BHARATI VIDYAPEETH
(DEEMED TO BE UNIVERSITY), PUNE

Faculty of Science
B. Tech. Chemical
New Syllabus

Bharati Vidyapeeth

(Deemed to be University)

Pune, India

College of Engineering, Pune

B. Tech. Chemical Curriculum

(2021 Course)

VISION OF UNIVERSITY

Social transformation through dynamic education

MISSION OF UNIVERSITY

(i) To make available quality education in different areas of knowledge to the students as per their choice and inclination

(ii) To offer education to the students in a conducive ambience created by enriched infrastructure and academic facilities in its campuses.

(iii) To bring education within the reach of rural, tribal and girl students by providing them substantive fee concessions and subsidized hostel and mess facilities

(iv) To make available quality education to the students of rural, tribal and other deprived sections of the population

VISION OF THE INSTITUTE

To be world class institute for social transformation through dynamic education.

MISSION OF THE INSTITUTE

(i) To provide quality technical education with advanced equipment, qualified faculty members, infrastructure to meet needs of profession and society.

(ii) To provide an environment conducive to innovation, creativity, research and entrepreneurial leadership.

(iii) To practice and promote professional ethics, transparency and accountability for social community, economic and environmental conditions.

VISION OF THE DEPARTMENT

To be globally recognized Chemical Engineering department for academic excellence and research.

MISSION OF THE DEPARTMENT

(i) To impart quality Chemical Engineering education to provide professionally competent engineers.

(ii) To develop conducive research environment to meet ever-changing aspirations of chemical and allied fields.

(iii) To promote entrepreneurship and leadership qualities with a strong foundation of social and professional ethics.

PROGRAM EDUCATIONAL OBJECTIVES

(i) Practice Chemical Engineering in conventional, multidisciplinary and emerging fields

(ii) Pursue advanced studies or other forms of continuing education

(iii) Demonstrate professionalism, ethical and social responsibility and desire for lifelong learning

PROGRAM OUTCOMES

(i) Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

(ii) Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

(iii) Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

(iv) Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

(v) Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

(vi) The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

(vii) Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

(viii) Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

(ix) Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

(x) Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
(xi) Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
(xii) Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES

(i) Utilize the fundamentals of unit operations and unit processes for the design and development of chemical products
(ii) Implement the pollution abatement methodologies in chemical and allied industries
(iii) Adopt sustainable energy strategies in professional practice

SALIENT FEATURES OF CURRICULUM

The B. Tech. Chemical program comprises 200 credits distributed over eight semesters, with each semester accounting for 25 credits. The curriculum is meticulously designed, taking into consideration the current placement scenario, technological progress, and insights gathered from industry professionals. Course outcomes (COs) are clearly outlined for each course, along with detailed course contents. Additionally, the COs of each course are aligned with both program outcomes (POs) and predefined program-specific outcomes (PSOs). The current curriculum has undergone a revision, incorporating more than a 40% change in comparison to the 2014 course curriculum. Few notable features of curriculum are as follows:

1. Curriculum components

An overview of the abroad components of the curriculum along with their associated contributions is as follows:

Sr. No.	Broad component	Credit	Percentage contribution
1	Basic Science Courses	35	17.50
2	Engineering Science Courses	09	4.5
3	Social Science and Humanities Courses	08	4
4	Professional Core Courses	115	57.50
5	Electives Courses	10	5

6	Computational Courses	11	5.50
7	Internship	03	1.50
8	Project	09	4.50

2. New courses

The B. Tech. Chemical curriculum is structured in response to technological progress, employment trends and feedback received from alumni and employers. The curriculum incorporates the following new courses to address current needs:

(i) Chemical Engineering: Scope and Significance

(ii) Biological sciences

(iii) Analytical Chemistry

(iv) Material Science and Engineering

(v) Design of Heat Transfer Equipment

(vi) Pollution Control and Abatement

(vii) Biochemical Engineering

(viii) Renewable Energy

(ix) Process development and Engineering

(x) Quantitative Techniques, Communication, and Values

(xi) Chemical Process Control and Automation

(xii) Optimization Techniques in Chemical Engineering

3. Elective courses

The elective courses listed in Semester VII and VIII aim to provide specialized knowledge in particular areas.

Sr. No.	**Elective I**	**Elective I**
	Semester VII	**Semester VIII**
1	Polymer Technology	Nanomaterial Synthesis and Application
2	Petroleum Refinery Engineering	Membrane Separation
3	Advanced Oxidation Processes	Artificial Intelligence
4	Natural Products	Bio-separations

4. Interdisciplinary courses

Contemporary engineering education is undergoing a transformation towards interdisciplinary integration. In consideration of this, the current curriculum includes the following interdisciplinary courses to promote a culture of interdisciplinary learning:

Sr. No.	Semester	Interdisciplinary course
1	IV	ITC-II: Industrial Pollution and Abatement
2	V	ITC-III: Renewable Energy
3	VII	Elective I: Polymer Technology
4	VII	Elective I: Petroleum Refinery Engineering
5	VII	Elective I: Advanced Oxidation Processes
6	VII	Elective I: Natural Products
7	VIII	Elective II: Nanomaterial Synthesis and Application
8	VIII	Elective II: Membrane Separation
9	VIII	Elective II: Artificial Intelligence
100	VIII	Elective II: Bio-separations

5. Industry taught courses

To narrow the divide between industrial practices and theoretical classroom learning, a novel curriculum element known as an industry-taught course has been incorporated. Within this component, professionals from the industry are engaged to instruct at least one theoretical course in each semester, spanning from Semester III to Semester VIII. As a result, a minimum of six theory courses are delivered by industry experts.

6. Vocational courses

In addition to traditional theoretical classroom instruction, there is a crucial need for skill-based education. Hence, four vocational courses, relevant to Chemical Engineering disciplines, have been integrated into the program curriculum spanning from Semester III to Semester VI.

7. Internship

Internship constitutes a fundamental component of the B. Tech. Chemical curriculum. A mandatory 45-day internship is required for students following the completion of Semester VI.

8. Project work

In the B. Tech. Chemical curriculum, it is compulsory for each student to undertake and complete project work during Semester VII and VIII, earning a credit of 09.

9. Research publication

Students will receive an extra two credits upon successfully publishing a research paper in reputable academic publications.

Bharati Vidyapeeth

(Deemed to be University)

Faculty of Engineering and Technology

Programme: B. Tech. (Chemical) (2021 Course)

Curriculum Structure

Bharati Vidyapeeth
(Deemed to be University)
Faculty of Engineering and Technology

Program: B. Tech. (Chemical) Semester – I CBCS 2021 Course

Sr. No.	Course Code	Name of Course	Teaching Scheme (Hours/week)			Examination Scheme (Marks)						Credits			
			L	P	T	UE	IA	TW	OR	PR	Total	L	P	T	Total
1		Algebra and Statistics	4	-	1	60	40	-	-		100	4	-	1	5
2		Organic Chemistry- I	4	2	-	60	40	25	-	25	150	4	1	-	5
3		Material and Wave Physics	4	2	-	60	40	25	-	25	150	4	1	-	5
4		Computer Aided Graphics	4	2	-	60	40	25	25	-	150	4	1	-	5
5		Chemical Engineering (Scope and Significance)	4	-	-	60	40	-	-	-	100	4	-	-	4
6		Data Structure (C Programming)	-	2	-	-	-	50	50	-	100	-	1	-	1
Total			**20**	**08**	**1**	**300**	**200**	**125**	**75**	**50**	**750**	**20**	**4**	**1**	**25**

