural Resource Management - Environmental Monitoring Assessment– basic, time, cost, resources, techniques, guidelines - Natural Resource Economics - Society, Ethics and Participatory Development - Environmental Impact Assessment (EIA) and Auditing - Livelihoods and Natural Resources	8		
	Assignment 1: Discussion and presentation of selected research paper in groups of two/three students.		05	
3.	Integrated watershed management - Definition of watershed - Watershed development strategy - Socio-economic and natural resource information through PRA's - Land surveys through land class determination for area, slope, depth of soil, texture, erodability; soil and water testing - Engineering surveys – topographical surveys, drainage line survey, contour survey - Ecological assessment of the area – A statement of significance; site description-significant habitat types, native species of wild plants and animals of conservation importance, significant corridors, biotic pressures and threats, significant ecological services. People and their relationship with natural areas (valid and invalid stakes). - Microplanning – microplanning process, difficulties faced during microplanning, advantages of microplanning - Principles of soil and water conservation	12		

	Assignment 2: Ecological assessment of a given area		05	
	Assignment 3: Collection of data using GIS compatible participatory rural appraisal technique		10	
4	Analytical aspects of Natural Resource Management • Remote sensing and GIS application in NRM • Statistical analysis in NRM • Vegetation inventory and rapid assessment • Financial analysis and project management in NRM	09		
5	Managerial aspects of Natural Resource Management • Wildlife conservation and management • Wetland management • Watershed management • Urban forestry, biodiversity and landscape • Climate change and carbon trading • Agro-ecosystems and Agro forestry • Environmental modeling • Eco-tourism and other environmental services • Bio-resources	18		
	Final Assessment			03
	Total	45	20	03

Suggested Readings

1. Francois Ramade 1984. Ecology of Natural Resources. John Wiley & Sons Ltd.
2. Coastal Ecology & Management, Mann, K.H. 2000. Ecology of Coastal Waters with Implications for Management (2nd Edition). Chap. 2-5, pp.18-78 & Chap. 16, pp.280-303.
3. Global Change and Natural Resource Management, Vitousek, P.M. 1994. Beyond global warming: Ecology and global change. Ecology 75, 1861-1876.
4. Agarwal, K.C., 2001. Environmental Biology, Nidhi Publication Ltd. Bikaner.
5. Cunningham, W.P. Cooper, T.H. Gorhani, E & Hepworth, M.T. 2001, Environmental Encyclopedia, Jaico Publishing House.
6. Heywood, V.H. & Watson, R.T. 1995. Global Biodiversity Assessment. Cambridge Univ. Press.
7. Miller T.G.Jr. Environmental Science, Wadsworth Publishing Co. (TB)
8. Townsend C., Harper J, and Michael Begon. Essentials of Ecology, Blackwell Science.
9. Barber, E. 1989. Economics: Natural Resources Scarcity and Development. Earthscan.
10. Harris, J.M. 2006. Environmental and Natural Resource Economics: A Contemporary Approach, 2nd edition. Houghton Mifflin.

Course No: CA 201

Course Title: Wildlife Health, Rescue and Rehabilitation

Number of Credits: 4

No. of Lectures-Tutorial: 45-20-03

Course Coordinator: Dr. Kazveen Umrigar

Course Outline

The course provides in depth understanding of the various issues involved in wildlife health, capturing and handling wild animals, wildlife forensics and conservation breeding along with wildlife rehabilitation.

Learning Outcomes

Students will:

- Demonstrate a basic knowledge of complexities involved in animal welfare, wild animal health, conservation breeding, rehabilitation of wild animals
- Resolve applied ecological problems using basic biological information

Pre-requisite

EST 101, EST 201

Evaluation Procedure: 0.6/0.4 University

Assignments	40 % (3)	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment • Completed home assignment submitted timely and excellent written presentation	Assignments must be in the prescribed format. One journal may contain assignments of different elective courses separated by a separator. Index must reflect all the assignments duly signed by the concerned teacher. Marks for every assignment must reflect on the assignment itself.	Internal Assessment
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	A	T/E
1	Wildlife Health • Introduction to disease and epizootiology • Determinants of disease and disease transmission, disease and population dynamics • Review of major viral, bacterial, protozoan, fungal and parasitic diseases of Indian wild mammals, birds, amphibians and reptiles. • Noninfectious diseases – nutritional diseases, poisoning, stress, shock, capture, myopathy, physical trauma • Emerging and reemerging diseases, zoonosis • Assessment of condition, health and nutritional status in free ranging populations, disease control operations.	8		
2	Capture and handling of wild animals • Capture and handling of wild animals –purpose, restraint techniques, different capture methods and animal barriers • Drug immobilization – drug delivery equipment and accessories • Immobilization drugs – action, dosage, response and side effects, safety measures, complications • Handling and transport of wild animals, designing sledge, crate and holding enclosures.	5		
3	Conservation genetics and wildlife forensics • Introduction of bio-molecules – DNA, RNA and Proteins; Central dogma of molecular biology • Replication, Transcription and Translation; Medelian genetics – Mendel's laws; Genetic Code – characteristics and feature of genetic code; Molecular markers ; PCR, DNA • Sequencing, Genotyping; Allelic variation; Interpretation of genetic data	10		

	• Applications of genetics for wildlife conservation • Loss of genetic diversity • Resolving taxonomic uncertainties • Wildlife forensics – Overview, various forensic protocols for species identification, molecular markers used in wildlife forensics; Wildlife forensics based on DNA			
4	Conservation Breeding • Captive breeding and propagation; Founder population, rehabilitation, education, utilization, gene banks • Ex-situ and in-situ linkages • Conservation breeding management plans • Role of scientific institutions and NGOs in conservation breeding programs • Principles of conservation breeding – understanding biological requirements of species, design of facilities, food, hygiene, disease control, breeding • Propagation of threatened plants ; Case studies • Case studies on conservation breeding program of endangered wild animals	10		
5	Wildlife Utilization • Non-consumptive and consumptive utilization, their economic benefit • Game ranching and controlled off-take from wild population, rationale, management design, harvesting by management or hunting licenses, marketing procedures • Use of wildlife products – skins, meat, musk, etc. • Wildlife tourism – objectives, planning and economics	06		
6	Wildlife rehabilitation • Approaches to establish new populations -Wildlife introduction, reintroduction and rehabilitation programs • Considerations for successful programs - social behavior of released animals, selection of animals, enabling field conditions, monitoring of released animals	06		

	• Case studies			
	Assignments 1, 2, 3 : As discussed by the concerned faculty		20	
	Final Assessment			03
	Total	45	20	03

Suggested Readings

1. Atkinson, C. T., N. J. Thomas, and D. B. Hunter. Parasitic Diseases of Wild Birds. Wiley Online Library, 2008.
2. Avise, J. C. "The History, Purview, and Future of Conservation Genetics." Conservation biology: evolution in action. Oxford University Press, New York (2008): 5–15. Print.
3. Avise, J. C., and J. L. Hamrick. Conservation Genetics. Springer, 1996.
4. Frankham, R., J. D. Ballou, and D. A. Briscoe. A Primer of Conservation Genetics. Cambridge University Press, 2004.
5. Introduction to Conservation Genetics. Cambridge University Press, 2002.
6. Grenfell, B. T., and A. P. Dobson. Ecology of Infectious Diseases in Natural Populations. Vol. 7. Cambridge University Press, 1995.
7. Hoff, G. L., and J. W. Davis. Noninfectious Diseases of Wildlife. Iowa State University Press, 2121 South State Avenue, 1982.
8. Hudson, P. J. et al. Ecology of Wildlife Diseases. Oxford University Press, 2002.
9. Loeschcke, V., and J. Tomiuk. Conservation Genetics. Vol. 68. Birkhäuser, 1994.
10. Nielsen, L., and R. D. Brown. "Translocation of Wild Animals." Translocation of wild animals. (1988)
11. Nunn, C. L., and S. Altizer. Infectious Diseases in Primates: Behavior, Ecology and Evolution. Oxford University Press, 2006.

Course No. EST 207

Course Title: Environment and Health

Number of Credits: 4

No. of Lectures-Tutorial-Practical: 21-20-20

Course Coordinator: Dr. Thomas Krafft, University of Maastricht, Netherlands

Course Outline

The aim of this course is to provide the students with a comprehensive understanding and applicable knowledge of health geography as a scientific concept using tools like GIS for a holistic approach to public health that promotes the wellbeing of human populations through organizing data and understanding links between environment and health. The health of human population reflects the complex interplay between population characteristics and the environment. Genetic makeup can predispose certain populations to chronic or acute conditions. Cultural factors, such as stress, economic status, and access to health care, can play a significant part on disease onset. Students will learn how to assess environment and health related issues with different methodologies and they will be able to conduct a critical analysis on health and environment related research. The use of environmental health chain to study mechanism by which environmental hazards impacts health will be discussed as well as the aspect of the governance process to mitigate or eliminate environmental health hazards. Special focus will be laid on measuring health outcomes, mortality, incidence, prevalence etc.

Outcomes

Students will develop:

- Ability to apply the theoretical frameworks offered during the course to actual cases of environmental health problems.
- Ability to prioritize different interventions to manage environmental health risks.
- Ability to formulate simple research protocols for environmental measurements, exposure assessment or health effect assessment.
- Conduct simple analysis on health and environment using Geographic Information Systems and spatial cluster detection software.
- Discuss the suitability of various study designs and approaches in environmental and health research

Pre-requisite : None

Assessment

Assignments	40 %	Marking pattern for every assignment	Assignments must be in the prescribed I	Internal Assessment

	(3)	- Innovativeness and accuracy in completing the assignment - Completed home assignment submitted timely and excellent written presentation	format. One journal may contain assignments of different elective courses separated by a separator. Index must reflect all the assignments duly signed by the concerned teacher. Marks for every assignment must reflect on the assignment itself.	
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	T	P
1.	Outline of the course - Introduction to Health Geography and Environmental Health Introduction - Health Geography and Environmental Health Human Ecology Models - A theoretical approach to study the forces in a person's environment that affects and influences development and interaction between individuals. One Health Concept - The approach recognizes that health of humans, animals and ecosystems are interconnected. It involves applying a coordinated, collaborative, multidisciplinary and cross-sectoral approach to address potential or existing risks that originate at the animal-human-ecosystems interface.	3		2

	Emerging and Re-emerging diseases This topic focuses on formerly unknown diseases that are increasing in time and a specific location. They are considered to be emerging. Diseases that were eradicated or controlled and present themselves again in a specific location are considered re-emerging diseases. Task: background literature for reading till next session			
2.	PBL Case 1: Environmental Health Hazards		4	2
3.	Global Environment Change, Human Health and Public Health Environmental Health Chain - In environmental health, research is primarily concerned with the relationships between environment and human health. These relationships comprise a set of causes and effects and typically involve many of each. They may therefore be best studied as a causal chain, which shows the links between sources and impacts. Environmental Determinants of Health - Environmental determinants of health are typically considered as external factors such as access to safe water, air pollution, droughts and others that can be causally linked to a change of health status. Social Determinants of Health - Social determinants of health are the conditions, in which people were born, live, grow up and age. The social determinants of health are mostly responsible for health inequities - the differences in health status within and between countries. Task: Answering questions during a group discussion round, prepare for presenting the results during the next session.	2		1

4.	Urbanization and Health Impacts Urbanization and Migration - The ongoing rapid urbanization leads to an increased migration away from rural areas to urban areas. Although urbanization usually accompanies social and economic development, the rapid urbanization strains local and national governments to provide basic services such as safe water, electricity and sewerage. This in turn affects the health status of a large amount of today's population. Urban – Rural Health Divide - Although the majority of India's population lives in rural areas, most medical infrastructure is concentrated in urban areas. This, among other factors such as access to safe water, sanitation and hazardous working and living conditions leads to high prevalence of infectious diseases in rural areas as compared to urban areas. Urban Health Models - Urban health models address the challenge of communicating and modeling the complex relationships and interdependencies of various determinants of health in urban areas. Healthy City Concept - The approach seeks to put health high on the political and social agenda of cities and to build a strong movement for public health at the local level. It strongly emphasizes equity, participatory governance and solidarity, intersectoral collaboration and action to address the determinants of health. Health and Wellbeing in the Changing urban environment - ICSU approach - The approach of the International Council for Science (ICSU) is to establish a system analysis to study the causal chain and various complex interactions between different processes and factors that influence health and wellbeing in	2		1

	urban environments. Ambient Particulate Matter (PM) • Particulate matter in its various form has a profound impact on human health. Exposure may be higher in urban areas and industrial areas due to an increase in the number of sources. This topic will focus on the impact of PM on health. <u>Task:</u> Answering questions during a group discussion round, prepare for presenting the results during the next session.			
5.	PBL Case 2: Exposure to bad Air Quality		4	2
6.	Methodologies in the field of Health Geography and Environmental Health Health Impact Assessment • Economic sectors such as transport, agriculture and housing have profound impacts on health. Health Impact Assessment is a means of assessing the health impacts of policies, plans and projects in diverse economic sectors using quantitative, qualitative and participatory techniques. Geographic Field Work Methodologies • This topic will focus on a wide range of quantitative and qualitative methodologies applied in the field of health geography. Pressure and Release model • The pressure and relief model explains the interactions that lead to an increase of vulnerability within a society and its relation to hazards that may become a disaster through the progression of vulnerability. Introduction to Health GIS as a tool of health geography and environmental health research • This topic will present the application of GIS to monitor health related data and evaluate contributing environmental factors on human	4	2	

	health. <u>Task:</u> Paper (10 page) on one of the topics presented during the lectures or a topic of their own research interest. This paper needs to be handed before the symposium. The paper will be presented during the symposium via PowerPoint.			
7.	Vulnerability and Global Environmental Change Drivers of Change - Global environmental hazards to human health include climate change, stratospheric ozone depletion, changes in ecosystems due to loss of biodiversity and a wide range of other factors. Drivers of global environmental change and its interdependencies will be explored in this topic. Concept of Vulnerability and Resilience - Societal response, particularly the societal capacity to adapt to climate change impacts, determines both, the severity of impacts and the costs of adaptation. The focus of this topic is to give an understanding of the concepts that define vulnerability and resilience. Vulnerable populations - Understanding the wide variety of driving factors that contribute to the vulnerability of a specific population is essential to target areas for interventions. Risk Assessment - A risk assessment is a process to identify potential hazards, vulnerable populations and to measure the impact a potential hazard might have on the vulnerable populations. This topic will provide insight in the process of conducting risk assessments. Mitigation and Adaptation - Adaptation and mitigation refer to two different ways of adjusting to climate change. This topic will focus on the different ways to adapt to climate	2		2

	change that are comprised within these two terms. Exposure To fully understand the concept of vulnerability and resilience, it is necessary to study the exposure of populations to various hazards. <u>Task:</u> Practical Framing research question, design research and prepare a poster for presentation at the workshop			
8.	PBL Case 3: Exposed?		4	2
9.	Training Workshop on Health Geography and Environmental Health The training workshop will be designed including lectures on GIS application, spatial cluster detection using SaTScan, visualizing health data, design maps for health study and projection and using spatial data. The students have to present and discuss the findings of their practical tasks in a special session at the end of the training workshop. Students will learn how to address health-related challenges, from disease analysis to policy planning. During the training workshop the students will present their papers via Power Point. Further the students will present in a special session their research posters. The time duration for the training workshop will be 5 days.	8	6	8
	Total	21	20	20

Assignments

Reading: The students have to get a broad overview of the topic by reading assigned background literature.