Program: B. Tech. (Chemical) Semester – II CBCS 2021 Course

Sr. No.	Course Code	Name of Course	Teaching Scheme (Hours/week)			Examination Scheme (Marks)						Credits			
			L	P	T	UE	IA	TW	OR	PR	Total	L	P	T	Total
1		Differential and Integral Calculus	4	-	1	60	40	-	-		100	4	-	1	5
2		Organic Chemistry- II	4	2	-	60	40	25	-	25	150	4	1	-	5
3		Inorganic Chemistry	4	2	-	60	40	25	-	25	150	4	1	-	5
4		Biological Science	4	2	-	60	40	25	25	-	150	4	1	-	5
5		Material and Energy Balance Calculations	4	-	-	60	40	-	-	-	100	4	-	-	4
6		Java Programming	-	2	-	-	-	50	50	-	100	-	1	-	1
Total			**20**	**08**	**1**	**300**	**200**	**125**	**75**	**50**	**750**	**20**	**4**	**1**	**25**

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Program: B. Tech. (Chemical) Semester – III CBCS 2021 Course

Sr. No.	Course Code	Name of Course	Teaching Scheme (Hours/week)			Examination Scheme (Marks)						Credits			
			L	P/D	T	UE	IA	TW	OR	PR	Total	L	P	T	Total
1		Chemical Engineering Thermodynamics- I	4	-	1	60	40	-	-	-	100	4	-	1	5
2		Process Heat Transfer	4	2	-	60	40	25	-	25	150	4	1	-	5
3		Fluid Mechanics	4	2	-	60	40	25	-	25	150	4	1	-	5
4		Particulate Technology	3	2	-	60	40	25	-	25	150	3	1	-	4
5		Material Science and Engineering*	4	-	-	60	40	-	-	-	100	4	-	-	4
6		Python Programming	-	2	-	-	-	25	25	-	50	-	1	-	1
7		Vocational Course- I: Analytical Techniques	-	2	-	-	-	25	25	-	50	-	1	-	1
Total			**19**	**10**	**1**	**300**	**200**	**125**	**50**	**75**	**750**	**19**	5	**1**	**25**

*** Industry Taught Course I;**

Sr. No.	Course Code	Name of Course	Teaching Scheme (Hours/week)			Examination Scheme (Marks)						Credits			
			L	P/D	T	UE	IA	TW	OR	PR	Total	L	P	T	Total
8	Mandatory	Environmental Studies#	2	-	-	50	-	-	-	-	50	-	-	-	-
9	ADD-on	MOOC-I	-	-	-	-	-	-	-	-	-	-	-	-	2

 # Mandatory Audit Course with end semester examination of 50 marks

Program: B. Tech. (Chemical) Semester – IV CBCS 2021 Course

Sr. No.	Course Code	Name of Course	Teaching Scheme (Hours/week)			Examination Scheme (Marks)						Credits			
			L	**P/D**	**T**	**UE**	**IA**	**TW**	**OR**	**PR**	**Total**	**L**	**P**	**T**	**Total**
1		Numerical Methods for Chemical Engineering	4	-	-	60	40	-	-	-	100	4	-	-	4
2		Chemical Engineering Thermodynamics- II	4	-	1	60	40	-	-	-	100	4	-	1	5
3		Design of Heat Transfer Equipment	4	2	-	60	40	25	-	25	150	4	1	-	5
4		Chemical Technology	4	2	-	60	40	25	-	25	150	4	1	-	5
5		Industrial Pollution and Abatement*	3	2	-	60	40	25	25	-	150	3	1	-	4
6		MATLAB programming	-	2	-	-	-	25	25	-	50	-	1	-	1
7		Vocational Course- II: Industrial Heating Systems	-	2	-	-	-	25	25	-	50	-	1	-	1
Total			**19**	**10**	**1**	**300**	**200**	**125**	**75**	**50**	**750**	**19**	5	**1**	**25**

*** Industry Taught Course II;**

Sr. No.	Course Code	Name of Course	Teaching Scheme (Hours/week)			Examination Scheme (Marks)						Credits			
			L	**P/D**	**T**	**UE**	**IA**	**TW**	**OR**	**PR**	**Total**	**L**	**P**	**T**	**Total**
8	ADD-on	Social Activities- I	-	-	-	-	-	-	-	-	-	-	-		2

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Program: B. Tech. (Chemical)   Semester – V   CBCS 2021 Course

Sr. No.	Course Code	Name of Course	Teaching Scheme (Hours/week)			Examination Scheme (Marks)						Credits			
			L	P/D	T	UE	IA	TW	OR	PR	Total	L	P	T	Total
1		Mass Transfer Operations	4	2	-	60	40	25		25	150	4	1	-	5
2		Homogeneous Reaction Engineering	4	2	-	60	40	25	-	25	150	4	1	-	5
3		Biochemical Engineering	4	2	-	60	40	25	25	-	150	4	1	-	5
4		Renewable Energy*	4	-	-	60	40	-	-	-	100	4	-	-	4
5		Chemical Process Instrumentation	4	2	-	60	40	25	-	25	150	4	1	-	5
6		Vocational Course III: Fluid Moving Machineries	-	2	-	-	-	25	25	-	50	-	1	-	1
Total			**20**	**10**	**-**	**300**	**200**	**125**	**50**	**75**	**750**	**20**	**5**	**-**	**25**

*** Industry Taught Course III**

Sr. No.	Course Code	Name of Course	Teaching Scheme (Hours/week)			Examination Scheme (Marks)						Credits			
			L	P/D	T	UE	IA	TW	OR	PR	Total	L	P	T	Total
8	ADD-on	MOOC-II	-	-	-	-	-	-	-	-	-	-	-		2

Program: B.Tech. (Chemical)   Semester – VI   CBCS 2021 Course

Sr. No.	Course Code	Name of Course	Teaching Scheme (Hours/week)			Examination Scheme (Marks)						Credits			
			L	P/D	T	UE	IA	TW	OR	PR	Total	L	P	T	Total
1		Separation Techniques	4	2	-	60	40	25	-	25	150	4	1	-	5
2		Heterogeneous Reaction Engineering	4	2	-	60	40	25	-	25	150	4	1	-	5
3		Process Development and Engineering*	4	2	-	60	40	25	25	-	150	4	1	-	5
4		Chemical Process Modelling and Simulation	4	2	-	60	40	25	-	25	150	4	1	-	5
5		Quantitative Techniques, Communication and Values	4	-	-	60	40	-	-	-	100	4	-	-	4

7		Vocational Course IV: Piping Design	-	2	-	-	-	25	25	-	50	-	1	-	1
Total			**20**	**10**	**-**	**300**	**200**	**125**	**50**	**75**	**750**	**20**	**5**	**-**	**25**

*** Industry Taught Course IV**

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Program: B. Tech. (Chemical) Semester – VII CBCS 2021 Course

Sr. No.	Course Code	Name of Course	Teaching Scheme (Hours/week)			Examination Scheme (Marks)						Credits			
			L	P/D	T	UE	IA	TW	OR	PR	Total	L	P	T	Total
1		Elective – I	4	2	-	60	40	25	25	-	150	4	1	-	5
2		Chemical Process Equipment Design and Drawing	4	2	-	60	40	25	25	-	150	4	1	-	5
3		Chemical Process Control and Automation	4	2	-	60	40	25	-	25	150	4	1	-	5
4		Plant Utility and Process Safety*	4	-	-	60	40	-	-	-	100	4	-	-	4
5		Chemical Process Simulation- I	-	2	-	-	-	25	25	-	50	-	1	-	1
6		Project: Stage-I	-	2	-	-	-	50	50	-	100	-	2	-	2
7		Internship	-	-	-	-	-	25	25	-	50	-	3	-	3
Total			**16**	**10**	**-**	**240**	**160**	**175**	**125**	**25**	**750**	**16**	9	**-**	**25**

*** Industry Taught Course V**

Sr. No.	Course Code	Name of Course	Teaching Scheme (Hours/week)			Examination Scheme (Marks)						Credits			
			L	P/D	T	UE	IA	TW	OR	PR	Total	L	P	T	Total
8	ADD-on	MOOC-III	-	-	-	-	-	-	-	-	-	-	-		2

Program: B. Tech. (Chemical) Semester – VIII CBCS 2021 Course

Sr. No.	Course Code	Name of Course	Teaching Scheme (Hours/week)			Examination Scheme (Marks)						Credits			
			L	P/D	T	UE	IA	TW	OR	PR	Total	L	P	T	Total
1		Elective – II	4	2	-	60	40	25	25	-	150	4	1	-	5
2		Chemical Project Engineering and Economics	4	2	-	60	40	25	25	-	150	4	1	-	5
3		Optimization Techniques in Chemical Engineering	4	-	-	60	40	-	-	-	100	4	-		4
4		Industrial Management*	4	-	-	60	40	-	-	-	100	4	-	-	4
5		Chemical Process Simulation- II	-	2	-	-	-	25	25	-	50	-	1	-	1
7		Project: Stage-II	-	4	-	-	-	100	100	-	200	-	6	-	6
Total			**16**	**10**	**-**	**240**	**160**	**175**	**175**	**-**	**750**	**16**	9	**-**	**25**

*** Industry Taught Course VI**

Sr. No.	Course Code	Name of Course	Teaching Scheme (Hours/week)			Examination Scheme (Marks)						Credits			
			L	P/D	T	UE	IA	TW	OR	PR	Total	L	P	T	Total
8	ADD-on	Social Activities- II	-	-	-	-	-	-	-	-	-	-	-		2

ELECTIVES

Elective – I	**Elective – II**
Polymer Technology	Nanomaterial Synthesis and Application
Petroleum Refinery Engineering	Membrane Separation
Advanced Oxidation Processes	Artificial Intelligence
Natural Products	Bio-separations
Reactive Separations	Solid Waste Management

Bharati Vidyapeeth

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Faculty of Engineering and Technology

Programme: B. Tech. (Chemical) (2021 Course)

Syllabi of Semester I and Semester II Courses
(BoS: Chemical Engineering)

Programme: B. Tech Chemical (2021) Sem – I

CHEMICAL ENGINEERING: SCOPE AND SIGNIFICANCE			
Designation: Basic Science			
Course Pre-requisites: Basic Chemistry			
Teaching Scheme	**Examination Scheme**	**Credits Allotted**	
Lectures : 04 Hours/Week	End Semester Examination : 60Marks	Theory : 04	
Total : 04 Hours/Week	Internal Assessment : 40Marks	Total credits : 04	
	Total : 100Marks		
Course Outcomes			
After completion of the course students will be able to			
1.	Appraise the importance of chemical engineering and related processes		
2.	Select unit operations and processes for desired application		
3.	Justify the importance of chemical engineering in Petroleum and Petrochemical industries		
4.	Justify the importance of chemical engineering in Food and Pharmaceutical industries		
5.	Justify the importance of chemical engineering in agricultural industries		
6.	Design a pathway to face todays and upcoming challenges using knowledge of chemical engineering		
Topics Covered			
UNIT - I	**Introduction** Chemical Engineering: Origin and development; Definition of Chemical Engineering; Major components and scope of Chemical Engineering; Role of Chemical Engineer in Chemical and allied industries; Chemical Engineering and national economy	**(06 Hours)**	

UNIT - II	**Unit operations and Unit processes** Definition of unit operations and unit processes; Unit operations: fluid flow, heat and mass transfer, and mechanical operations; Unit processes: Addition, condensation, substitution; Application of unit operations and unit processes: industrial case studies.	**(06 Hours)**
UNIT - III	**Petroleum and Petrochemical Industry** Overview of petroleum and petrochemical industry; Major petroleum and petrochemical products; Unit operations and processes in petroleum and petrochemical industry; Economical impact.	**(06 Hours)**
UNIT - IV	**Food and Pharmaceutical Industry** Overview of food and pharmaceutical industries; Unit operations involved in food and pharmaceutical industries; Application of Chemical Engineering: industrial case studies; Role of Chemical Engineers; Economical impact.	**(06 Hours)**
UNIT - V	**Agro-chemical Industry** Significance of agro-chemicals; Role of chemical engineer in synthesis of agro-chemicals; Value added products: biofertilizers, biofuel, bioadsorbents, etc.; Fertilizers, pesticides, herbicides, crop growth enhancers, etc.; Social and economical importance of agricultural chemicals	**(06 Hours)**
UNIT - VI	**Chemical Engineering and challenges** ***(i) Energy:*** Sources of energy and constraints; Need for renewable energy ***(ii)Air:*** Sources of air pollution; Air quality parameters; Air pollution control ***(iii)Water:*** Water quality parameters; Water recycle and reuse; Water treatment methodologies Role of Chemical Engineer in Energy, Air and Water sectors; Economical impact.	**(06 Hours)**
Text Books/ References:		
1	Watcher: Kirk OthmerEncyclopaedia of Chemical Technology, 4th Ed, Jonh Wiley and Sons, New York, 2000	
2	F.Ullmann: Ullmann'sEncyclopaedia of Industrial Chemistry, 16th Ed, Wiley VCH, Edinberg, 2016	
3	R. H. Perry, D. W. Green: Perry's Chemical Engineering's Handbook, 9th Ed., McGraw Hill, New York, 2018	
4	I. D. Wilson: Encyclopaedia of Separation Science,3rd Ed., Wiley VCH Edinberg, 2007	

5	R. Trebal: Mass Transfer operations, McGraw Hill Publications 1997
6	McCabe, Smith, Harriot: Unit Operations of Chemical Engineering, McGraw Hill Publications, 1997

Project based learning: Below is the list of possible topics, which is for guidance faculty can design and provide relevant topics in addition to these	
1	Study and prepare a report on the activities and roles carried out by chemical engineers in different industries
2	Study and prepare a report on the chemical and allied industries and their importance in national economy and social upliftment
3	Study and prepare a report on the fluid flow operations used in any one chemical industry and their importance on overall processing
4	Investigate and prepare a report on the heat transfer operations used in any one chemical industry and their importance on overall processing
5	Investigate and prepare a report on the mass transfer operations used in any one chemical industry and their importance on overall processing
6	Investigate and prepare a report on the mechanical operations used in any one chemical industry and their importance on overall processing
7	Investigate and prepare a report on the unit processes used in any one chemical industry and their importance on overall operation
8	Study the life and work of eminent chemical engineer from India and prepare a report on the economical and societal impact of their work
9	Investigate and prepare a report on formation, processing, life cycle, application and role of chemical engineering in any one petroleum product and its societal and economical impact, along with the role of chemical engineer
10	Investigate and prepare a report on formation, processing, life cycle, application and role of chemical engineering in any one petrochemical product and its societal and economical impact
11	Investigate and prepare a report on formation, processing, life cycle, application and role of chemical engineering in any one processed food product and its societal and economical impact
12	Investigate and prepare a report on formation, processing, life cycle, application and role of chemical engineering in any one processed pharmaceutical product or drug and its societal and economical

	impact
13	Investigate and prepare a report on formation, processing, life cycle, application and role of chemical engineering in any agrochemical and its societal and economical impact
14	Investigate and prepare a report on the challenges of air and water pollution, its effects and role of chemical engineering in overcoming the same
15	Investigate and prepare a report on the challenges in energy sector, its effects and role of chemical engineering in overcoming the same

Syllabus for Unit Test:

Unit Test : I	UNIT : I, II, and III
Unit Test : II	UNIT : IV, V, and VI

DATA STRUCTURE (C PROGRAMMING)		
Designation: Computational		
Pre-requisite Courses: Basic knowledge of computers		
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Practical : 04 Hours/Week	Term-work (TW) : 50 Marks	TW/OR/PR : 02
Total : 04 Hours/Week	Practical/Oral : 50 Marks	Total Credits : 02
	Total : 100 Marks	

Course Outcomes	
1	Apply the knowledge of constant, variables, data types and various standard input output functions to write C-programs.
2	Design a flow chart and write C-programs using control constructs and looping statements and arrays.
3	Develop C-programs using string and pointers.
4	Elucidate the basic concepts of Data structure
5	Clarify dynamic store management.
6	Plot graphs using C- Programming

Topics Covered	
UNIT-I	**C-Programming Language** Introduction; Character sets; Constant; Variables and Data Types: integer, float, double, char, string; Operators: arithmetic, relational, logical, increment and decrement, assignment, conditional; Standard input-output functions: printf ( ), scanf ( ), getch ( ) or getchar( );Programs using if statement, if-else statement, goto statement, etc.; Programs based on standard input-output functions used in C-Programming. 1. Programs based on if-else statements.