PBL elements: Answering research questions on environment and health issues in a group discussion and presenting the results during the class based on problem-based learning (PBL).

Paper: The students will be asked to prepare a paper on one of the topics presented during the lecture or a topic of their own research interest. The paper will be a 10 page document which

will be need to be handed in up to a clear deadline and will be assessed by the teachers of the course.

Poster presentation: The students will be asked to prepare a poster on one of the topics presented during the lecture or a topic of their own research interest. This poster will be presented during the symposium. The students will have 10 minutes for presentation followed by a 5 minute open discussion. The goal of this exercise is to familiarize the students with poster presentation for conferences.

Research proposal exercise: The students will be divided in small groups, the groups will be asked to design a research proposal that address one of the research issues that were presented during the lectures. The results will be presented by the groups via PowerPoint during the symposium.

Methodologies: During the course there will be a focus on methodologies to assess Environment and Health related issues. During the symposium there will be an assignment for the students to carry out a cluster detection using SaTScan software. Further there will be a special session on Health GIS were students will learn basic application of GIS for health related research questions.

Suggested Readings

1. Brown T and Moon G. (2012) Commentary- Geography and global Health, *The Geographical Journal*, 178, 13-17.
2. McMichael A, Woodruff E, Hales S. (2006) Climate Change and human Health: present and future risks, *Lancet*, 367, 859-869
3. Haines A, Kovats R S, Campbell-Lendrum D, Corvalan C. (2005) Climate Change and human health: Impacts, vulnerability and public health, *Public Health*, 120, 585-596
4. Haines A, Kovats R S, Campbell-Lendrum D, Corvalan C. (2006) Climate change and human health: impacts, vulnerability, and mitigation, *Lancet*, 367, 2101-2109
5. Atul A, Khasnis, Nettleman M D. (2005) Global Warming and Infectious Disease, *Archives of Medical Research*, 36, 689-696
6. Patz J, Campbell-Lendrum D, Holloway T, Foley A. (2005) Impact of regional Climate Change and human health, *Nature*, 438, 310-317
7. Climate Change and Health: Research Challenges for Health in the Developing Countries, *Indian Journal of Occupational and Environmental Medicine*, 14,
8. Castello A et al. (2009) Managing the health effects of climate change, *The lancet Commissions*, 373, 1693-1733
9. Kovats S, Akhtar R (2008) Climate, Climate Change and Human Health in Asian Cities, *Environment and Urbanization*, 20, 165-175

10. Allen D E, Donham R S, Bernhardt S A (2011) Problem-Based Learning, *New Direction for Teaching and Learning*, 128, 21-29
11. Thomas I (2009) Critical Thinking, Transformative Learning, Sustainable Education, and Problem-based Learning in Universities, *Journal of transformative Education*, 7, 245
12. Pawson E, Fournier E, Haigh M, Muniz O, Trafford J, Vajocki S (2011) Problem-based Learning in Geography: Towards a critical Assessment of its Purposes, Benefits and Risks, *Journal of Geography in Higher Education*, 30:1, 103-116
13. Dummer T (2008) Health Geography: supporting public health policy and planning, *Canadian Medical Association Journal*, 178:9, 1177-1180.
14. Curtis S E, Oven K J (2011) Geographies of health and climate change, *Progress in Human Geography*, 36, 654-666.
15. Smyth F (2007) Medical geography: understanding health inequalities, *Progress in Human Geography*, 32, 119-127.
16. Bei X, Nath I, Capon A, Hasan N, Jaron D (2012) Health and wellbeing in the changing urban environment: complex challenges, scientific responses and the way forward, *Current opinion in Environmental Sustainability*, 4, 465-472.

Journals

1. Lancet
2. Environment and urbanization
3. Indian Journal of Occupational and Environmental Medicine
4. Nature
5. BMC Public Health
6. International Journal of Health Geographic (<http://www.ij-healthgeographics.com/>)
7. Progress in Human Geography

Course No: EST 208

Course Title: Climate change science and strategies

Number of Credits: 4

No. of Lectures-Tutorial: 45-20-03

Course Coordinator: Arch. Aditi Lanke / Mr. Parag Khatavkar/ Dr. Girish Jathar

Course Outline

Global climate change is a planetary scale phenomenon that impacts upon all socioeconomic and natural systems. Despite the growing consensus about the fundamentals of climate warming, scientific understanding of the complex interactions of ocean, land, clouds, and atmosphere remains highly uncertain, particularly with respect to environmental, social, and economic disruptions affecting human societies. This course will provide students with the scientific literacy to understand the issue itself and consider existing solutions such as the Kyoto Protocol, voluntary measures, etc. The guiding principle will be to promote the understanding needed to evaluate, develop, and propose emerging and creative solutions at individual, campus, and local levels. This course will examine the dilemmas faced in climate science, politics, economics, management, and ethics – all with an eye to the implications for global and regional sustainability.

Learning Outcomes

The student will be able to:

- Think intelligently about the issue and to understand what processes are currently underway and what more can be undertaken.
- Understand the precarious feedbacks from the climate system that could create dramatic impacts.
- Understand, plan and propose creative solutions at temporal, spatial, political, scientific, and social scale.

Evaluation Procedure: 0.6/0.4 University

Assignments	40 % (3)	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment • Completed home assignment submitted timely and	Assignments must be in the prescribed format. One journal may contain assignments of different elective courses separated by a separator. Index must reflect all	Internal Assessment

		excellent written presentation	the assignments duly signed by the concerned teacher. Marks for every assignment must reflect on the assignment itself.	
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	A	T/E
1	Climate science and impacts • Introduction: overview of the topic • Climate change: cause and effect • Climate disruption • Impact analysis: freshwater sources and oceans • Impact analysis: food and forests • Economic impacts of climate change	10		
	Assignment 1: Discussion and presentation of selected research paper in groups of three students.		05	
2	Policies and market issues • International treaties • Carbon trade and taxation • Strategies for low cost carbon abatement • Climate policy: global scenario • Climate policy: Indian scenario • Green business initiatives	10		
	Assignment 2: Discussion and presentation of selected research paper in groups of three students.		05	
3	Climate solutions • Energy solutions: past and present • Transportation • Building and habitation • Industry and waste management • Land use, agriculture and forestry	15		

	• Adaptation and tropical forest sequestration • Geo-engineering of earth's atmosphere			
	Assignment 3 : Discussion and presentation of selected research paper in groups of three students.		10	
4	Future direction • Mobilizing the world to action • Trends and futures of food scarcity solutions • Trends and futures of green and clean energy supply and consumption • The negotiating challenges ahead	10		
	Final Assessment			03
	Total	45	20	03

Assignments

In the assignments the students will be expected to express their view on promise and limitations of sustainability ideas and practices for dealing with climate threats. They will also be expected to understand and illustrate the nature of climate controversies and the positions of various stakeholders. The assignments will also help to create an interdisciplinary understanding of climate interactions with human and natural systems.

Suggested Readings

1. Stephen Schneider, Armin Rosencranz, Michael Mastrandrea, eds., 2010. Climate change science and policy. Island Press.
2. Bert Metz, 2010. Controlling climate change, Cambridge University Press.
3. Lester Brown, 2009. Plan b 4.0: mobilizing to save civilization. W.W. Norton.
4. Kerry Emanuel, 2007. What We Know About Climate Change. Boston: Boston Review/MIT Press
5. Tim Flannery, 2006. The Weather Makers. New York: Atlantic Monthly Press
6. Bill McKibben, 2010. Earth. NY: Times Books,
7. David Blockstein and Leo Weigman 2010. The Climate Solution Consensus NCSE/Island Press.
8. Monty Hempel, 1996. Environmental Governance: The Global Challenge. Washington, DC: Island Press.
9. Arnold J. Bloom, 2009. Global climate change: convergence of disciplines. Sinauer Associates.

Course No: EST 209

Course Title: Environmental biotechnology

Number of Credits: 4

No. of Lectures-Tutorial: 45-15

Course Coordinator:

Course Outline

This course aims to help the student understand the theoretical bases of some biotechnological applications in the environmental sciences. Specialized tools and techniques used in such applications, as well as case studies are included to illustrate the development and application of general principles in a context-dependent manner. Contemporaneous topics such as biosafety, food security and bioenergy will be used to highlight societal concerns raised by these applications.

Learning Outcomes

The student will:

- Develop a broad understanding of the applications of biotechnology in the environmental sector.
- Clearly debate and reflect on the pros and cons of using biotechnological techniques.

Pre-requisite

None

Evaluation Procedure: 0.6/0.4 University

Assignments	40 % (3)	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment • Completed home assignment submitted timely and excellent written presentation	Assignments must be in the prescribed format. One journal may contain assignments of different elective courses separated by a separator. Index must reflect all the assignments duly signed by the concerned teacher. Marks for every assignment must reflect on the assignment itself.	Internal Assessment
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Introduction - The scope of environmental biotechnology - Biodegradation of macromolecules - Biodegradation of xenobiotics; Vermicomposting. Heavy metal pollution; Bioremediation of metal contaminated soils, spilled oil and grease deposits and synthetic pesticides. - Biosensors to detect environmental pollutants. Microorganisms and organic pollutants;	10	
	Assignment 1		3
2	Agriculture and biotechnology interface - Introduction to history of agriculture, food security and sustainable development - Plant breeding and crop improvement: perspectives from green revolution, contemporary plant biotechnology and its promise. - Transgenic plants for food security, nutrition and healthcare: Case Studies - Transgenic technology, principle, tools, techniques and methodologies - Imparting tolerance to abiotic and biotic stresses, nutritional enhancement, molecular farming for plant proteins and biomolecules of pharmaceutical and therapeutic value.	10	
	Assignment 2		4
3	Applications in plant genetics - Basic concept of genetic engineering of plants and its applications- herbicide and stress tolerant plant - Biotechnology strategies in forestry and wasteland management. - Biotechnology in biodiversity conservation: gene banks, germplasm conservation and DNA Banks. - Genetically modified organisms and Biosafety- a general account.	15	

	Biotechnology for germplasm conservation and marker assisted breeding. Fundamentals of molecular markers, DNA fingerprinting for conservation and management of genetic resources, marker assisted breeding and selection for crop improvement		
	Assignment 3		4
4	Environmental applications - Bioenergy, ethanol fermentation. - Liquid waste treatment; Biofilters, activated sludge systems; membrane bioreactors. - Biotechnological approaches for solid waste management, Phytotechnology-terrestrial phytosystems, metal phytoremediation, Phytotechnology-aquatic phytosystems, nutrient film techniques, algal treatment systems.	10	
	Total	45	15

Suggested Readings

1. Buchanan B.B., Gruissem W. and Jones R.L. (2000) Biochemistry and Molecular Biology of Plants, American Society of Plant Physiologists.
2. Cornish W.R. (1999) Intellectual Property (4th edition), Sweet & Maxwell, London.
3. Divan S. and Rosencranz A. (2005) Environmental Law and Policy in India, (2nd edition), Oxford, New Delhi.
4. Erbisch F.H. and Maredia K.M. (eds.) (2004) Intellectual Property Rights in Agricultural Biotechnology (2nd edition), CABI Publishing, Oxon.
5. McMannis C., (ed.) (2007) Biodiversity and the Law, Earthscan, London.
6. National Biotechnology Development Strategy (Draft), Department of Biotechnology, Ministry of Science and Technology, Government of India.
7. Prescott L.M., Harley J.H. and Klein D.A. (1999) Microbiology (4th edition), McGraw Hill.
8. Report of the Task Force on Application of Agricultural Biotechnology, Ministry of Agriculture, Government of India, (2004).
9. Sankaran K. and Singh U.K. (eds.) (2008) Towards Legal Literacy: An Introduction to Law in India, Oxford University Press.
10. Stern K.R. (1997) Introductory Plant Biology, WM Brown Publishers.
11. Useful Web sites/notes/handouts (to be provided by instructors).
12. Watal J. (2001) Intellectual Property Rights in the WTO and Developing Countries, Oxford, New Delhi.

Course No: EST 2010

Course Title: Instrumentation and lab management for environmental analysis

Number of Credits: 4

No. of Lectures-Practical: 30-30

Course Coordinator:

Course Outline

The course is designed to develop sampling and analytical skills of the students which are required in environmental monitoring. Through this course, the students will be able to perform quantitative analysis of various physical, chemical and biological parameters involved in water, air, soil and microbiology research. The students will be exposed to various standard protocols used in environmental monitoring.