	2. Programs based on goto statements. 3. Programs based on switch-case statements
UNIT-II	**Loops and Arrays** Programs using while loop; do-while loop and for loop; Single dimensional and multi-dimensional arrays. 4. Programs based on while loop. 5. Programs based on do-while loop. 6. Programs based on for loop. 7. Write algorithm and flowchart for array. 8. Programs based on single dimensional arrays. 9. Programs based on multi-dimensional arrays.
UNIT-III	**String and Pointers** Programs using string; String functions: strlen( )/ strcpy( )/ strrev( )/ strcat ( )/strlwr ( )/ strupr ( )/ strcmp ( ); Programs using pointers; Use of * and & operators; Pointer arithmetic's; Use of pointers; Pointer and function: parameter passing to function by reference and by value; File handling; Linked list. 10. Programs based on strings and string functions. 11. Programs based on pointers and function.
UNIT-IV	**Introduction to data structures** Storage structure for arrays; Sparse matrices, Stacks and Queues: Representation and application; Linked lists: Single linked lists, linked list representation of stacks and Queues; Operations on polynomials; Double linked list; circular list. 12. Programs based on Array implementation of stack and queues. 13. Programs based on Linked list implementation of stack and queues
UNIT-VI	**Dynamic storage management** Garbage collection and compaction; Infix to post fix conversion; postfix expression evaluation; Trees: Tree terminology, Binary tree, Binary search tree. 14. Programs based on checking balanced parentheses in an expression.

	15. Programs based on implementation of tree and tree traversal. 16. Programs based on implementation of binary search tree.
UNIT-VI	**Graphs**: Graph terminology; Representation of graphs; path matrix; BFS (breadth first search); DFS (depth first search); Topological sorting;Warshall's algorithm (shortest path algorithm.); Sorting and Searching techniques : Bubble sort, selection sort, Insertion sort, Quick sort, merge sort, Heap sort, Radix sort. Linear and binary search methods. 17. Programs based on bubble sort, insertion sort, quick sort, merge sort 18. Programs based on implementation of linear and binary search methods

In addition to these above stated programs / practical's concern faculty member may design his/her own programs / practical's.

Term Work

Term work will consist of the programs/practical's listed above, out of which any ten programs/practical's are to be performed in laboratory by the students.

Text Books/References

1	Y. C. Kanetkar, Let Us C, 15thedition, BPB Publications, New Delhi, 2016.
2	M. Cooper, The Spirit of 'C': An Introduction to Modern Programming, First edition , Jaico Publishing House, 1998
3	Rajaraman V, Adabala N, Fundamentals of Computers, 6th edition, Prentice Hall India Learning Private Limited, 2014.
4	R. Thareja, Data Structures Using C, 2nd edition, Oxford University Press India, 2014.
5	A. N. Kamthane, Introduction to Data Structures in C, Pearson India, 2010
6	A. K. Sharma, Data Structure Using C, Pearson India, 2010

Programme: B. Tech
Chemical (2021)
Sem –II (Chemical)

BIOLOGICAL SCIENCES		
Designation: Professional Core		
Pre-requisite Courses: Biology, Chemistry		
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Lectures : 3 Hours/Week	End Semester Examination : 60 Marks	Theory : 03
Practical : 4 Hours/ Week	Internal Assessment : 40 Marks	TW/OR/PR : 02
Total : 7 Hours / Week	Term-work (TW) : 25 Marks	Total Credits : 05
	Practical/Oral : 25 Marks	
	Total : 150Marks	

Course Outcomes:

After completion of the course students would be able to:

1	Identify the microorganism and its structure.
2	Learn the basics of biochemistry.
3	Analyze the enzyme technology with different aspects.
4	Identify the biomaterials and their applications.
5	Learn the concept of Biodiversity and applications of biological science.
6	Analyze the Bio safety framework in India.

Topics covered

UNIT-I	**Molecular Cell Biology** Introduction to cell; Eukaryotes and prokaryotes; Classification of microorganisms and important cell types; Structures of the bacterial cell; Classification and Identification of microorganisms; Cultivation of bacteria; Reproduction and growth.	**(06 Hours)**

UNIT-II	**Biochemistry** Biological oxidations; Photosynthesis; Carbohydrates, lipids and their metabolism; Structure of biomolecules; Intra and intermolecular forces; Introduction to kinetics of biological systems.	**(06 Hours)**
UNIT-III	**Enzymes for Life Sciences** Classification of enzymes; Specificity of enzyme action; Factors modifying enzyme activity; Biotechnological applications of enzymes in various industries; Enzyme Immobilization.	**(06 Hours)**
UNIT-IV	**Bio-materials** Classification of biomaterials; Comparison of properties of some common biomaterials; Effects of physiological fluid on the properties of biomaterials; Biodegradable materials; Introduction to bio-materials in medicine.	**(06 Hours)**
UNIT-V	**Biodiversity and Applications of Biological science** Components of Biodiversity; Biodiversity crisis and biodiversity loss, Importance of biodiversity in daily life; Biodiversity and climate change; Biofuel; Bio fertilizers; Biocides; Application in food industry.	**(06 Hours)**
UNIT-VI	**Biosafety-regulatory Framework in India** Food Adulteration Act (1955), Standard safety methods for handling microorganisms; National Environment Policy (2006); Storage of hazardous microorganisms/genetically engineered organisms or cells; Case studies for handling of various microorganisms.	**(06 Hours)**

***Project Based Learning**

1	Identification of microorganisms according to structure of bacterial cell
2	Learn to cultivate bacteria
3	Analyze enzyme applications in medical field
4	Analyze enzyme applications in chemical engineering
5	Analyze enzyme applications in food industry
6	Illustration of Biomaterial applications in medical field

7	Learn the concept of Biodiversity and climate change
8	Analyze application of biofuel
9	Analyze application of biocides in agricultural industry
10	Learn handling of microorganisms at various conditions
*Students in a group of 3 to 4 shall complete any one project from the above list.	
Term Work	
Term work will consist of the experiments listed below, which are to be performed in laboratory by the students.	
1	Enzyme catalysis
2	Enzyme activity assay
3	Yeast fermentation
4	Enzyme concentration
5	Substrate concentration effect on enzyme activity
6	Temperature effect on enzyme activity
7	Effect of pH on enzyme activity
8	Effect of inhibitors on the enzymatic activity
9	Effect of inhibitors on the enzyme activity
Text Books/References:	
1	Bruce A. Alexander J. Julian L., Martin R. Keith R. and Peter W.: "Molecular Biology of the Cell", 5th Edition, CRC Press, India.
2	Paul D.: "Physics in Biology and Medicine", 3rd Edition, Academic Press, USA.
3	Colin R. Bjorn K. : "Basic Biotechnology", 3rd Edition, Cambridge University Press, UK
Syllabus for Unit Test:	
Unit Test : I	Units : I, II, and III
Unit Test : II	UNIT : IV, V, and VI

MATERIAL AND ENERGY BALANCE CALCULATIONS			
Designation: Professional Core			
Course Pre-requisites: Basic knowledge of chemistry			
Teaching Scheme		**Examination Scheme**	**Credits Allotted**
Lectures : 04 Hours/Week		End Semester Examination : 60 Marks	Theory : 04
Total : 04 Hours/Week		Internal Assessment : 40 Marks	Total Credits : 04
		Total : 100 Marks	
Course Outcomes:			
1	Solve problems based on basic chemical calculations with considering the concepts of units and dimensions.		
2	Estimate material balance calculations without chemical reaction for the systems involved in various unit operations.		
3	Estimate material balance calculations involving chemical reaction for the unit processes carried out in chemical industry.		
4	Elaborate the concept of recycle, bypass, purge operations and solve problems based on humidification, recycle, bypass and purge operations.		
5	Interpret the concept of energy balance and solve the problems based on energy balance calculations.		
6	Evaluate gross and net calorific values of fuel and solve the problems based on them.		