Learning Outcomes

The student should be able to:

Understand the principle and working of the various instruments

Pre-requisite

EST 102, EST 103

Evaluation Procedure: 0.6/0.4 University

Assignments	40 % (3)	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment • Completed home assignment submitted timely and excellent written presentation	Assignments must be in the prescribed format. One journal may contain assignments of different elective courses separated by a separator. Index must reflect all the assignments duly signed by the concerned teacher. Marks for every assignment must reflect on the assignment itself.	Internal Assessment
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Introduction Introduction of various equipments of environmental monitoring and analysis: High volume air sampler, Atomic absorption spectrophotometer, Flame photometer, Infrared gas analyzer, UV spectrophotometer, H.P.L.C, scanning electron microscope, transmission electron microscope. Cooling centrifuge, growth chamber, Autoclave, polarograph, nuclear magnetic resonance.	8	
	Practical 1		6
2	Machines involved in various equipments, working principles of all the equipments used in environmental monitoring and analysis.	4	
	Practical 2		6
3	Environmental analysis Air pollution analysis, monitoring of SO ₂ , NO ₂ , CO ₂ and analysis of SPM, sampling methods for aerosol, organic gases and vapor analysis. Water pollution analysis, Physical analysis, chemical analysis, Biological Analysis, analysis of minor components, Industrial and domestic effluent analysis, Primary, Secondary and tertiary treatment of water.	10	
	Practical 3		3
4	Soil pollution and pesticide analysis, agricultural pollution, Role of micronutrient in soil, trace elements in soil, pesticide and soil pollution ,chromatography characterized zones, polarographic spectroscopic analysis. Soil pollution and crop health, soil microbes and plants diseases. Physical, chemical and biological analysis of soil.	8	
	Practical 4		3
	Total	30	30

Suggested Readings

1. Kim Y.J. and Platt U. (Eds.) (2008) *Advanced Environmental Monitoring*, XXII, 420 p. Springer.
2. Laboratory Analytical Techniques Series (LATS), published by CPCB.

3. Roa M. (2008) *Environmental Science Activities Kit*, Jossey-Bas.
4. Wagner T.P. and Robert S. (2009) *Environmental Science: Active Learning Laboratories and Applied Problem Sets*, 2nd Edition, Wiley.
5. Wells E. (2009) *Lab Manual for Environmental Science*, Cengage Learning.

Course No: GEN 201

Course Title: General English

Number of Credits: 2

No. of Lectures-Tutorial: 24-8

Course Coordinator:

Learning Outcomes

The student should be able to:

- Construct sentences with correct grammar
- Write simple reports correctly

Evaluation Procedure: Continuous

Assignment	1	100%	Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Basic language skills: grammar and usage The ability to fill in blanks, correct errors, choose correct forms out of alternative choices, join clauses, rewrite sentences as directed, replace indicated sections with single words/opposites/synonyms, etc. Skills such as punctuation of passages, changing between direct and indirect speech, expanding points into complete sentences.	08	
	Comprehension This implies (a) an understanding of the passage in question and (b) a grasp of general language skills and issues with reference to words and usage within the passage and (c) the power of short independent composition based on themes and issues raised in the passage.	08	
	Composition: Paragraph-writing Formal training in composition and précis/summary writing through instruction, discussion and written work. Letter writing, Basic report writing	08	
	Assignment		4
	Total	24	8

Course No: GEN 202

Course Title: Project Management

Number of Credits: 2

No. of Lectures-Tutorial: 18-20

Course Coordinator: Mr. Parag Khatavkar

Course Outline

The course provides an overview of techniques of project management with an emphasis on project management, organizational structures, teams, functions, planning, scheduling, cost controls, trade-offs, risk management and other related topics. The course prepares students to conceptualize, implement, monitor and evaluate the project.

Learning Outcomes

The student will:

- Construct, organize and explain project management.
- Devise, plan and compile work breakdown structures (WBS) and understand life cycle phases as quantitative tools in project management.
- Design, generate and explain scheduling techniques.

Pre-requisite

None

Evaluation Procedure: Continuous

Assignment	1	100%	Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	A
1	Introduction to project management • Definition and attributes of project and project management • Strategy in project management – establishing objectives, scoping the boundaries, priority setting, strategic development • Understanding project management and resistance to change • Project management life cycle • Critical success factors in project management	06	

	• Best practices in project management • Project monitoring		
2.	Project management methodologies • Modeling the project system – WBS, responsibility, communication plan • Estimations in projects – basic, time, cost, resources, techniques, guidelines • Developing project plans – Gantt charts, evaluating and constructing networks • Overcoming development and implementation barriers • Critical components of project management • Implementing a methodology • Strategic planning for project management	06	
3.	Issues in project management • Management Styles • Project Management Skills • Involvement of senior managers and stakeholders • Identification of projects • Project management information systems • Risk management • Change management • Role of culture in project management	06	
	Assignment		15
	Total	18	20

Assignments

In the assignments the students will be expected to design WBS, review of best practices in project management, role of change management, etc.

Suggested Readings

1. Baker, B. N., D. C. Murphy, and D. Fisher. "Factors Affecting Project Success." Project Management Handbook, Second Edition (2008): 902–919.
2. Dyball, R., and M. Keen. Social Learning in Environmental Management: Towards a Sustainable Future. Routledge, 2012.
3. Kerzner, H. Advanced Project Management: Best Practices on Implementation. Wiley, 2003.
4. Project Management: a Systems Approach to Planning, Scheduling, and Controlling. Wiley, 2009.

5. Strategic Planning for Project Management Using a Project Management Maturity Model. Wiley, 2002.
6. Meredith, J. R., and S. J. Mantel Jr. Project Management: a Managerial Approach. Wiley, 2011.

Course No: EST 211

Course Title: Field Techniques II

Number of Credits: 2

Course Coordinator: Dr. Kranti Yardi

Course Outline

The course provides hand on expertise with using various quantification techniques and tools for wildlife assessment including use of advanced equipment's like camera traps, bat detectors, mobile mappers, etc.

Learning Outcomes

Students will develop:

- Proficiency in using quantitative assessment techniques
- Ability to use mobile mappers, camera traps and other equipment for data collection.

Evaluation Procedure: 0.6/0.4 University

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed Journal submitted timely (within 7 days): 5 marks	Internal Assessment
Major exam	60%		University Assessment

Details of course content

1. Assessing plant diversity by belt transect method.
2. Assessing plant diversity by point count and PCQ method.
3. Calculating plant diversity index.
4. Estimating bird density by distance sampling –line transect and point count methods
5. Assessment of selected sites for measurement of species richness and diversity of birds.
6. Calculation of bird diversity index.
7. Planning a census operation
8. Estimation of animal populations using any one of (block counts, road counts, King census method)
9. Estimation of animal population using indirect evidence (pugmarks, dung)
10. Ecological assessment of a given area
11. Conducting Participatory Rural Appraisal using household surveys.
12. Conducting Participatory Rural Appraisal using participatory mapping.
13. Conducting Participatory Rural Appraisal using matrix scoring.
14. Conducting Participatory Rural Appraisal using seasonality calendar

Course No: EST 212

Course Title: Lab Analytical Techniques II

Number of Credits: 2

Course Coordinator: Ms. Archana Kalyani/Ms. Pradnya Kalekar

Course Outline

The course provides sound understanding of lab analytical techniques in water and water engineering and air and noise assessment and management and sets the foundation for application of these techniques in projects as well as further research.

Learning Outcomes

Students will develop:

- Proficiency in use analytical instruments.
- Ability to analyse samples using specific techniques
- Competency in interpretation of results.

Pre-requisite

None

Evaluation Procedure: 0.6/0.4 University

Continuous assessment during practical	40 %	Marking pattern for every practical: • Performance during the practical and completion of practical in the lab itself : 5 marks • Completed Journal submitted timely (within 7 days): 5 marks	Internal Assessment
Major exam	60%		University Assessment

Details of course content

1. Estimation of Suspended Particulate Matter (SPM) and Respirable Particulate Matter (RPM) using high volume sampler.
2. Construction of calibration curve for SO_x.
3. Construction of calibration curve for NO_x.
4. Estimation of SO_x and NO_x in ambient air (including sampling).
5. Monitoring of wind speed and wind direction using anemometer and construction of wind rose.

6. Measurement of ambient noise using noise meter.
7. Determination of physical properties of water and wastewater: pH, conductivity.
8. Determination of acidity and alkalinity (carbonate, bicarbonate and hydroxide).
9. Determination of turbidity and optimum alum dose by jar test.
10. Determination of fluorides in given water sample.
11. Determination of chlorides in given water sample.
12. Determination of chlorine demand and residual chlorine for potable water.
13. Determination of phosphates in water / wastewater sample.
14. Determination of sulphates in water / wastewater sample.
15. Determination of BOD and COD of wastewater sample.
16. Determination of Sludge Volume Index and Mixed Liquor Suspended Solids.
17. Determination of total solids and its fractions (Suspended, dissolved, volatile and fixed solids)
18. Determination of oil and grease in wastewater sample.

SEMESTER III

Course No: EST 301

Course Title: Integrated Impact Assessment

Number of Credits: 4

No. of Lectures-Tutorial: 46-14

Course Coordinator: Mr. Mahesh Kulkarni

Course Outline

There is growing realization that the multi-dimensional nature of sustainable development targets requires the use of different disciplinary approaches, in an integrated framework, to the impact assessment of development projects/programmes. Integrated Impact Assessment (IIA) provides such a framework for a balanced consideration of the economic, environmental, social and health impacts of development interventions at the project, sector and economy levels. The course in Integrated Impact Assessment (IIA) is designed to build detailed knowledge, understanding and skills among students for conducting IIA, so that they are able to identify sustainable modes of environmental operation. The course starts with an overview of IIA—the different methodologies on which it draws the state of the art, current practices, constraints and future directions.

Pre-requisite

None

Evaluation Procedure : Continuous

Assignments	20 %	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment : 5 marks • Completed home assignment submitted timely and excellent written presentation (within 7 days): 5 marks	Assignments must be in the prescribed journal format. One journal may contain assignments of different elective courses separated by a separator. However each course must have a separate index duly signed by teacher. Marks for every assignment must reflect on the	Internal Assessment

			assignment itself.	
Minor Tests	20%	3 minor tests will be conducted		
Major exam	60%	Theory examination		University Assessment

Details of course content and allotted time

Sr. No.	Topic	Time (Hours)	
		L	T
1.	Introduction and overview of Integrated Impact Assessment (IIA) Defining IIA; Sustainable Development challenges and need for IIA; Key Approaches of IIA: Environment, Social, Health and Economic; Current Practices, Changing Perspectives and Debate in IIA	2	
2	Assessing Environmental Impacts: The EIA Approach • Evolution of EIA, purpose of EIA, steps in EIA process, Environmental Impact Statement (EIS), impact indicators; • EIA in developed and developing countries, EIA notification. Environment clearance process; project screening, scoping, consideration of alternatives, establishing the environmental baseline, impact identification, prediction and evaluation; Mitigation: • Public Participation (PP): purpose, procedure, interested parties, PP in India, PP in decision making. • EIA methodologies - ad hoc, overlays, checklists, matrices, networks; strategies for selection of EIA methodologies, methodologies for prediction: judgmental approach, mathematical models, simulation, and physical models. • Environmental monitoring: purpose, scope, pre and post monitoring. • Preparing an EIA report: General requirements, Topical and generic outline: Executive Summary, Description of the Project, base line data, Anticipated Environmental Impacts and Mitigation Measures, Alternatives, Environmental Monitoring	14	

	Program, Additional Studies, Environmental Management Plan, Summary and Conclusion, Annexes, review of EIA report. • EIA as a planning process: developmental plans, policies and strategies for developmental projects • Case studies of EIA for few Indian industries – eg: oil, metallurgical, petrochemical, iron and steel, fertilizer, projects of roads / dams etc		
	Assignment 1 Impact assessment using the methods studied above of a given case study (individual assignment)		4
3	Assessing Environmental Impacts: Biodiversity Inclusive Impact Assessment (BIA) • Role of BIA in the existing EIA process • Identification, prediction and evaluation of impacts on biodiversity • Techniques of biodiversity impact assessment and monitoring, threat reduction methods; Case study	8	-
	Minor Test 1		1
4.	Strategic Environmental Assessment (SEA) • Defining an SEA and its importance • Comparing SEA and EIA • SEA arrangements and procedures • SEA aims, principles and elements of approach • Methodology of SEA with case studies of SEA	10	
5.	Integrative Approaches to Impact Assessment and Planning • Introduction • Horizontal integration of impacts in EIA • Vertical integration of EIA and Environment Management Systems • Integration of wider sustainability issues • Integrative methods and tools	6	
6.	Monitoring and Evaluation Basic concepts of monitoring and evaluation, guidelines tool for M&E (logic model, monitoring plan, evaluation plan), measures and indicators, evaluation designs and its	6	

	applications–case study		
	Assignment 4 Designing an integrated impact assessment strategy for any given problem. (assignment in groups of three students each).		4
	Minor Test 2		1
	Major Test		2
	Total	46	14

Textbooks

1. Shukla and Shrivastav, Concepts in environmental impact analysis, Common wealth Publication, 2000.
2. Environmental Impact Assessment, Selected reading, Wildlife Institute of India, 1991.
3. Biswas A.K, Environmental Impact Assessment, Tycooly International, 1987.
4. SINAR MAS pulp and paper (India), Ltd. Engineering Projects Pvt, Ltd. February, 1997
5. Natarajan Banerjee, Environment impact assessment and control measures adopted in Neyvelli lignite project, N.L.C Printing Press, 1985.
6. Environmental Impact study for Bongaigain refinery and petrochemicals, Ltd, Engineers India Ltd.
7. Trivedi, Environmental Impact Assessment, A P H Publishing Corporation, 2004.
8. Kulkarni and Ramchandra, Environment Management, Capital Publishing Company, 2006.
9. Desh Bandhu, Environment management, Indian environment Society, 1981.
10. Baumgartner Ruedi, The search for sustainable livelihood system sage Publications, 2004.
11. Bathwal R.R. (1988) *Environmental Impact Assessment*, New Age, International Publishers.
12. Canter L.W. (1996) *Environmental Impact Assessment*, 2nd Edn. New York, McGraw Hill.
13. Dale R. (2004) *Evaluating Development Programme and Project*, Second Edition, Sage Publication.
14. Lee N. and Kirkpatrick C. (Eds) (2000) *Integrated Appraisal and Sustainable Development in a Developing World*, Cheltenham, Edward Elgar.
15. Vanclay F. and Bronstein D.A. (1995) *Environmental and Social Impact Assessment*, Wiley Publishers.

Course No: EST 302

Course Title: Environmental Laws and Policies

Number of Credits: 4

No. of Lectures-Tutorial: 44-12

Course Coordinator: Adv. Gouri Joshi

Course Outline

The course aims at enhancing awareness about existing conservation / protection legislations and pollution control mechanisms. Participants will gain a deeper understanding of governance structures, process of legislation and the role of different legislative mechanisms in protection of natural resources. This course will enable participants to use the law as a tool in environment management.

Learning Outcomes

Students will :

- Understand the structure of Constitution, Government, and institutional setup useful for conservation and protection of environment
- Interpret the legal language of law
- Understand the function of law in solving problems presented to society through the natural sciences.