Topics covered		
UNIT-I	**Basic Chemical Calculations** Units and dimensions;Mole, atomic mass, and molar mass concept; Gas mixtures; Gas –liquid mixtures; Joule Thomson effect; Basic composition calculations for homogeneous two phase and three phase systems.	**(08 Hours)**
UNIT-II	**Material Balances without Chemical Reactions** Generalized law of conservation of mass; Mass conservation without chemical reaction; Mass balances for unit operations encountered in chemical process	**(08 Hours)**

	industry : Distillation, extraction, evaporation, crystallization, blending etc.	
UNIT-III	**Material Balances involving Chemical Reactions** Generalization of law of conservation of mass involving chemical reaction and its simplification; Chemical equations and stoichiometry; Basic concepts: conversion, yield, selectivity; Material balance for unit processes encountered in chemical process industry: nitration, esterification, acylation, sulfonation etc.	**(08 Hours)**
UNIT-IV	**Recycle, Bypass and Purge Operations** Necessity of recycle, bypass and purge streams; Basic calculations of recycle, bypass and purge streams for unit operations and unit processes; Industrial examples of recycling, bypassing and purging with complete mass balance viz. biofuel synthesis, food processing etc.; Humidification operation.	**(08 Hours)**
UNIT-V	**Energy Balance** Basic concepts; Heat capacity; Sensible heat and latent heat: Clausius-Clapeyron equation; Standard heat of formation, combustion and reaction; Hess's law; General equation of energy balance; Energy balance approach and calculations for exothermic and endothermic reactions with industrial examples; Steam table and its utility; Utility energy balance calculations; Simultaneous heat and energy balance; Humidification operation.	**(08 Hours)**
UNIT-VI	**Fuels and Combustion** Types of fuels: solid, liquid and gas; Calculations of energy content of fuel; Analysis of fuel; Oxygen requirement and excessity; Adiabatic flame temperature calculations; Endothermic and exothermic reaction; Energy analysis and calculations.	**(08 Hours)**

Project Based Learning:	
1.	Investigate and prepare a report on mass and energy balance for any one of following unit operations for given system.
	a) Distillation
	b) Evaporation
	c) Extraction
	d) Crystallization

	e) Drying. etc
2.	Investigate and prepare a report onmass and energy balance for any one of following unit processes for given system. It may include overall energy and/or mass balance over a given chemical process equipment.
	a) Nitration
	b) Esterification
	d) Fermentation
	e) Sulfonation etc.
3.	Visit chemical industry and prepare a detailed report on various unit operations and unit processes used in industry along with their mass and energy balance.
4.	Measure the calorific values of any two types of fuel and prepare an assessment on the factors affecting calorific value.
5.	Prepare an report and present the mass and energy balance for unit operations and unit processes with chemical reaction carried out in chemical industry.
6.	Solve last five years GATE question papers with reference to material and energy balance calculations.
7.	Students have to study any five NPTEL videos related to material and energy balance calculations and prepare/present power point presentation.
8.	Technical interview based on knowledge of material and energy balance calculations.
9.	Prepare models for recycle, bypass and purge operations carried out in chemical industry.
10.	With the help of this subject knowledge, write a report on how you would apply your concepts in industry.
11.	Prepare a report on unit operations which are newly introduced in the current year.
12.	Write a report on your visit to research and development laboratory of national/international repute.
Students in a group of 3 to 4 shall complete any one project from the above list. In addition to these above stated topics concern faculty member may design his/her won topics.	
Text Books/References:	
1.	B. I. Bhatt and S. M. Vora, Stoichiometry (SI Units), 5th Ed., Tata McGraw Hill Publishers, New Delhi,

	2010.
2.	D. M. Himmelblau, Basic Principles and Calculations in Chemical Engineering, 8th Ed. Prentice Hall Publications, 2015.
3.	O. A. Hougen, K. M Watson and R. A. Ragatz, Chemical Processes Principles, Part-I, Material and Energy Balances, Asia Publishing House, Bombay, 2004.
4.	R.M. Felder and R.W. Rousseau, Elementary Principles of Chemical Processes, 3rd edition, John Wiley & Sons Publications, 2005.
5.	D. F. Rudd, G. J. Powers and J. F. Sirola, Process Synthesis, Prentice Hall Publications.
6.	S.D. Shukla and G. N. Pandey, Chemical Engineering Calculations, Lion Press, Kanpur.
7.	W.E. Ranz, Describing Chemical Engineering Systems, McGraw Hill Publications, 1970.

Syllabus for Unit Test:

Unit Test -I	UNIT – I ,II,III
Unit Test -II	UNIT – IV,V,VI

JAVA PROGRAMMING		
Designation: Computing		
Pre-requisite Courses: Basic knowledge of computer fundamentals, C/C++ programming.		
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Practical : 04 Hours/Week	TW : 50 Marks	TW/OR/PR : 02
	Practical/Oral : 50 Marks	Total Credits : 02
	Total : 100 Marks	

Course Outcomes	
1	Elucidate basic OOPs concepts and requirement of Java
2	Clarify class fundamentals
3	Apply OOPs concept using inheritance
4	Elucidate runtime exceptions
5	Comprehend reading and writing files in java
6	Clarify collection of objects with searching and sorting.

Topics Covered	
UNIT-I	**Introduction to Java** : OOPs concepts; Need of Java; Java Virtual Machine (JVM); Java Development Kit (JDK); byte code; variable; Data types, Handling strings, arrays, operators, and control flow statements: command line arguments, Automatic type promotion. 1. Programs based on if-else, switch-case statements. 2. Programs based on loop statements. 3. Programs based on arrays.
UNIT-II	**Class Fundamentals:** Java classes and objects; Methods and constructors; ‘this’ keyword; Method accepting and

	returning objects; Method overloading and constructor overloading; static and final keywords; Nested classes. 4. Programs based on method accepting and returning objects. 5. Programs based on method overloading and constructor overloading. 6. Programs based on object arrays.
UNIT-III	**Inheritance:** Simple inheritance; Member access in inheritance; super class variable can refer subclass object; super keyword; Multilevel hierarchy of inheritance; Method Overriding; Dynamic method dispatch (Run time polymorphism); Abstract classes; Interfaces; DMD using abstract classes and interfaces; Interfaces can be extended; final keyword to restrict inheritance; Creating packages. 7. Programs based on multilevel hierarchy of inheritance. 8. Programs based on super keywords. 9. Programs based on dynamic method dispatch (DMD).
UNIT-IV	**Exception handling:** Exception introduction; Uncaught exception; try-catch blocks; Describing an exception; 'throw' keyword; 'throws' keyword; finally keyword; Manual exception. 10. Programs based on dynamic method dispatch using abstract classes and interfaces 11. Programs based on manual exception. 12. Programs based on Buffered Reader class.
UNIT-V	**IO Mechanism:** Byte stream; Character stream; Reading data from console: BufferedReader, DataInputStream class; Reading and writing files: FileInputStream and FileOutputStream class. 13. Programs based on DataInputStream class. 14. Programs based on FileInputStream class. 15. Programs based on File Output Stream class.
UNIT-VI	**Collection Framework:** Equals ( ) and hashCode ( ) methods, instanceof operator; Lists; Sets; Maps; Sorting and searching. 16. Programs based on Sorting. 17. Programs based on searching.

In addition to these above stated programs / practicals concern faculty member may design his/her own programs / practicals.

Term Work

Term work will consist of the programs/practicals listed above, out of which any ten programs/practicals are to be performed in laboratory by the students.