Pre-requisite

None

Evaluation Procedure : 0.6/0.4 University

Assignments	20 %	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment : 5 marks • Completed home assignment submitted timely and excellent written presentation (within 7 days): 5 marks	Assignments must be in the prescribed journal format. One journal may contain assignments of different elective courses separated by a separator. However each course must have a separate index duly signed by teacher. Marks for every assignment must	Internal Assessment

			reflect on the assignment itself.	
Minor Tests	20%	3 minor tests will be conducted		
Major exam	60%	Theory examination		University Exam

Details of course content and allotted time

Sr. No.	Topic	Time (Hours)	
		L	T
1.	Concept of Rule Law - Historical development - Jurisprudence- Sources of environmental law - Basic concepts and principles	4	
2	Bifurcation of laws - Civil Law - Criminal Law - Law of Torts	4	
3	Constitutional Law - Magna Carta - Salient features of Constitution including institutions of law - Important provisions related to Environment	6	-
	Assignment 1 A 5 page paper on a predecided topic to be submitted as per guidelines given by faculty.		4
4.	Forest Laws - Indian Forest Act, 1927 - Forest (Conservation) Act, 1980 - Forest Rights Act, 2006	8	
	Minor Test 1		1
5.	Other Conservation Legislations - Wildlife Protection Act, 1972 - BDA, 2002 - Wetland Conservation - CITES, India	6	

	• TRAFFIC		
	Assignment 2 Seminar presentation by individual students on predecided topics based on NGT cases		5
6.	Pollution Control Laws • Water (P & CP) Act, 1972 • Water (P & CP) Rules, 1973 • Water Issues and allied developments • Air(P & CP) Act, 1981 • Air (P & CP) Rules, 1982 • Noise Pollution Control Rules, 2002 • Water Issues and allied developments	6	
7.	Environment Protection Act • Environment (Protection) Act, 1986 • Different Notifications Ex. EIA, CMZ • Different Rules thereunder Ex. Waste Management Rules, Hazardous waste Handling and Disposal Rules etc.	10	
	Minor Test 2		1
	Total	44	12

Reference Books:

1. Mohanty S. K., Environment and Pollution Law Manual, Universal Law Publishing Vompany Ltd., 3rd edition, 2002.
2. Environment and Pollution Laws, Law Publishers, 2000.
3. Leelakrishnan P, Environmental Law in India, Butterworths, 2000.
4. Singh Kuldeep, Environmental Jurisprudence, Modern Law House, 2nd edition 2002.
5. ChoudhuriS.K, Environmental Legislations in India, Oxford and IBH Publishing 1996.
6. Pollution Control Acts, Rules and Notifications, Pollution Control Law Series – Volume – I, Central Pollution Control Board, 1992.
7. Conserving Life – Implications of Biodiversity conservations for India, Kalpavriksh, 1994.
8. Convention of Biological Diversity, World Wide Fund for Nature India 1992.
9. Singh Kuldeep, Handbook of Environment, Forest and Wildlife Protection Laws in IndiaNatraj Publishers, 1998.

10. The Environment (Protection) Act and Rules 1986, Law Publishers.
11. Traffic Bulletin, Traffic International.
12. Vanguri Kishore, Environmental Laws in India – A guide, C.P.R. Environmental Education Centre, Madras, 1994.
13. The Water (Prevention and Control of Pollution) Act, 1974 and Rules 1975, Akalank Publications, 1999.
14. The Air (Prevention and Control of Pollution) Act, 1981 Akalank Publication 1999.
15. The Indian Forest Act, 1927 along with Forest (Conservation) Act 1980, Indira Gandhi National Forest Academy, Natraj Publishers 2002.
16. The Wildlife (Protection) Act 1972, Natraj Publishers, 1994.
17. Understanding Biodiversity Law Module, Center of Environmental Education Research and Advocacy (CEERA)
18. Trivedy R.K., Handbook of Environmental Law, Acts, Guidelines, Compliances and Standards, Volume Environment Media, 1996.
19. Nair Manju, The Montreal Protocol – in the Indian Context, Centre for Environmental Law, WWF India, 1996.
20. Environmental Legislation in India – A guide for Industry and Business, Environment Management Division, Confederation of Indian Industry, 1999.

Course No: EST 311

Course Title: Dissertation

Number of Credits: 14

Evaluation Procedure: 0.6/0.4 University

Assessment 1 (February)	Internal	10%	<i>Presentation on introducing the topic and its feasibility (literature review and methodology to prove feasibility of the project)</i>
Assessment 2 (May)	Internal	15%	<i>Detailed literature review, methodology with data collection protocols,</i>
Assessment 2 (August-September)	Internal	15%	<i>Mid-course review. Presentation of results and preliminary analysis</i>
Major Exam (Phase 1) (November-December)	External	60%	University Assessment (Phase 1)

Guidelines for dissertation

Topic:Candidates will write a dissertation on issues related to environmental/geospatial issues under the guidance of their respective guides. Each student will work independently on the topic. The dissertation must consist of review of literature and produce a deep insight of the subject on the basis of personal research.

Initiation of work: Dissertation work will be initiated during the second semester during the course of the paper on Research Methodology. During the Research Methodology course in Semester II, students will be allotted guides (from within the faculty associated with the Institute) based on their area of interest. As part of their assignments in the Research Methodology course students will write their introduction and literature review.

Evaluation of thesis:The thesis will be evaluated in **two phases** over two semesters (third and fourth). **For the first phase** (in the third semester), 14 credits are allotted. The schedule for evaluation (internal and external) is given in the table above. For the University presentation the student is expected to submit one spiral bound copy of the thesis consisting of introduction, literature review, aims and objectives, methodology, data and preliminary analysis along with a content page and interim certificate signed by the guide. The dissertation should be typed on A4 size bond paper with 1.5 line spacing. Illustrations and photographs should be of high quality. Font to be used is Times New Roman or Arial with the text not less than 12 pt. Referencing must be done in Zotero or any other referencing software strictly in standard referencing style (Vancouver). The report should be flawless without any spelling mistakes and grammatical errors etc. If the dissertation contains such mistakes, the student will have to resubmit their dissertation after the necessary corrections.

Guidelines for presentation: For every presentation students will prepare a power point presentation highlighting the objectives, research question, methodology and key findings and defend the same. The presentation must not be texty. It should be aesthetically appealing and contain relevant graphs and analysis. Wordy presentations are likely to get marked down. Students should be smartly dressed and speak in a clear voice. Do ensure that your presentations are loaded as per the given deadlines.

The student will be permitted to appear for the second phase of the thesis ONLY if he/she has cleared the first phase.

Course No: EST 304

Course Title: Internship

Number of Credits: 4

Course Coordinator: Dr. Kranti Yardi

Course Outline

The internship of two month duration to be completed during the break between the second and the third semester is an opportunity for students to develop research skills and/or gain professional expertise as well as academic knowledge. Students must plan for the internship towards the end of the first semester itself. While the Institute will facilitate the placement for internships, students are encouraged to find placements for internships and make initial contact with prospective organization as this builds skills of communication.

Learning Outcomes

- Plan, execute and present findings of tasks completed in the two month period.
- Write concisely and effectively in order to communicate concepts and ideas in a logical and coherent manner.
- Produce effective data presentations and use them to enhance the communication of quantitative information.
- Work effectively in a team.

Pre-requisites

The student must apply for the internship/scan internship opportunities atleast six to eight months in advance. Requisite correspondence with the concerned organization is the responsibility of the student. The Institute will support with a letter of intent.

Throughout the internship, the student must maintain a work log that includes dates, time spent on site, and a summary of the work performed and its relevance. An updated copy of the log must be turned into the supervisor (at the place of work) and the faculty supervisor in the form of monthly reports. The student must meet with the supervisor (at the place of work) on a regular schedule (determined by the supervisors at their discretion). The supervisor must be willing to submit a written evaluation of the student at the conclusion of the internship.

Evaluation: Continuous

End project report submitted with a report by the supervisor	Within fifteen days of completion of the internship (1 st August)	40%	Details of tasks assigned, tasks completed till date
Presentation on internship	As per University schedule	40%	Detailed presentation of tasks completed with concrete outcomes and learnings.

Format of Internship Report

1. Cover page with title, your name and name of company
2. Certificate from the employer on employer letterhead stating tasks completed and level of achievement and

Name of the student

Place of internship

Supervisor

Duration of internship (Date of commencement of internship – date of completion)

3. Background of the organisation
4. Introduction
5. Objectives
6. Tasks done with methodology and date
7. Outputs
8. Learnings (to be added only for final report, not interim report)
 - A. Work experience
 - B. Academic and scientific and experience
 - C. Social and cultural experience

The internship report should be typed on A4 size bond paper with 1.5 line spacing. Illustrations and photographs should be of high quality. Font to be used is Times New Roman or Arial with the text not less than in 12 pt. Referencing must be done in Zotero or any other referencing software in standard referencing style (Vancouver) for both intext citing and bibliography. The report should be flawless without any spelling mistakes and grammatical errors etc. If the report contains such mistakes, the student will have to resubmit their dissertation after the necessary corrections. The students are expected to prepare 3 copies (Spiral Bound/ Wiro Bound). Two copies of the report with original certificates in both must be submitted. Good photos of the student in the place of internship (in action) must also be included in the report apart from other relevant photos.

Logo of the Bharati Vidyapeeth University must be inserted on the cover page. Take care to see that it is not stretched.

Course No: GEO 303

Course Title: Applications of geospatial technologies

Number of Credits: 4

No. of Lectures-Tutorial: 45-15

Course Coordinator: Mr. Lakshmikanta Kumar

Pre-requisite

GEO 102

Evaluation Procedure : Continuous

Assignments	40 % (3)	Marking pattern for every assignment - Innovativeness and accuracy in completing the assignment - Completed home assignment submitted timely and excellent written presentation	Assignments must be in the prescribed format. One journal may contain assignments of different elective courses separated by a separator. Index must reflect all the assignments duly signed by the concerned teacher. Marks for every assignment must reflect on the assignment itself.	Internal Assessment
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Remote sensing and GIS applications in ecosystem, forest studies and conservation Key concepts in ecosystem studies: ecosystem services,	8	

	threats to ecosystems, management of ecosystems, classification levels • Key concepts of forest types, distribution, forestry practices, forest management • Satellites commonly used in forest studies • Satellites commonly used in ecosystem studies: global, national, regional, local, micro levels • Vegetation Indices used- NDVI, SAVI, Tassel Capped Index • Agencies involved (ancillary data sources) Case studies • Biodiversity characterization • Monitoring ecosystems (forests, wetlands) • Landuse/landcover classification (state level) • Human - Wildlife conflicts • EIA using GIS & RS • Habitat evaluation, Corridor mapping • Eco-tourism using advanced techniques like PDA • Forest fire risk zone mapping • Forest / vegetation classification and mapping. • Forest inventory and sampling technique. • Forest carbon management/sequestration • Using LIDAR data in forestry management • Wildlife Habitat Suitability Analysis with respect to : Statement of problem, feasibility of RS and GIS, methodology (flow chart) for each case study, RS needs (satellite, resolution, seasons, method of classification, vegetation indices), field studies needed and methodology used for the same, GIS database building (layers-sources, methods), analysis tools (GIS, statistical).		
	Assignment 1 Hands on session with any one application (demo followed by an exercise and presentation)		2
2	Remote sensing and GIS applications in agricultural applications • Key concepts in agriculture: problems in agriculture, agricultural impact on the environment, sustainable	6	

	agriculture, global significance of agriculture • Satellites commonly used for agricultural studies • Vegetation Indices - NDVI, SAVI, TasselCapped Index, remote sensing properties of soil • Agencies involved (ancillary data sources) Case studies • Crop yield estimation • Crop disease monitoring • Crop water requirement • Soil Mapping • WebGIS for agriculture • Precision farming with respect to : Statement of problem, feasibility of RS and GIS, methodology (flow chart) for each case study, RS needs (satellite, resolution, seasons, method of classification, vegetation indices), field studies needed and methodology used for the same, GIS database building (layers-sources, methods), analysis tools (GIS, statistical).		
	Assignment 2 Hands on session with any one application (demo followed by an exercise and presentation)		2
3	Remote sensing and GIS applications in urban application • Satellites commonly used for urban studies • Agencies involved (ancillary data sources) Case Studies • Urban Sprawl • Land Information Systems • Utilities management (water, sewage) • Fringe Area Development • Planning of facilities (green spaces, hospitals, etc) • Emerging Technologies • Urban heat islands with respect to : Statement of problem, feasibility of RS and GIS, methodology (flow chart) for each case study, RS needs (satellite, resolution,	8	

	seasons, method of classification, vegetation indices), field studies needed and methodology used for the same, GIS database building (layers-sources, methods), analysis tools (GIS, statistical).		
4	Remote sensing and GIS applications in water resources and related applications • Satellites used • Agencies involved (ancillary data sources) Case Studies • Groundwater modeling • Bathymetric mapping • Watershed development and management • Water Resource Assessment and Preparation of Management Planning Strategy • Water pollution monitoring/assessment • Vulnerability assessment of rivers/ waterbodies with respect to : Statement of problem, feasibility of RS and GIS, methodology (flow chart) for each case study, RS needs (satellite, resolution, seasons, method of classification, vegetation indices), field studies needed and methodology used for the same, GIS database building (layers-sources, methods), analysis tools (GIS, statistical).	8	
	Assignment 3 Hands on session with any one application (demo followed by an exercise and presentation)		2
5	Remote sensing and GIS applications in health studies • Key concepts: causes of epidemics, basic concepts of epidemiology-transmission of diseases, responsible environmental factors, challenges in disease / health management • Agencies involved (ancillary data sources) Case studies • Disease mapping (3 case studies from different parts of	8	

	the world) • WebGIS for human health issues • GIS as a tool for monitoring Health Management Information System • Environment Mapping for Viral Disease Survey • Emergency Medical Systems • Access to health care with respect to : Statement of problem, feasibility of RS and GIS, methodology (flow chart) for each case study, RS needs (satellite, resolution, seasons, method of classification, vegetation indices), field studies needed and methodology used for the same, GIS database building (layers-sources, methods), analysis tools (GIS, statistical).		
	Remote sensing and GIS applications in Utilities • Key concepts of utilities-power, telecom, transport • Satellites commonly used in utilities • Agencies involved (ancillary data sources) Case studies • GIS in management of electricity distribution network • GIS for power plant site selection (hydro, thermal) • GIS in telecommunications • GIS in transportation design and management • Managing sewage/water supply systems through GIS • GIS in monitoring of infrastructure projects • GIS in business applications (2 case studies) with respect to : Statement of problem, feasibility of RS and GIS, methodology (flow chart) for each case study, RS needs (satellite, resolution, seasons, method of classification, vegetation indices), field studies needed and methodology used for the same, GIS database building (layers-sources, methods), analysis tools (GIS, statistical).	7	
6.	Remote sensing and GIS applications in Utilities • Key concepts of utilities-power, telecom, transport • Satellites commonly used in utilities • Agencies involved (ancillary data sources)	5	

	Case studies • GIS in management of electricity distribution network • GIS for power plant site selection (hydro, thermal) • GIS in telecommunications • GIS in transportation design and management • Managing sewage/water supply systems through GIS • GIS in monitoring of infrastructure projects • GIS in business applications (2 case studies) with respect to : Statement of problem, feasibility of RS and GIS, methodology (flow chart) for each case study, RS needs (satellite, resolution, seasons, method of classification, vegetation indices), field studies needed and methodology used for the same, GIS database building (layers-sources, methods), analysis tools (GIS, statistical).		
	Assignment 4 Hands on session with any one application (demo followed by an exercise and presentation)		2
	Total	50	8

Reference Books

- Subudhi A P,B. S. Sokhi, P. S. Roy, Remote Sensing and GIS Application in Urban and Regional Studies, IIRS,2001
- Roy. P. S, Natural Disaster and their Mitigation, IIRS, 2000.
- Roy P S, Biodiversity Characteristics at Landscape Level in North East using satellite Remote AndGeographical Information System, IIRs, 2002.
- Roy P S, Forest Cover Assessment in Asia, IIRS, 2002.
- Roy P S, Biodiversity and Environment, IIRS, 2000.
- Sudershana R, D Mitra, Mishra , P.S Roy., D.P Rao, Subtle Issues in Coastal Management, IIRS, 2000.
- Deekshatulu B. L., Description and use of Landuse/ Landcover, NRSA, 1990.
- Remote Sensing for Sustainable Development, Proceedings of National Symposium organized by ISRS and RSAC, ISRS, Nov 1992.
- Proceeding of National Symposium on RS for Agricultural Application held at New Delhi, ISRS/IARI, Dec 1990.

- Proceedings of ISPRS Commission VII Symposium Resource and Environmental Monitoring, Hyderabad, Dec 2002.
- Pre-Symposium Tutorial on Sustainable Agriculture (Volume of Lectures), Dec 2002, NRSA
- National Agricultural Drought Assessment and Monitoring System, India, Summary Report, Sept 2001.
- ISPRS Technical Commission VII Symposium on Resource and Environmental Monitoring and ISRS Annual Convention- ABSTRACTS, NRSA, Dec 2002.
- Spatial Technologies for Natural Hazards Management (Proceedings of ISRS National Symposium Nov 21-22, 2000, IIT Kanpur)
- Application of RS and GIS in Disaster Management, Lectures notes by CSSTEAP, IIRS.
- Forest Resource Management, Lectures notes by CSSTEAP, IIRS.
- Application of RS and GIS in Marine Sciences, Lectures notes by CSSTEAP, IIRS.
- Application of RS and GIS in Urban Mapping, Lectures notes by CSSTEAP, IIRS.
- Application of RS and GIS in Geosciences, Lectures notes by CSSTEAP, IIRS.
- Application of RS and GIS in Water Resources, Lectures notes by CSSTEAP, IIRS.

Course No: EST 305

Course Title: Urban Environment Management

Number of Credits: 4

No. of Lectures-Tutorial: 45-15

Course Coordinator/Instructor: Ms. Samruddhi Pathak

Course outline

With increasing urbanisation all across the world there are rapid changes in quality of life and living space. This course provides an overview of present management of urban areas both nationally as well as internationally with special reference to the environmental aspects. The course will provide a practical insight into the development process of an urban area keeping in mind open spaces, basic needs like water supply and sanitation, protection from disasters, traffic issues and overall governance of a city. Various economic and social policies involved in urban housing and slums and importance of environment laws and management in today's urban areas will be discussed.

Learning Outcomes

At the end of the course students will :

- Develop an understanding of the urban environment.
- Develop an understanding of the process of urban planning and governance in India
- Develop skills of analysis of urban issues especially housing – formal and informal, disasters affecting urban areas, transportation issues, green spaces, open spaces and zoning and bye laws in urban areas
- Develop an insight into the importance of development plans and their processes.

Evaluation Procedure : 0.6/0.4 University

Assignments	40 % (3)	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment • Completed home assignment submitted timely and excellent written	Assignments must be in the prescribed format. One journal may contain assignments of different elective courses separated by a separator. Index must reflect all the assignments duly	Internal Assessment

		presentation	signed by the concerned teacher. Marks for every assignment must reflect on the assignment itself.	
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Introduction - Basic concepts of planning and development planning, bye-laws, surveys, landuse etc. levels of planning - Planning as a tool for development and control - Historical planning and environmental concerns from ancient times to contemporary developments Environmental incorporation through planning principles, infrastructural provisions and utility layouts	6	
2	Urbanization and its impacts - Urban concentration and its impacts on natural and urban resources - Causes of degeneration - Core and peripheral area developments Planning development and its impacts Urban climatology - Urban form and energy usage - Climate responsive interventions Ancient and contemporary case-studies	6	
	Assignment 1 Analysis and written presentation (individual) and oral presentation (in groups of three students) of the environmental problems in the urban fringe		4
3	Disasters and urbanization Impacts of disasters on urban areas City collapse – trends from ancient to modern times	5	
4	Housing	6	

	• Brief introduction to various concepts of demand, need, supply, tenures, densities, income groups etc. • Characteristics of urban housing • Urban forms of housing • Indian housing scenario • Housing economics		
5	Slums • Introduction • Causes of slums, characteristics of slums • Impacts of slums on the urban city image, slum improvements and prevention of slums	4	
	Assignment 2 Analysis and written presentation (individual) and oral presentation (in groups of three students) of the environmental problems in informal housing sector.		5
6	Urban traffic • Concerns • Types of roads • Requirement of good roads • Traffic management • Urban traffic problems • Mass vs individual transportation systems • Impacts of roads and vehicles over environment	4	
7	Urban utility planning • Water, solid waste, waste water, garbage etc. Norms and standards • Spatial, social, economic and environmental considerations	4	
	Assignment 3 Analysis and written presentation (individual) and oral presentation (in groups of three students) of water management in the urban sector. OR Analysis and written presentation (individual) and oral presentation (in groups of three students) of urban green spaces.		5

8	Open space provisions • Requirement and needs • Hierarchy and importance • Urban social infrastructure planning • Urban environment and environmental status • Public private partnerships • Role of various non-governmental agencies and organisations in environmental upkeep	4	
9	Planning laws and environment • Historical perspective • Mega projects and developmental control and concerns New town developments Planning agencies • Duties and responsibilities • Environmental agendas • Efforts undertaken for environmental conservation and upgradation • Globalisation and urbanisation Consumptive changes and its impacts on cities	6	
	Major Test 3		2
	Total	45	15

Suggested Readings

1. Bhatt S, Environment Protection and Sustainable Development, A.P.H.Publishing Corporation, 2004.
2. Rangwala, Town planning, Charotar Publishing House, Eighteenth Edition, 2003.
3. Bandyapadhyay A, Town Planning, Books and Allied Ltd, 2002.
4. Koperdekar and Diwan, Urban and Regional Planning – Principles, Practice and Law, Sudhanwa Kopardekar Publishers, 1994
5. Hiraskar G. K, Fundamentals of Town Planning, Dhanpat Rai Publications Ltd, 1997.
6. Khosla P.K, D.K.Uppal, R.K.Sharma, R.K.Kohli, Y.C.Jain, Ecofriendly Trees for Urban Beautification. Indian society of tree scientists, Jolan and National Horticulture Board, Gurgaon, 1996.
7. Cerver Francisco, Urbanismo – Urban Planning, Axis Books
8. Ohri M. L, Water Supply and Sanitary Engineering, India Publishing House, 1995.

Course No: EST 306

Course Title: Environment Management techniques

Number of Credits: 4

No. of Lectures-Tutorial: 45-15

Course Coordinator: Mr. Mahesh Kulkarni

Course Outline

The course provides an indepth insight into the various environment management techniques embedded in the concept of sustainability. Tools such as certification, life cycle analysis, cost benefit analysis as well as various aspects of environmental design are dealt with in details. The course is designed to build detailed knowledge, understanding and skills among students about the concepts and technical skills for environment management so that they are able to identify sustainable modes of environmental operation.

Pre-requisite

None

Evaluation Procedure : Continuous

Assignments	40 % (3)	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment • Completed home assignment submitted timely and excellent written presentation	Assignments must be in the prescribed format. One journal may contain assignments of different elective courses separated by a separator. Index must reflect all the assignments duly signed by the concerned teacher. Marks for every assignment must reflect on the assignment itself.	Internal Assessment
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1.	Sustainable Development (SD) - Goals, concept of sustainability - Approaches towards sustainability - Concept of ecological footprint, application of ecological footprint in SD, effects of quality of life on environment.	2	
2.	ISO 14000 and 14001 - Environment Management System: Definition, general requirements, why do we need EMS, EMS technology, Elements of EMS. - Implementation and Documentation: General information, essential documents, environment related legal requirements, implementation of EMS. - ISO 14000 and ISO 14001: About ISO, background of ISO 14000, ISO 14000, ISO 14001, management principles for adopting ISO 14000, correlation between ISO 9000 and ISO 14000	08	
3.	Environment Management tools Environmental auditing: Definition and scope, types of audits, Audit methodology (basic structure of EA, EA steps), Elements of audit process, waste audit and pollution prevention, assessment of EA in industrial projects, auditing of EMS (audit objectives, roles, responsibilities, scope and review, preparing the audit, conducting the audit, content of audit report	08	
	Assignment 1: Develop a format to conduct and environment audit for a selected industry (sector)(Work in groups of three students)		4
	Life Cycle Assessment (LCA): Definition, stages in product LCA, procedure for LCA (defining the goal, scope, analyzing the inventory, assessing environmental impact, evaluating environmental profiles, Applications of LCA (private sectors and government applications)	10	
	Assignment 2: Life cycle Assessment of packaged drinking		5

	water		
	Environmental Design (ED): Scope and principles of ED, benefits of ED, ED for manufactured products (ED considerations in product life stages, ED tools for products (checklists, LCA, matrices, eco-indices), concept of eco-labeling; ED for buildings (green buildings, principles of green buildings, ED strategies for building construction), examples of ED	10	
	Assignment 3: Using the MET (materials, energy, toxicity) matrix perform an assessment of environment design for a given product.		
	- Cost Benefit Analysis - Environmental taxes (carbon emission taxes) - Environmental marketing (green marketing)	5	
	Assignment 4: Using a structured format analyze cost benefit aspect for a given project/product.		2
	Total	45	15

Suggested Readings

1. Shukla and Shrivastav, Concepts in environmental impact analysis, Common wealth Publication, 2000.
2. Environmental Impact Assessment, Selected reading, Wildlife Institute of India, 1991.
3. Biswas A.K, Environmental Impact Assessment, Tycooly International, 1987.
4. SINAR MAS pulp and paper (India), Ltd. Engineering Projects Pvt, Ltd. February, 1997
5. Natarajan Banerjee, Environment impact assessment and control measures adopted in Neyvelli lignite project, N.L.C Printing Press, 1985.
6. Environmental Impact study for Bongaigain refinery and petrochemicals, Ltd, Engineers India Ltd.
7. Trivedi, Environmental Impact Assessment, A P H Publishing Corporation, 2004.
8. Kulkarni and Ramchandra, Environment Management, Capital Publishing Company, 2006.
9. DeshBandhu, Environment management, Indian environment Society, 1981.
10. Baumgartner Ruedi, The search for sustainable livelihood system sage Publications, 2004.

Course No: EST 307

Course Title: Advanced Pollution Control Technology

Number of Credits: 4

No. of Lectures-Tutorial: 45-15

Course Outline

The course provides an indepth insight into the various pollution control technologies and also green technologies. Various technologies to ensure air,water, waste water will be discussed in detail. The course is designed to build detailed knowledge, understanding and skills among students about technologies for pollution abatement and control.

Pre-requisite

None

Evaluation Procedure : Continuous

Assignments	40 % (3)	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment • Completed home assignment submitted timely and excellent written presentation	Assignments must be in the prescribed I format. One journal may contain assignments of different elective courses separated by a separator. Index must reflect all the assignments duly signed by the concerned teacher. Marks for every assignment must reflect on the assignment itself.	Internal Assessment
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1.	• Advances in air pollution control • Air pollution control in industries: Fertilizer, Pharmaceutical, cement manufacturing, mining,	7	

	plating, automobile, paint booths, etc.(Manufacturing process, sources and control) Design: Gravity settler, cyclone, Fabric filters, ESP		
	Assignment 1: Design of one unit		4
2.	Advanced wastewater treatments - Tertiary treatments: Significance, Colour removal (Activated Carbon Adsorption,) nutrient removal (Nitrification and de-nitrification, nitrogen stripping), phosphorus removal (Biological and chemical precipitation method) , ion exchange, etc - Membrane processes: Objectives, Principle and working mechanism of ultrafiltration, reverse osmosis, electrodialysis	6	
	Assignment 2: Design of one unit		4
3.	Industrial effluents Waste water management: End of pipe treatment, polluter pays principle, art of control of pollution, waste reduction, recycling and reuse, Common Effluent Treatment Plant Sources of waste water from different industries (Sugar industry, distillery, dairy, fertilizer, pharmaceutical, textile and dyeing industry, pulp and paper, automobile, electroplating etc), characterization of industrial effluents, treatability analysis, flow sheets for effluent treatment plant, Flow measurement, quantification	14	
4	Effluent treatment plant - Significance of Equalization and Neutralisation process, - Design of unit operations: Design criteria for Screens, grit chamber, oil and grease trap, design of bar screen, grit chamber - Modifications of Activated Sludge Process (Extended aeration, stepped aeration, tapered aeration, contact stabilization, oxidation ditch) - Design of biological process: Design criteria for conventional and modified ASP (including oxygen requirement and sludge return)	15	

	• Design criteria for trickling filter, design of trickling filter • Design consideration for anaerobic digester, principle and working mechanism of up-flow anaerobic sludge blanket process • Design of for oxidation pond and lagoon • Design of septic tank Layout of effluent treatment plant, general considerations for location of sewage treatment plant		
	Assignment 3: Design of one unit		4
5	Optimization Techniques • Waste minimization • Reduction of wastewater quantity (reuse, recycling) • Strength reduction by recovery, application in different industries, case studies	3	
	Total	45	15

Suggested Readings

1. Bhatiya S.C., Hand book of industrial pollution and control, Volume I and II, CBS Publishers & Distributors, 2002.
2. Metcalf and Eddy, Wastewater engineering treatment and reuse, Tata Mc-Grawhill Publishing Company Ltd, 4th edition, 2003.
3. Gaikwad, R.S. Sapkal Environmental Engineering Denett & Co. 2006
4. Rao M. N. and H. V. N. Rao, Air pollution, Tata Mc-Grawhill Publishing Company Ltd, 1989.
5. Paevy, Rowe and Tschobanoglous, Environmental Engineering, Tata Mc Graw Hill Publishing Company Ltd, 1995.
6. Pandey G.N. and G.C. Carney Environmental engineering, Tata Mc Graw Hill Publishing Company Ltd, 1994.
7. Metcalf and Eddy, Wastewater engineering: Treatment, disposal and reuse, Tata Mc Graw Hill Publishing Company Ltd, 3rd edition, 1991.
8. Rangawala S.C, Water supply and sanitary engineering, Charotar Publishing House, 2005.
9. Punmia B.C and Ashok Jain, Wastewater engineering, Laxmi Publications, 2005
10. Shukla S.K. and P.K. Shrivastav, Waste management and control, Common Wealth Publishers, 1992.
11. Noyer Robert, Unit operations in environment engineering, JAICO publishing House, 2005.