Text Books/References

1	H. Schildt, Java 2 Complete Reference, 5th Edition, Tata Mc-Gra Hill.
2	SCJP 1.6 – Khalid Mughal.
3	SCJP 1.6 – Kathy Sierra.
4	JAVA 7 Programming, Black Book ,Kogent Learning Solutions Inc.
5	K. Arnold, J. Gosling, D. Holmes, The Java Programming Language, 3rd Edition, Sun Microsystems.
6	A Primer, E. Balaguruswamy, Programming with Java, Tata Mc-Graw Hill Companies.
7	P. Naughton, H. Schildt, The complete reference Java 2 Third Edition, TMH publication.

Bharati Vidyapeeth

(Deemed to be University)

Faculty of Engineering and Technology

Programme: B. Tech. (Chemical) (2021 Course)

Syllabi of Semester III and Semester IV Courses

Programme: B. Tech Chemical (2021)

Sem -III (Chemical)

CHEMICAL ENGINEERING THERMODYNAMICS- I		
Designation: Professional Core		
Pre-requisite Courses: Basic knowledge of chemistry, physics and mathematics, Material and energy balance calculations.		
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Lectures : 04Hours/Week	End Semester Examination : 60 Marks	Theory : 04
Tutorial : 01Hours/Week	Internal Assessment : 40 Marks	Tutorial : 01
Total : 05 Hours/Week	Total : 100 Marks	Total Credits : 05

Course Outcomes

1	Differentiate between energy, work and heat
2	Estimate energy requirement for a system using first law of thermodynamics
3	Estimate efficiency of heat engines and entropy of system using second law of thermodynamics
4	Estimate pressure, volume and temperature of fluid.
5	Estimate thermodynamic properties of pure fluids using pressure, volume and temperature conditions.
6	Apply laws of thermodynamics to refrigeration and steam power plants

Topics Covered

UNIT-I	**Basic concepts of Thermodynamics** Scope of Thermodynamics; Macroscopic and microscopic Thermodynamics; Dimensions and units; Thermodynamic properties: pressure, temperature, volume; Work, energy and heat; Thermodynamic systems: Closed, open, and isolated systems; Concept of continuum; Intensive and extensive properties;	**(08 Hours)**

	State function and path function; Thermodynamic equilibrium: Mechanical, thermal and chemical; Phase rule; Reversible and irreversible processes.	
UNIT-II	**First Law of Thermodynamics and its applications** Joule's experiment and internal energy; First law of Thermodynamics and its generalized mathematical form; Enthalpy; Heat Capacity; Constant volume and constant pressure processes; Applications of first law of Thermodynamics: Mass and energy balance equations for flow process; Limitations of first law of Thermodynamics.	**(08 Hours)**
UNIT-III	**Second Law of Thermodynamics** Necessity of second law of Thermodynamics; Kelvin-Plank and Clausius statements of second law of thermodynamics; Heat engine: Carnot cycle and efficiency; Entropy; Clausius entropy inequality; Entropy change of ideal gas; Mathematical statement of second law of thermodynamics; Third law of thermodynamics and its mathematical statement.	**(08 Hours)**
UNIT-IV	**Volumetric Properties of Pure Fluids** PVT behaviour of pure substance: PT and PV diagrams; Basic equation of state; Ideal gas and real gas; PVT behaviour of ideal gas; Thermodynamic relations for ideal gas for isochoric, isobaric, isothermal, adiabatic, and polytropic processes; PVT behaviour of real gas: (i) the Viral equations, (ii) two parameter equations such as van der Waal equation, Redlich-Kwong equation, etc. (iii) compressibility factor: two and three parameter theorems of corresponding state.	**(08 Hours)**
UNIT-V	**Thermodynamic Properties of Fluids** Fundamental property relations for homogeneous phases: (i) Internal energy, Enthalpy, Helmholtz energy, and Gibbs energy, (ii) Maxwell relationships; Two-phase systems: Clausius - Clapeyron equation and Antoine equation; Fugacity and fugacity coefficient: Estimation of fugacity of pure gas; Thermodynamic diagrams: (i) temperature-entropy, (ii) pressure-enthalpy, and (iii) enthalpy-entropy (the Mollier diagram).	**(08 Hours)**
UNIT-VI	**Major Applications of Laws of Thermodynamics** **(i) Refrigeration** Carnot theory and ideal efficiency for refrigeration; Industrial refrigeration cycles and efficiency calculations: Vapor compression cycle and gas absorption cycle. **(ii) Steam power plant** Carnot theory and ideal efficiency for steam power plant; Industrial steam	**(08 Hours)**

	power plants and efficiency calculations: Rankine cycle, reheat cycle, and regenerative cycle.	

Project Based Learning	
1.	Draw P-T and P-V diagrams for pure substances.
2.	Numerical involving Pure Fluid Properties Coupled to 1st and 2nd Laws.
3.	Solving numerical based on application of thermodynamics to transient open and closed systems
4.	Students have to study any five NPTEL videos related to Chemical Engineering Thermodynamics I and prepare/present power point presentation.
5.	Group discussions on any of the following topics: a) Importance of Chemical Engineering Thermodynamics in chemical industries. b) Practical applications involving various thermodynamic processes. c) Ideal Gas, Real Gas, Ideal gas mixture, Ideal solution.
6.	Questions involving first law applied to pure component systems.
7.	Solving numerical in connection with entropy changes of ideal gas for various thermodynamic processes.
8.	Solving numerical based on Refrigeration and Liquefaction.
9.	Enhancement in collaborative learning is done through, group assignments that will be given to encourage students to work with classmates to discuss and complete homework assignments.
10.	Solve question papers of CET I of previous THREE years.
11.	Unsolved numerical from the reference books on various topics studied.
12.	Preparation of a brief report on applicability of equations of states (EOS) in chemical engineering systems.
Text Books/References	

1	J. M. Smith and H. C. Van Ness, “Introduction to Chemical Engineering Thermodynamics”, McGraw- Hill Publication
2	T. E. Daubert, ” Chemical Engineering Thermodynamics”, McGraw- Hill Publication
3	K.V. Narayanan,” Chemical Engineering Thermodynamics”, PHI Learning Pvt. Ltd.
4	B. F. Dodge, “Chemical Engineering Thermodynamics”, McGraw- Hill Publication
5	M. D. Koretsky, “Engineering and Chemical Thermodynamics”, 2nd Edition, John Wiley & Sons
6	S. I. Sandler, “Chemical Engineering Thermodynamics”, McGraw- Hill Publication
7	S. Glasstone, “Thermodynamics for Chemists”, Affileated East West Press Pvt.Ltd.

Syllabus for Unit Tests	
Unit Test I	Units I, II, and III
Unit Test II	Units IV, V, and VI

PROCESS HEAT TRANSFER		
Designation: Professional Core		
Pre-requisite Courses: Basic knowledge of physics and mathematics; Material and energy balance calculations		
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Lectures : 04 Hours/Week	End Semester Examination : 60 Marks	Theory : 04
Practical : 02 Hours/Week	Internal Assessment : 40 Marks	TW/OR/PR : 01
Total : 06 Hours/Week	Term-work (TW) : 25 Marks	Total Credits : 05
	Practical/Oral : 25 Marks	
	Total Marks : 150	

Course Outcomes

1	Estimate rate of heat transfer by conduction mode.
2	Estimation of overall heat transfer coefficient.
3	Estimation of heat transfer coefficient for natural and forced convection using appropriate empirical correlation.
4	Estimate rate of heat transfer in boiling and condensation phenomena.
5	Estimation of radiative heat transfer rate.
6	Estimation of time required to raise/reduce the temperature of given process/operation by a desired degree.

Topics Covered

UNIT-I	**Conduction** Concept of heat conduction; Fourier's law of heat conduction; Thermal	**(08 Hours)**

	conductivity: solids, liquids and gases; Effect of temperature and pressure on thermal conductivity; Steady state heat conduction through composite wall; Steady state heat conduction through a variable area: Cylinder and sphere; Steady state heat conduction with heat sources: plane wall, cylinder and sphere; Average temperature calculations.	
UNIT-II	**Heat Transfer Coefficient** Concept of convective heat transfer and heat transfer coefficient; Newton's law of convective heat transfer; Overall heat transfer coefficient: Heat transfer between fluids separated by plane wall and cylindrical wall; Heat transfer from extended surfaces; Thermal contact resistance; Critical insulation thickness; Optimum insulation thickness.	**(08 Hours)**
UNIT-III	**Natural and Forced Convection** Concept of natural and forced convection; Estimation of heat transfer coefficients: Dimensional analysis and dimensionless groups; Factors affecting individual heat transfer coefficient; Empirical correlations for natural convection: flat plate, cylinder and sphere; Empirical correlations for forced convection: Internal flows (laminar and turbulent flow through circular and non-circular pipes) and external flow (flat plate, cylinder and sphere); Heat transfer with variable driving force: Counter current and co-current operations; Momentum and heat transfer analogies.	**(08 Hours)**
UNIT-IV	**Boiling and Condensation** Concept of boiling; Boiling regimes and heat transfer rate: Natural convection, nucleate boiling, transition boiling and film boiling; Concept of condensation; Film-wise and drop-wise condensation; Film condensation on vertical and horizontal surfaces; Estimation of condensation heat transfer coefficient: Nusselt's theory; Factors affecting the rate of condensation.	**(08 Hours)**
UNIT-V	**Radiation** Concept of radiation; Blackbody radiation; Radiative heat transfer laws: Planck's law, Wien's law, Stefan-Boltzmann law, Kirchhoff's law; Radiativeheat exchange between surfaces: View factor; Rate of radiation exchange between black and grey bodies; Radiation intercepted by shield; Radiation combined with conduction and convection.	**(08 Hours)**
UNIT-VI	**Unsteady State Heat Transfer** Unsteady state heat conduction; Concept of thermal diffusivity; Unsteady state heat transfer in mechanically agitated contactors (MAC): MAC configurations, Overall heat transfer calculations, Estimation of time needed to attain desired temperature for a given operation/process using isothermal and non-isothermal heating medium; Unsteady state heat transfer in multiphase reactors: Estimation of overall heat transfer	**(08 Hours)**

	coefficient and time needed to calculate process temperature attainment.	

Project Based Learning

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1	Bydeterminingoptimumthicknessofinsulationgivesolutiontoanindustrialproblemtominimizetheheat loss.
2	Designlaboratorymanualsbetterthanexistingoneswithclearlyshownspecimencalculations.
3	With the help of this subject knowledge, write a guide line report on how you would apply your concepts in Industry.
4	Writeatechnicalreport onyourvisittoaprocessindustry.
5	Solveold(lasttenyears)GATEquestionpaperswithreferencetoheat transfersubject.
6	Groupdiscussionontherecent advancesinheattransferprocesses.
7	Writeareport onyourvisittoresearchanddevelopment laboratoryofnational/internationalrepute.
8	Technicalinterviewbasedontheknowledgeof heattransfer.
9	Writeareport ontherecentadvancesinheattransferprocesseswithreferencetothe current year.
10	Solveold(lastfiveyears) questionpaperswithreferenceto particulartopic.
11	Prepareamodelforanyofthe heattransfer equipment.
12	Preparereport on heattransferequipments whicharenewlyintroducedin thecurrent year.
13	Givefifteenminutespresentation(seminar)onparticular topicandpreparereport.
14	Evaluatecapacityand economyfor anyindustrial evaporator.
15	Estimatehowmuch heattransfer rateisdecreaseddue tothescaleformation onsurfaceofindustrial heattransfer equipment?

Term Work

Term work will consist of the experiments listed below, which are to be performed in laboratory by the students

1	To determine rate of heat flow and thermal conductivity of an insulating material.
2	To determine thermal conductivity of a metal bar.
3	To study Newton's law of cooling to find rate of heat flow.
4	To determine the local heat transfer coefficients using the various correlations in natural convection.
5	To determine heat transfer coefficient in forced convection.
6	To study film wise condensation.
7	To study drop wise condensation.
8	To determine the critical heat flux

9	To study Stefan-Boltzman law and find the value of its constant.
10	To study heat transfer through a composite wall.
11	To determine emissivity of an aluminum plate.
12	To study unsteady state processes.

Text Books/References

1	Holman, J.P., "Heat Tansfer", 9th edn. The McGraw-Hill Companies, 2008
2	Dutta B. K., "Heat Transfer: Principles and Applications", PHI, 2001
3	Kern D. Q., "Process Heat Transfer", Tata McGraw-Hill Edition, 1997
4	McCabe, W. L., Smith, J. C., and Harriott, P., "Unit Operations of Chemical Engineering", McGraw-Hill, 6th. Ed., 2001
5	Chapman, A.J. "Heat Transfer", 4th edn. Maxwell Macmillan International Edition, 1984.

Syllabus for Unit Tests

Unit Test I	Units I, II, and III
Unit Test II	Units IV, V, and VI

FLUID MECHANICS		
Designation: Professional Core		
Course Pre-requisite: Material and Wave Physics.		
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Lectures : 04 Hours/Week	End Semester Examination : 60 Marks	Theory : 04
Practical : 02 Hours/Week	Internal Assessment : 40 Marks	TW/OR/PR : 01
Total : 06 Hours/Week	Term-work (TW) : 25 Marks	Total Credits : 05
	Practical/Oral : 25 Marks	
	Total : 150 Marks	

Course Outcomes

1	Evaluate properties of fluids using basic concept of fluid flow.
2	Apply the basic equations of fluid flow to study various flow systems
3	Select anappropriate type of flow measuring device.
4	Determine the major and minor energy losses for fluid flowing through a pipe.
5	Identify and select various types of fluid moving equipments for fluid flow.
6	Determine the friction factors and pressure drop for flow through packed and fluidized bed.

Topics Covered

UNIT-I	**Basic Concepts of Fluid Flow** Fluid statics and dynamics: Scope and applications; Rheological classification of fluids; Incompressible and compressible fluids; Types of flow: laminar, transition and turbulent flow and their characteristics, Reynolds experiment; Properties of fluids: concept of viscosity,Newton’s law of viscosity,viscosity of gases and liquids, eddy viscosity; Concept of fluid pressure and hydrostatic	**(06Hours)**

	equilibrium.	
UNIT-II	**A. Equations of Fluid Flow** Equation of continuity and motion: Cartesian coordinates, Navier Stokes equation; Bernoulli's equation: assumptions, equation with and without friction, limitations of Bernoulli's equation, correction factors; Applications of equations of fluid flow. **B. Flow of Incompressible Fluids** Characteristics of pipe flow: laminar flow in pipes, shear stress distribution and velocity profiles, relationship between skin friction and wall shear, Hagen Poiseuille equation, relation between average and maximum velocity.	**(06 Hours)**
UNIT-III	**A. Turbulent flow** Basics of turbulent flow, equations of continuity and motion for turbulent flow, Boussinesq hypothesis, Prandtl mixing length theory, turbulent pipe flow, basis of Universal velocity profile and its use. **B. Flow metering devices** Pitot tube, orifice meter, venturi meter, rotameter, notches and weirs.	**(06Hours)**
UNIT-IV	**Major and Minor Losses in Pipe Flow** Major losses: Head loss due to friction, Darcy–Weisbach equation; Friction factor: concept, correlations of friction factor for laminar, transition and turbulent flow, friction factor chart (Moody's diagram), frictional loss in highly turbulent flow, effect of wall roughness; Minor losses: pipe entrance and exit, sudden expansion and contraction, fittings, valves, bends etc.	**(06 Hours)**
UNIT-V	**Flow Moving Machinery** Pumps: types, selection and specifications, characteristic curves, cavitation phenomena, net positive suction head (NPSH) calculations, operating parameters affecting the performance of a pump, calculation of power requirement; Blowersand compressors: selection and specifications, factors affecting performance, power calculations for given duty.	**(06 Hours)**
UNIT-VI	**Flow Past Immersed Bodies** Hydrodynamic boundary layer: concept, boundary layer thickness, growth over a flat plate, boundary layer separation, drag on a flat plate for laminar and turbulent flow, drag on immersed bodies; Flow through packed and fluidized beds: flow through beds of solids, motion of particles through the fluid, particle settling, mechanism of fluidization, minimum fluidization velocity, friction	**(06 Hours)**

	factors for flow through beds of solids, pressure drop calculations, particulate and aggregative fluidization, applications of fluidization.	