Course No: CA 101

Course Title: Human Ecology

Number of Credits: 4

No. of Lectures-Tutorial: 42-9

Course Coordinator: Dr. Kranti Yardi

Course Outline

The course applies the principles of ecosystem sciences to the study of the human environment. The emphasis is on the significance and function of ecosystems, how humans have affected these systems over time, and what are the opportunities of and barriers to making positive changes. Dynamical systems' thinking is introduced as a means of comprehending the behavior of these complex situations. Human-nature interactions over human history are critically reviewed, including hunter gatherer societies, early agricultural societies and modern globalised urban and industrial societies through relevant case studies. Field trips allow students to experience firsthand the complexity of these human-ecological interactions and the challenges of managing them sustainably.

Learning Outcomes

Students will:

- Demonstrate a good understanding of human ecology, including knowledge of the history and background to the topic
- Demonstrate an understanding of key ecosystem and social processes and how they relate to human-nature interactions, and to integrate this understanding with knowledge drawn from their own undergraduate, workplace or research backgrounds
- Use systems approach to 'get at' an understanding of the complex, multi-scaled, interactions that characterize human-ecological situations, and their associated problems
- Understand both opportunities of and barriers to making positive changes in human-nature interaction.
- Develop an ability to critically analyze, evaluate and judge competing perspectives on the environment and development.

Pre-requisite

None

Evaluation Procedure

Assignments	40 % (3)	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment • Completed home	Assignments must be in the prescribed format. One journal may contain assignments of different elective courses separated by	Internal Assessment

		assignment submitted timely and excellent written presentation	a separator. Index must reflect all the assignments duly signed by the concerned teacher. Marks for every assignment must reflect on the assignment itself.	
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Introduction - Fundamental principles of human ecology - Understanding habitat, community and landscape - Understanding sustainable development	4	
2.	Evolution and human society - Evolution of the ecosystem and growth of human society in different landscapes; hunters and gatherers, pastoralism, agricultural development, urbanization (from prehistory to present) - Human population history; Exponential population growth; positive and negative feedback	10	
2	Perceptions towards nature - Common perceptions of nature; traditional ecological knowledge - Attitudes of religions towards nature - Coevolution and coadaptation of human social systems and ecosystems – coadaptation in traditional social systems and modern systems	8	
	Minor test 1		1

	Assignment 1 Discussion and presentation of selected research paper in groups of three students.		4
3	Control, Conflict and Development ▪ Early environment and community debate (forest and community) ▪ Ecological change, development and social tension, human –wildlife conflict ▪ Critical review of community based practices in India using case studies	10	
	Minor test 2		1
	Assignment 2 Seminar presentation by individual students on predecided topics.		2
5	Community Resource Management in practice Joint Forest Management – principles, problems, advantages using case studies Ecodevelopment – Success and the way forward	10	
	Major test 3		1
	Total	42	9

Assignments

In the assignments the students will carry out a review of community-nature interactions that are related to the subject or topics students have worked on during the field trips or any current issue.

Suggested Readings

1. Bernis, C. and M. Sandin. 1987. *Prospecting Human Ecology*. Madrid: Universidad Autonoma de Madrid.
2. Borden, R.J. 1984. *Directory of Human Ecologists*. College Park, MD: Society for Human Ecology.
3. Borden, R.J., J. Jacobs and G.L. Young (eds.). 1985. *Human Ecology: A Gathering of Perspectives*. College Park, MD: Society for Human Ecology.
4. Borden, R.J., J. Jacobs and G.L. Young (eds.). 1988. *Human Ecology: Research and Applications*. College Park, MD: Society for Human Ecology.

5. Borden, R.J. and J. Jacobs. 1989. *International Directory of Human Ecologists*. Bar Harbor, ME: Society for Human Ecology.
6. Cohen, J. 1995. *How Many People Can the Earth Support?* New York: Norton and Co.
7. Eisenberg, E. 1998. *The Ecology of Eden*. New York: Knopf.
8. Grossman, E. 2006. *High Tech Trash: Digital Devices, Hidden Toxics and Human Health*. Washington, D.C.: Island Press.
9. Huib, E. (ed.). 1994. *Pathways to Human Ecology: From Observations to Commitment*. Bern, Switzerland: P. Lang.
10. McDonnell, M.J. and S.T. Pickett. 1993. *Humans as Components of Ecosystems: The Ecology of Subtle Human Effects and Populated Areas*. New York: Springer-Verlag.
11. Miller, J.R., R.M. Lerner, L.B. Schiamberg and P.M. Anderson. 2003. *Encyclopedia of Human Ecology*. Santa Barbara, CA: ABC-CLIO.
12. Nathawat, G.S., Z. Daysh and G.J. Unnithan (eds.). 1985. *Human Ecology: An Indian Perspective*. Jaipur, India: Indian Human Ecology Council.
13. Ostrom, E., T. Dietz, N. Dolsak, P.C. Stern, S. Stonich, and E.U. Weber(eds.). 2002. *The Drama of the Commons*. Washington D.C.: National Academy Press.
14. Pratt, J., G.L. Young and J. Jacobs. 1990. *Human Ecology: Steps to the Future*. Sonoma, CA: Society for Human Ecology.
15. Sargent, F. (ed.). 1974. *Human Ecology*. New York: American Elsevier.
16. Siniarska, A. and F. Dickinson. 1996. *Annotated Bibliography in Human Ecology*. Delhi, India: Kamla-Raj Enterprises.
17. Sontag, M.S., S.D. Wright, G.L. Young and M. Grace. 1991. *Human Ecology: Strategies for the Future*. Ft. Collins, CO: Society for Human Ecology.
18. Suzuki, T. and R. Otsuka. 1987. *Human Ecology of Health and Survival in Asia and the South Pacific*. Tokyo, Japan: University of Tokyo Press.
19. Theodorson, G.A. 1961. *Studies in Human Ecology*. Evanston, IL: Row, Peterson and Co.
20. Wang, R. 1990. *Human Ecology in China*. Beijing, China: China Science and Technology Press.
21. Wright, S.D., R. Borden, M. Bubolz, L. Hens, J. Taylor and T. Webler. 1995. *Human Ecology: Progress Through Integrative Perspectives*. Fort Collins, CO: Society for Human Ecology.
22. Young, G.L. (ed.). 1989. *Origins of Human Ecology*. Stroudsburg, PA: Hutchinson Ross.

Course No: EST 303

Course Title: Environmental Modeling

Number of Credits: 4

No. of Lectures-Tutorial: 45-15

Course Coordinator:

Course Outline

The environmental problems result from a complex interaction of physical, chemical and biological processes, involving land, water, air and energy resources that significantly affect human activities and attitudes. The complex and multidisciplinary nature of environmental problems requires that they are dealt in an objective and integrated manner. Quantitative tools provide the requisite objectivity in environmental decision-making. These tools help in investigating, understanding, representing the current and predicting the future state of environment and generating 'what-if' scenarios under alternative policy interventions. These are crucial for any integrated environmental assessment and management strategy. This course aims to provide introduction to the fundamental modeling concepts through use of geospatial technologies for application in various sectors.

Learning Outcomes

At the end of the course, students will:

- Be proficient in designing models
- Test the accuracy of their models, perform sensitivity and uncertainty analyses

Pre-requisites (mandatory)

GEO 102: Fundamentals of geoinformatics

GEO 203: Digital Image Processing

Evaluation Procedure : Continuous

Assignments	40 %	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment : 5 marks • Completed home assignment submitted timely and excellent written presentation (within 7 days): 5 marks	Assignments must be in the prescribed journal format. One journal may contain assignments of different elective courses separated by a separator. However each course must have a separate index duly signed by teacher. Marks for every assignment must reflect on the	Internal Assessment

			assignment itself.	
Major exam	60%	Theory and practical examinationa		Internal Assessment

Details of course content and allotted time

Sr. No.	Topic	Time (Hours)	
		L	T
1.	Introduction Modelling: scope and problem definition, goals and objectives, definition; modelling approaches– deterministic, stochastic and the physical approach; applications of environmental models; the model building process	02	
2	Ex. 1: Vector based modeling – Regression Analysis (Linear and Regression) (ArcGIS)	05	
4	Ex. 2: LULC Temporal-Spatial Change Analysis (IDRISI)	05	
5	Ex. 3: Connectivity Analysis /Corridor (ArcGIS)		
6	Ex. 4: Urban Modeling Cellular Automata	05	
7	Ex. 5: Hydrological Modeling (SWAT)	05	
8	Ex. 6: Species modeling (ENFA)	05	
9.	Ex.7: Habitat Suitability Analysis (HSI)	05	
10.	Ex. 8: SatSan	05	
	Total	36	10

Suggested Readings

All relevant material will be provided as handouts. Students can also refer to the following books.

1. Maguire, Batty, & Goodchild: GIS, Spatial Analysis, and Modeling. ESRI Press, 2005.
2. Clarke, K. et. al.: Geographic Information Systems and Environmental Modeling. Prentice Hall, 2001.
3. DeMers, M.: GIS Modeling in Raster. Wiley, 2002.
4. Goodchild et. al.: GIS and Environmental Modeling: Progress and Research Issues. GIS world, Inc., 1996.

Course No: GEN 301

Course Title: Personality Development

Number of Credits: 2

No. of Lectures: 30

Course Coordinator:

Evaluation Procedure : Continuous

Assignment	1	50%	Internal Assessment
Assignment	2	50%	Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Introduction to Personality a) Basic of Personality b) Human growth and Behavior c) Theories in Personality d) Motivation Communication skills and Personality Development a) Intra personal communication and Body Language b) Inter personal Communication and Relationships c) Leadership Skills d) Team Building and public speaking	07	
	Assignment 1		4
2	Techniques in Personality development I a) Self confidence b) Mnemonics c) Goal setting d) Time Management and effective planning	07	
3.	Techniques in Personality Development II a) Stress Management b) Meditation and concentration techniques c) Self hypnotism d) Self-acceptance	08	
	Assignment 2		4
	Total	22	8

Course No: GEN 302

Course Title: Communication

Number of Credits: 2

No. of Lectures-Tutorial: 24-8

Course Coordinator: Dr. Shamita Kumar

Course Outline

The course provides an outline of how to develop communication skills with an emphasis on scientific writing, proposal preparation and scientific but attractive way of presentation of research findings along with proper means of audio-visual documentation. The course prepares students to think, read and write scientific papers; conceptualize, frame and prepare complete project proposals and also will help them to realize the basics of audio-visual communication systems.

Learning Outcomes

The student will be able to:

- Think, read and prepare scientific manuscripts
- Conceptualize, frame and prepare project proposals
- Prepare oral presentations and posters
- Document, edit and publish findings in field and related topics

Pre-requisite

None

Evaluation Procedure

Assignment	1	50%	Internal Assessment
Assignment	2	50%	Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	Technical writing Outlining content • Organizing content: Checklist for components of journal articles and research papers • Difference between Abstract and Executive Summary	8	

	• Writing an Introduction and Conclusion • Using logic to present content: the building blocks of analytical writing • Using graphics to represent data: making data more readable and using graphics to present analysis • Using keywords to enhance search: Effective use of keywords to enhance online reach of your articles Using language effectively • Using effective words and editing content: Using a tool kit for writing; what to avoid when writing • Creating flow of information: understanding the difference between listing or cataloguing details and analyzing and interpreting them for your reader Submitting papers • Understanding submission guidelines • Using appropriate resources • Handling manuscript rejections		
	Assignment 1		
2	Preparing project proposals • Mapping the donor needs to organisational needs • Structuring content • Specifying deliverables and timelines • Asking for commitment • Checklist for a complete proposal	6	
3	Oral and Poster Presentations • Designing the presentation and flow of content • Communicating with the audience: verbal and non-verbal soft skills • Using visuals effectively: basics of using graphics, illustrations and copyright issues	4	
	Assignment 2		
4	Visual Documentation • How to take a good picture • Videos • Video documentation and editing clips with movie maker • Using keywords for cataloguing and for online	6	

	search engine optimization		

SEMESTER IV

No: EST 401

Course Title: Eco-restoration, Eco-development and Ecotourism

Number of Credits: 4

No. of Lectures-Tutorial/Assignment: 35-25

Course Coordinator: Dr. Rahul Mungikar

Course Outline

The objectives of the course are to make students familiar with the restoration methods of different fragile ecosystems such as wetlands as well as develop an understanding of restoring degraded waste land in urban landscape. The ecotourism section of the syllabus will familiarize students with using this approach for community involvement in the conservation scenario with special emphasis on Indian context.

Learning Outcomes

The student will :

- Have a deep understanding of eco-restoration including different approaches applicable for the restoration practices of different landscapes.
- Design an ecorestoration program for a specific ecosystem
- Design an ecotourism plan for a given location.

Pre-requisite

None

Evaluation Procedure : Continuous

Assignments	40 % (3)	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment • Completed home assignment submitted timely and excellent written presentation	Assignments must be in the prescribed I format. One journal may contain assignments of different elective courses separated by a separator. Index must reflect all the assignments duly signed by the concerned teacher. Marks for every assignment must reflect on the assignment itself.	Internal Assessment
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T/A
1	Fundamentals of Eco-restoration • Definition and different concepts of eco-restoration • Restoration of degraded waste land • Restoration of degraded forests and soil fertility • Groundwater restoration • Restoration of wetlands and coastal habitats • Restoration of habitats in urban and industrial areas • Indicators for restoration and reclamation	10	
	Assignment 1		05
2	Fundamentals of Eco-development • Definition and concepts of development and concepts of sustainability • Brundtland commission • Sustainable agriculture and forestry • Sustainable fisheries • Sustainable earth economy • Environmental world-views and ethical issues in eco-development concept	08	
	Assignment 2		05
3	Fundamentals of Ecotourism • Definition and historical background • Identification of potential sites for ecotourism • Conventional and mass tourism • Role of parks and gardens • Community involvement in the process of ecotourism	10	
	Assignment 3		05
4	Ecotourism development and management • Role of photography in promotion of ecotourism • Measures of minimizing environmental impacts • Trends and future of ecotourism • Impact of ecotourism—Awareness, Education, Recreation, Conservation and Economic development	07	

	Final assessment exam		03
	Total	35	25

Assignments

In the assignments the students will be expected to review the fundamental aspects of eco-restoration, to create hypothetical/practical ecologically sound developmental schemes, and to develop ecotourism plans for new areas and to review the existing ecotourism practices in India / discussion on relevant research papers in groups.

Suggested Readings

1. Hammitt, W.E. & Cole D.N. 1998. Wildland Recreation: Ecology and Management, 2nd Ed. New York: John Wiley & Sons. 361 pp. (ISBN: 0-471- 19461).
1. Liddle M. 1997. Recreation Ecology: The Ecological Impact of Outdoor Recreation and Ecotourism. New York: Chapman & Hall. 639 pp.
3. Mieczkowski, Z. 1995. Environmental Issues of Tourism and Recreation. Lanham, MD: University Press of America. 552 pp.
4. Wall G. & Wright C. 1977. The Environmental Impact of Outdoor Recreation. Publication Series No. 11. Department of Geography. Waterloo, Ontario: University of Waterloo. 69 pp.
5. Higgs, E. 1997. What is Good Ecological Restoration? Conservation Biology, pp. 338-348.
6. Egan, B. 1998. Ecological Restoration for British Columbia. British Columbia Environmental Report, pp. 7-9.
7. Martha Honey 1999. Ecotourism and sustainable development, Island Press, Washington DC
8. Martin Mowforth and Ian Munt 1998. Tourism and sustainability, Routledge, U.K.
9. B.K. Tiwari, Surendra Singh 1995. Ecorestoration of degraded hills.
10. Robert U Ayres, Paul M Weaver. Eco restructuring: Implications for sustainable development. IN-05457.

Course No: EST 411

Course Title: Dissertation

Number of Credits: 14

Evaluation Procedure: 0.6/0.4 University

Assessment by guide	40%	Internal Assessment
Major Exam	60%	University Assessment

This course is the second phase of the dissertation. A student cannot appear for the exam of this course unless he/she has cleared Phase I.

Evaluation of thesis: The second phase of the thesis will be evaluated for 14 credits. The internal and external assessment will be as indicated in the table above. Students have to appear for a final external viva to defend their thesis after submission of the thesis.

The dissertation will have to be submitted as per the dates indicated in Academic Calendar for appraisal and acceptance by the University. The students should submit their dissertation in the following format.

Cover Page

Inner Cover Page

Certificate duly signed by guide and head of institution

Acknowledgements

Contents

Chapter 1 – Introduction

A background with historical information and a review of existing material or data on the subject.

Chapter 2- Aims and Objectives

This chapter must contain the overall study design and aims and objectives of the study.

Chapter 3 – Literature Review

Detailed review of all existing literature related to the topic justifying the topic with a comprehensive bibliography generated using Zotero.

Chapter 3 –Methodology

Description of the issues, environmental setting and methodology adopted for the study etc.

Chapter 3 – Results

Presentation of results.

Chapter 4 – Discussion

Discussion on the data and results obtained and presentation of method suggested to solve the problem.

Chapter 5 – Summary and Conclusions

A summary of the dissertation and important conclusions drawn at the end of the investigation and a list of references cited in the text.

Chapter 6 - Bibliography

The dissertation should be typed on A4 size bond paper with 1.5 line spacing. Illustrations and photographs should be of high quality. Font to be used is Times New Roman or Arial with the text not less than in 12 pt. Referencing must be done in Zotero or any other referencing software in standard referencing style (Vancouver) for both intext citing and bibliography. The report should be flawless without any spelling mistakes and grammatical errors etc. If the dissertation contains such mistakes, the student will have to resubmit their dissertation after the necessary corrections. The dissertation should be bound in hard black mounted cover. Dissertations with spiral binding and paper cover will not be accepted.

The students are expected to prepare 3 copies (4 in case of a co-guide). If the guide gives a written consent that he/she does not need a hard copy a soft copy may be provided on a CD. The CD must contain a sticker with the cover page information. **The thesis will only be accepted after the relevant data used has been submitted to the faculty nominated and verified by them.** Students making special efforts to present their papers at conferences or publishing it will receive marks as below:

1.	Poster presented at a National level UGC recognized conference	5 marks
3.	Paper presented at a national level conference	10 marks
4.	Paper published in a SCOPUS/ WEB of SCIENCE indexed journal ONLY	25 marks

Guidelines for presentation:For every presentation students will prepare a power point presentation highlighting the objectives, research question, methodology and key findings and defend the same. The presentation must not be texty. It should be aesthetically appealing and contain relevant graphs and analysis. Wordy presentations are likely to get marked down. Students should be smartly dressed and speak in a clear voice. Do ensure that your presentations are loaded as per the given deadlines.

Guidelines for poster

For the final presentation students will prepare a poster as per the guidelines given below.

Poster size: 2ft (W) x 3ft (H)

Material:Vinyl (top quality)

Content: Aim, Objective, Method (in brief in a flow chart), findings (key graphs to be included), publications (if any), conclusion, suggestion

Name of the student and guide as well as institutional affiliation should be included.

Course No: EST 402

Course Title: Water Management

Number of Credits: 4

No. of Lectures-Tutorial: 45

Course Coordinator:

Course Outline

The reasons for increased interest in protecting water concern over increased vulnerability to water-related stress are not difficult to discern. The users of water fall into three sectoral categories namely, agriculture, domestic and industrial sector. While agriculture sector demands a huge share of water for irrigation, the industrial and domestic sectors are mainly responsible for contaminating fresh water sources. Long term sustainability of fresh water resources cannot be guaranteed measured in terms of both availability and quality. Efficient water resources management and water conservation practices are a need of the time. This course will expose the students to (i) Introduction to water resources evaluation and assessment - SPAC, WUE, methods of assessment, sectoral water use and demand, assessment of water stress and need for water conservation and (ii) Water resources conservation and management including institutional and policy aspects such as rainwater harvesting, conjunctive water use, catchment planning, watershed management, irrigation use and efficiency, advanced treatment systems and zero discharge, participatory irrigation management including methods of minimizing evaporation losses, water pricing, river basin organizations, collective action and decentralization etc.

Pre-requisite

None

Assignments	40 % (3)	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment • Completed home assignment submitted timely and excellent written presentation	Assignments must be in the prescribed format. One journal may contain assignments of different elective courses separated by a separator. Index must reflect all the assignments duly signed by the concerned teacher. Marks for every assignment must reflect on the	Internal Assessment

			assignment itself.	
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	• Introduction to water conservation and assessment, Severity of water crisis, importance of conservation • Soil, Plant, Atmosphere Continuum (SPAC); Water use efficiency (WUE) • Methods of water resources assessment (hydrology cycle, surface flow assessment, groundwater recharge assessment) • Water stress: principles and indicators for assessing water stress • Water quality assessment: indicators for assessing water quality	10	
	Assignment 1		5
2	• Water resources conservation and management, Water conservation measures • Soil moisture retention and conservation (cover crop, mulching, etc) • Traditional systems and man-made structures (ponds, tanks, reservoirs, Minimizing evaporation loses • Rainwater harvesting and groundwater recharging • Irrigation: types, scheduling, efficiency and designing	10	
	Assignment 2		2
3	• Water auditing; Water treatment, recycling and reuse leading to water conservation, Industrial and urban water management leading to cleaner production, Institutional mechanisms for water management, programmes and policies for integrated water management	10	
	Assignment 3		4
	Total	45	15

Suggested Readings

1. Larry M. (2003) *Urban Storm Water Management Tools*, McGraw Hill Publication.
2. Michael A.M. (2008) *Irrigation Theory and Practices*, 2nd Edition, Vikas Publishing House Private Limited, Noida.
3. Suresh R. (2005) *Soil and Water Conservation Engineering*, 2nd edition, Standard Publishers Distributors. GEN@)

Course No: EST 403

Course Title: Corporate Social Responsibility

Number of Credits: 4

No. of Lectures-Tutorial: 35-25

Course Coordinator: Dr. Shamita Kumar

Course Outline

This module provides an overview of the legal framework of corporate social responsibility (CSR) as well as its implementation, focusing on the interplay between large corporations and governments and non-governmental organizations (NGOs). The module provides case studies, conceptual frameworks and tools to help students understand the opportunity that CSR records in implementing sustainability projects.

Learning Outcomes

The student will:

- Understand the conceptual framework and components of CSR.
- Assess the effectively of different CSR programs.
- Design innovative CSR programs.

Pre-requisite

None

Evaluation Procedure : Continuous

Assignments	40 % (3)	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment • Completed home assignment submitted timely and excellent written presentation	Assignments must be in the prescribed format. One journal may contain assignments of different elective courses separated by a separator. Index must reflect all the assignments duly signed by the concerned teacher. Marks for every assignment must reflect on the assignment itself.	Internal Assessment
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
	Pre course assignment: Transition presentation by students on topics given to them atleast ten days in advance		
1	Introduction to CSR and responsible investment • Introduction of Corporate Social Responsibility (CSR) : Evolution and present status; The Triple Bottom Line approach • Drivers of CSR • Why CSR? The issues: resources, people, climate, and natural resources. The environmental impacts of global economic growth • Moral and economic arguments on CSR; CSR expectations in rich and in poor countries • Repercussions of failed corporate responsibilities: Landmark cases, economic fallout, regulatory response • Key challenges in doing good • The regulatory framework in India	12	
	Assignment 1		05
3	Engaging the stakeholder • Who are the stakeholders? Role of stakeholders in CSR; consumer awareness and willingness to pay for socially responsible corporate behaviour • Communications revolution and its impact on CSR • CSR as a balance between organizational means and ends; driving social responsibility throughout the organisation	10	
	Assignment 2		
4	Sustainability indicators and reporting • Frameworks for CSR reporting • Global Reporting Initiative Guidelines • The future of CSR • Sustainability Reporting: case study analysis	08	
	Assignment 3		05
	Total	45	12

Suggested Readings

1. What is a Business for? Charles Handy, Harvard Business Review, December 2002
2. The Competitive Advantage of Corporate Philanthropy, Michael E Porter and Mark R Kramer, Harvard Business Review, pp 6-16, December 2002
3. Green and Competitive: Ending the Stalemate, Michael E Porter and Class van der Linde, Harvard Business Review, pp 120-133, September-October 1995
4. What Matters Most: Corporate Values and Social Responsibility, Jeffrey Hollender, California management Review, pp 111-119, Volume 46(4), 2004
5. Corruption in International Business, Harvard Business Case 9-701-128, December 2001
6. Corporate Social Responsibility: Whether or How? N. Craig Smith, California Management Review, pp 52-76, Volume 45(4), Summer 2003
7. The Discipline of building character, Joseph L. Badaracco Jr., Harvard Business Review, pp 115-124, March – April 1998
8. Accounting Fraud at Worldcom, Robert S Kaplan and David Kiron, Harvard Business School Case study 9-104-071, May 2005, Management Lessons from Enron, B. Bowonder, TMTC, 2006
9. The Parable of the Sadhu, Bowen H. McCoy, Harvard Business Review, May-June 1997
10. Corporate Social Responsibility: the WBCSD, Geneva, 2004

General Reading:

1. Changing Course, Stephan Schmidheiny & BCSD, MIT Press, 1992
2. Harvard Business Review on Business & the Environment, Harvard Business School Press, 2000
3. The fortune at the Bottom of the Pyramid, C.K. Prahalad, Wharton School Publishing, 2005
4. The Skeptical Environmentalist: Measuring the real estate of the World, Bjorn Lomborg, Cambridge University Press, 2001
5. Cradle to Cradle: Remarking the Way We Make things, William KcDonough and Michael Braungart, North Point Press, 2002
6. Natural Capitalism: Creating the next Industrial Revolution, Paul Hawken, Amory Lovins & L. Hunter Lovins, 1999
7. The Sustainability Wave: Building Boardroom Buy-in (Conscientious Commerce), Bob Willard, 2007.

Course No: 404

Course Title: Comparative Environmental Law

Number of Credits: 4

No. of Lectures- Self Study -Case Studies: 39 – 20 – 3

Course Coordinator: Adv. Gouri Joshi

Course Outline

The course aims at achieving a deeper understanding of the historical development of International Environmental Law by eternalizing basic concepts and principles of international law, development of international conventions and treaties and further comparing it with the national legislation to understand differences and limitations in concept and implementation. The course will examine a number of cross-cutting themes, conflicts among differing legal regimes; the range of approaches to the regulation of activities within and beyond areas under national jurisdiction. The course provides an opportunity to the participants to have group discussions, tutorials and to analyze the case studies.

Learning Outcomes

Students will acquire

- Deeper understanding of fundamental principles of international law, and international environmental law;
- Overview of different conventions, treaties, and multilateral agreements with respect to environmental protection and conservation;
- A knowledge base of interrelationship between international agreements and implementation burdens on individual polities;
- Skills to compare national laws with international environmental law

Evaluation Procedure : Continuous

Assignments	40 %	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment : 5 marks • Completed home assignment submitted timely and excellent written presentation (within 7 days): 5 marks	Assignments must be in the prescribed journal format. One journal may contain assignments of different elective courses separated by a separator. However each course must have a	Internal Assessment

			separate index duly signed by teacher. Marks for every assignment must reflect on the assignment itself.	
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

Sr. No.	Topic	Time (Hours)		Case Study/ Article Review/ Debates/ Assignment (Hrs)
		L	T	
1.	Concept of International Law • Evolution of International Law • Development of International law • Basic concepts and principles • Source of International Environmental Law	4		-
2	Comparative Law and Comparative Environmental Law • Concept and development • Different methods of Comparative analysis • Different Approaches of comparison	4	-	
3	Constitutional Provisions and International Mandates • Concepts of Monism and Dualism • Provisions in Indian Constitution • Provisions in other Nation's Constitution	2		
	Assignment 1			05
4.	Institutions of Environmental Law • Political • Administrative • Dispute Redressal	4		
5.	Air Pollution	4	-	-

	• Air Pollution and world scenario • Total Conventions entered into • India's response to Conventions • World response			
6.	Water Pollution • Importance of this source • World over water pollution • India as a river rich nation • Issues and way forward	4	-	-
7.	Solid Waste • Background and development • Principles and concepts	2		
	Assignment 2			05
8.	Conservation treaties / conventions • Biodiversity • In situ conservation • Ex-situ conservation	4		
9.	Green Courts and PIL • Evolution and role of green courts in the global context • Green Tribunal in India: Evolution, jurisdiction and case studies	4		
	Assignment 3			05
10	Sustainable Development and the Law • Concept and its development • Economics of sustainable development • Role of law in sustainable development	4		
11	Using Litigation to Drive Science and Technology Global scenario Indian scenario	3		
	Major exam			03
	Total	39		23

Assignment

Assignment will be writing / presenting /debating for the given issues relevant to the respective topic. All the tutorials will have to be submitted as per the time schedule given in the class. Tutorials, case studies, review assessments shall be part of internal assessment.

Reference Books:

1. Guide to International Environmental Law, Alexandre Charls Kiss, Dinah Shelton 2007
2. International Environmental Law and Policy for 21st Centruary, by Ved P. Nanda, George (Rock) Pring, 2nd Edition, 2012, Martinus Nijhoff Publications;
3. Axelrod, Regina S. [not related to your professor], David L. Downie, and Norman J. Vig, eds. 2011. The global environment: institutions, law, and policy, 3rd edition. Washington: CQ Press. (subsequently noted as —Axelrod et al.||)
4. Benedick, Richard Elliot. 1998. Ozone diplomacy: new directions in safeguarding the planet. Cambridge, MA: Harvard University Press.
5. Chasek, Pamela S., David L. Downie, and Janet Welsh Brown. 2010. Global environmental politics, 5th edition. Boulder, CO: Westview Press. (subsequently Chasek et al.||)
6. Brown Weiss, Edith, and Harold K. Jacobson, eds. 1998. Engaging countries: strengthening compliance with international environmental accords. Cambridge, MA: MIT Press

Course No. EST 405

Course Title: Urban Sustainability

Number of Credits: 4

No. of Lectures-Tutorial-Practical/Assignment: 36-3-20

Course Coordinator:

Course Outline

The aim of the course is that the students understand urbanization processes on a global scale and the challenges and opportunities for sustainable development arising from the urban turn. Students will develop an understanding of measuring sustainability with different indicators and as well as an ability to analyse strengths, weaknesses, opportunities and threats of urban developments.

Evaluation Procedure : Continuous

Assignments	40 % (3)	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment • Completed home assignment submitted timely and excellent written presentation	Assignments must be in the prescribed format. One journal may contain assignments of different elective courses separated by a separator. Index must reflect all the assignments duly signed by the concerned teacher. Marks for every assignment must reflect on the assignment itself.	Internal Assessment
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	T	P/A

1.	Introduction The idea and history of urbanization and sustainable developments (definition, historical use, our common future, the Rio process etc.)	2		
2.	Urbanization on a global scale Problems in defining “the urban”, urbanization on a global scale in a historic perspective, drivers of current urbanization, differences in the urbanization patterns between different country groups	2		
	Assignment 1	2		5
3.	Risks and chances of urbanization Risks and chances of urban development in the four dimensions of sustainable development: Ecology, economy, politics and society; scenarios of future urban growth	4		
4.	Dimensions of urban sustainability Concepts and definition of sustainable development, urban sustainability: definition and targets, dimensions of urban sustainability, good urban governance: the implementation of urban sustainability	4		
	Assignment 2: Field trip: from core to fringe: Pune megacity	6		5
5.	Concepts of sustainable urban development Different concepts urban and urban sustainable development, strategies: efficiency, consistency and sufficiency, programs on urban sustainable development (UN, EU, etc.)	4		
	Assignment 3: Group work with different texts: different approaches towards urban sustainability Presentation and discussion of group work results	2		5
6.	Indicators for urban sustainability Relevance of indicators, concepts for sustainability indicators, sustainability indicators Group discussion based on text	4		
7.	Sustainable urbanization on a global scale Analysis of different case studies from countries with	4		

	different backgrounds. Introduction to tools of analysis			
	Major Exam		3	
	Total	36	3	20

Textbooks

Hardoy, J., Mitlin, D., Satterthwaite, D.: Environmental problems in an urbanizing world. Finding solutions for cities in Africa, Asia and Latin America, London 2001.

Suggested Readings

HUST, E.: Introduction: Problems of Urbanization and Urban Governance in India, in: Hust, E., Mann, M.: Urbanization and Governance in India, Neu Delhi 2005, S. 1-26.

KENNEDY, C., CUDDIHY, J., ENGEL-YAN, J.: The Changing Metabolism of Cities, in: Journal of Industrial Ecology 11 (2) (2007), S. 43–59.

KRAAS, F.: Urban Sustainability – Sustainability in Urban Areas: Basic Considerations., in: Gaese, H., Kraas, F., Mi Mi Kyi: Sustainability in Rural and Urban Environments. Proceedings of the First German-Myanmar Workshop in Yangon/Myanmar, 17-21 November 2003, Köln 2005.

MCGRANAHAN, G., SATTERTHWAITE, D.: Urban Centres: An Assessment of Sustainability, in: Annual Review of Environment and Resources 28 (2003), S. 243–274.

MEADOWS, D.: Indicators and Information Systems for Sustainable Development. A Report to the Balaton Group, Hartland 1998.

SATTERTHWAITE, D.: Sustainable Cities or Cities that Contribute to Sustainable Development?, in: Satterthwaite, David. The Earthscan reader in sustainable cities, London 1999, S. 80-106.

SATTERTHWAITE, D.: The scale of urban change worldwide 1950-2000 and its underpinning, London 2005.

UNHABITAT (2008): State of the world's cities 2010/2011: Bridging the urban divide.

Additional Readings

Journals

International Journal of Urban Sustainable Development
Urbanization and Environment

Course No. EST 406

Course Title: Industrial Safety and Occupational Health

Number of Credits: 4

No. of Lectures-Tutorial-Practical: 35-10-15

Course Coordinator:

Assignments	40 % (3)	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment • Completed home assignment submitted timely and excellent written presentation	Assignments must be in the prescribed format. One journal may contain assignments of different elective courses separated by a separator. Index must reflect all the assignments duly signed by the concerned teacher. Marks for every assignment must reflect on the assignment itself.	Internal Assessment
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	T	P
1.	Principles of accident prevention • Definitions: Accident, injury, hazard, Risk, Danger, unsafe acts, unsafe conditions, dangerous occurrences etc. • Accident prevention: H.W.Henrich, Frank bird & Multiple Causation theories of accident occurrences. Principles of accident prevention,	5		

	Models of accident prevention.			
2.	Planning for safety • Definition, purpose, nature, scope and procedure. Range of planning. Variety/forms of plans. • Strategic planning and process of implementation. Management by objectives and its role in • safety. Policy formulation and effective planning for safety.	5	2	3
3.	Organizing for safety • Definition, need, nature and principles. • Organization for Safety: Organization structure and safety department • Safety Officer: Role, responsibility, authority. Power and qualifications/attributes. • SAFETY COMMITTEE: Structure & functions. Line & Staff functions in safety department.	5	1	3
4.	Directing for safety • Direction: Definition, Process, Principles & Techniques. • Leadership: Role, functions & attributes of a leader. Leadership styles and safety management. • Communication: Fundamentals, importance, process, types & channels. • Five essential rules for communication. • Two-way communication. • Barriers and break-downs in communication. Communication with management, employees & • union. • Communication and group-dynamics. • Managerial Communication: A tool for management of frustrations, conflicts and attitudes towards safety & health.	10	2	3
6.	Safety Management Information System • Sources of information on Safety , Health, and	5	3	3

	Environment. Compilation, • Processing retrieval and analysis of information. • Status and future scope of computer utilization in Safety. Health and Environment • (SHE) Services in Industries. Introduction to national & international SHE Management Systems • Total Quality Management and its application to SHE, occupational Health & safety • appraisal system 18001 and 15001			
	Total	35	10	15

Course No. EST 407

Course Title: Green Technology and Management

Number of Credits: 4

No. of Lectures-Tutorial-Practical: 35-10-15

Course Coordinator:

Course Outline

The course aims to provide students with a strong foundation in science and technology to contribute effectively in the green industries, with a focus on environmental & waste management and energy optimization. Students will be equipped with skills, knowledge and attributes necessary in this sector.

Learning Outcomes

At the end of the course, students will:

- Be able to find sustainable solutions for environmental issues without compromising economic development.
- Will be able to provide scientific advice for policy development and decision-making.

Assignments	40 % (3)	Marking pattern for every assignment • Innovativeness and accuracy in completing the assignment • Completed home assignment submitted timely and excellent written presentation	Assignments must be in the prescribed format. One journal may contain assignments of different elective courses separated by a separator. Index must reflect all the assignments duly signed by the concerned teacher. Marks for every assignment must reflect on the assignment itself.	Internal Assessment
Major exam	60%	Theory examination		Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)		
		L	T	P
1.	Need for sustainability The inseparable linkages of life supporting systems, biodiversity and ecosystem services and their implications for sustainable development; global warming; greenhouse gas emissions, impacts, mitigation and adaptation	05	2	5
	Greening in different sectors Green Energy: Sustainable energy sources and alternative technologies, strategies and case studies Green IT and communication technologies, strategies and case studies Greening the transport sector, strategies and case studies Greening waste management, strategies and case studies Greening building, strategies and case studies	10		
2.	Assignment 1			10
3.	Green innovation and sustainability - Eco/green technologies for addressing the problems of Water, Energy, Health, Agriculture and Biodiversity- (eco-restoration/ phyto-remediation, ecological sanitation, renewable energy technologies) - Design for sustainability; Criteria for choosing appropriate green energy technologies, life cycle cost; the emerging trends – process/product innovation-, technological/ environmental leap-frogging Green Energy and sustainable development - Future energy Systems- clean/green energy technologies; International agreements/conventions on energy and sustainability	15		
	Assignment 2			
3.	Green Management - Environmental reporting and ISO 14001; ISO 14064; greenfinancing; financial initiative by UNEP; - Green tax incentives and rebates (to green projects and companies); green project management in action; Sustainable supply chain management	15		5
	Assignment 3			10
	Total	45		20

Suggested readings

1. Green Management and Green Technologies: Exploring the Causal Relationship by Jazmin Seijas Nogarida, 2008.
2. Green Marketing and Management: A global Perspective by John F. Whaik, 2005
3. The Green Energy Management Book by Leo A. Meyer
4. Green Project Management by Richard Maltzman And David Shiden
5. Green Marketing by Jacquelin Ottman
6. Green and World by Andrew S. Winston

Course No. GEN 401

Course Title: Entrepreneurship Development

Number of Credits: 2

No. of Lectures-Tutorial-Practical: 15-15

Course Coordinator:

Course Description

This course is designed to help students evaluate the business skills and commitment necessary to successfully operate an entrepreneurial venture and review the challenges and rewards of entrepreneurship. Students will learn about themselves, their decisions, and their goals to determine how entrepreneurship can play a role in their lives. Students will also be introduced to entrepreneurship from an economic perspective and the concepts of environmentally sustainable practices and social entrepreneurship.

Learning Outcomes

On completion of this course, the student will:

- Develop an understanding of personal attributes and skills that characterize the 'successful' entrepreneur.
- Be able to assess and compare their personal characteristics and interests to that of the 'successful' entrepreneur.
- Be able to identify and assess sources of support for small businesses and entrepreneurs. Be able to research and explain issues relevant to entrepreneurs such as 'green' business practices, environmental sustainability.
- Be able to identify the financial, marketing, legal, human resource, operations, and general management skills that are necessary to successfully launch and operate a successful new venture.

Evaluation Procedure: Continuous

Assignment	1	100 %	Internal Assessment

Details of course content and allotted time

S. No.	Topic	Time (Hours)	
		L	T
1	• Entrepreneurship-Enterprise: Conceptual issues. Entrepreneurship vs. Management. Roles and functions in relation to the enterprise and in	05	

	relation to the economy. Small business as seedbed of Entrepreneurship.		
2	• Opportunity scouting and idea generation: role of creativity and innovation and business research. Sources of business ideas. • Entrepreneur opportunities in contemporary business environment, for example opportunities in net-workmarketing, franchising, business process outsourcing in the early 21 century. • The process of setting up a small business: Preliminary screening and aspects of the detailed study of the feasibility of the business idea and financing/non-financing support agencies to familiarize themselves with the policies/programs and procedures and the available schemes. • Preparation of Project Report and Report on Experiential Learning of successful and unsuccessful entrepreneurs.	05	
	Assignment 1		08
3.	• Issues in small business marketing. The concept and application of product life cycle, advertising and publicity, sales and distribution management. • The idea of consortium marketing, competitive bidding/tender marketing, negotiating with principal customers. • The contemporary perspectives on Infrastructure development, Product and Procurement Reservation, Marketing Assistance, Subsidies and other Fiscal and Monetary Incentives. National state level and grass-root level financial and non-financial institutions in support of small business development.	05	
	Assignment 1		07
	Total	15	15