Term Work	
Term work will consist of the experiments listed below, out of which at least eight experiments should be performed in laboratory by the students.	
1	To determine kinematic viscosity and to study the effect of temperature on kinematic viscosity of given oil.
2	To study flow characteristics using Reynolds apparatus and determine Reynolds number.
3	To determine the coefficient of discharge for venturimeter.
4	To determine the coefficient of discharge for orificemeter.
5	To determine Darcy Weisbach coefficient of friction for laminar and turbulent flow.
6	To determine friction and pressure drop for flow through helical/spiral coils.
7	To find losses due to sudden expansion and contraction in pipe.
8	To calculate minimum fluidization velocity using fluidized bed reactor.
9	To verify Bernoulli's theorem.
10	To study characteristics of centrifugal pump.
11	To Study Darcy's law.
12	To study pressure drop in packed bed for different fluid velocities.
13	To determine the coefficient of discharge for different notches like rectangular notch, V notch, and trapezoidal notch.
14	To determine terminal velocity of particles in fluids of different viscosity and plot a graph of drag coefficient (C_D) as a function of NRe.
Project Based Learning:	
1	Investigate and prepare a report on any one of the following topics.
	a) Importance of fluid flow operations in chemical industries.

	b) Pumps, blowers and compressors.
	c) Flow measuring devices.
2	Students have to study any five NPTEL videos related to fluid flow operations and prepare/present power point presentation.
3	Visit to suppliers and prepare a report on detailed specifications of following fluid moving equipments.
	a) Pumps.
	b) Blowers.
	c) Compressors.
4.	Visit to suppliers and prepare a report on detailed specifications of following flow measuring devices.
	a) Venturimeter.
	b) Orificemeter.
	c) Pitot tube.
	d) Roatameters.
5.	Students have to visit chemical industry and make a detailed report on overall fluid flow operations.
6.	Prepare models for various types of valves and write industrial applications.
7.	Prepare models for various types of bends and write industrial applications.
8.	Prepare models for various types of fittings and write industrial applications.
9.	Prepare a report on fluid flow operations which are newly introduced in the current year.
10	Write a report on your visit to research and development laboratory of national/international repute.
11	Technical interview based on knowledge of fluid flow operations.
12	With the help of this subject knowledge, write a report on how you would apply your concepts in industry.

Students in a group of 3 to 4 shall complete any one project from the above list. In addition to these above stated topics concern faculty member may design his/her won topics.

Text Books/References

1	W. L. McCabe, J. C. Smith, and P. Harriott, Unit Operations of Chemical Engineering, 5th edition, McGraw Hill Publications, 2008.

2	J.M.Coulson, J. F.Richardson, J. R. Backhurst, J. H. Harker, Chemical Engineering Volume 1, 6thedition, Pergamon Press, 2003.
3	S.K.Gupta, Momentum transfer operations, Tata McGraw Hill Publishers.
4	R. K. Bansal, A text book of fluid mechanics and hydraulic machines, 9th Ed., Laxmi Publications (P) Ltd, New Delhi, 2010.
5	R.B. Bird, W.E. Stewart, E.N. Lightfoot, Transport Phenomena, John Wiley & Sons, New York, 2007.
6	M.M. Denn, Process fluid mechanics, Prentice Hall Publications, 1979.

Syllabus for Unit Tests

Unit Test I	Units I, II, and III
Unit Test II	Units IV, V, and VI

PARTICULATE TECHNOLOGY		
Designation: Professional Core		
Pre-requisite Courses: None.		
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Lectures : 03 Hours/Week	End Semester Examination : 60 Marks	Theory : 03
Practical : 02 Hours /Week	Internal Assessment : 40 Marks	TW/OR/PR : 01
Total : 05 Hours /Week	Term-work (TW) : 25 Marks	Total credits : 04
	Practical/Oral : 25 Marks	
	Total : 150 Marks	

Course Outcomes: After completion of the course students will be able to

1	To select suitable type of screening and size reduction equipment for different particle sizes
2	To select suitable type of thickeners and clarifiers for separation of suspended solid particles from liquid for example applications in Wastewater treatment plants.
3	To apply beneficiation techniques in Chemical Industries.
4	To select a suitable type of conveyor for transportation of different types of solids
5	To select a suitable type of agitator for mixing and agitation and to estimate power consumption in mixing and agitation.
6	To select a suitable type of filter for filtration of a slurry or a suspension.

Topics Covered

UNIT-I	**Screening and Size Reduction of Solids** Properties of solids; Performance of screening equipment; Testing sieves; Tyler standard sieve series; Sieve shaker; Types of screen analysis; Necessity of size reduction; Crushing efficiency; Energy requirement calculations by using crushing laws; Classification of size reduction equipment: Crushers,	**(06 Hours)**

	Grinders, Ultrafine grinders, Cutters, Dry versus wet grinding; Open and closed circuit grinding.	
UNIT-II	**Settling and Sedimentation** Motion of particle in fluid; Drag force; Drag coefficient; Gravity settling methods; Terminal falling velocity; Stoke's law and Newton's law of settling; Gravity sedimentation operations; Sedimentation test; Kynch theory; Determination of thickener area and depth of thickener; Thickeners, Clarifiers, Sedimentation centrifuges.	**(06 Hours)**
UNIT-III	**Beneficiation Equipment** Froth flotation; Magnetic separator; Scrubbers; Electrostatic precipitators: Mineral jig: Cyclone separator: Hydro cyclone types and centrifuges.	**(06 Hours)**
UNIT-IV	**Handling and Conveying of Solids** Storage of solids; Characteristics of bulk solids; Conveyors: Principle, Construction and Working, Advantages, Disadvantages and Design calculations of Belt Conveyors, Screw conveyors, Chain & Flight conveyors, Bucket elevators and Pneumatic conveyors.	**(06 Hours)**
UNIT-V	**Mixing and Agitation** Types of Impellers; Flow patterns in un-baffled and baffled tanks; Draft tube; Mechanically agitated vessel; Power requirement in mixing; Performance of mixers; Paste and viscous material mixing; Solid-solid mixing; Batch and continuous mixers; Agitator selection.	**(06 Hours)**
UNIT-VI	**Filtration** Classification of filtration and filters; Theory of filtration-equations; Filter media and filter aids; Batch and continuous filters; Plate and frame filter press; Filling and washing in a filter press; Horizontal pressure leaf filters; Rotary drum vacuum filters;Fabric filter: Centrifugal filters-basket type.	**(06 Hours)**

List of Experiments:

Term work will consist of the experiments listed below, of which at least eight should be performed in laboratory by the students.

1	To determine effectiveness of given set of standard screen.
2	To determine energy consumption and crushing law constants for jaw crusher.
3	To determine Critical speed of Ball mill & Average particle size of the product obtained in ball mill.
4	To determine mixing Index of a mixture in Ribbon Blender. **OR** To determine mixing Index of

	mixture in Sigma Mixer.
5	To determine filter medium resistance and cake resistance by using Vacuum Leaf filter.
6	To determine filter medium resistance and cake resistance by using Plate & frame Filter Press **OR** by using centrifuge machine.
7	To determine area of batch thickener by conducting batch sedimentation test.
8	To determine separation efficiency by using froth flotation cell.
9	To determine separation efficiency by using magnetic separator.
10	To determine efficiency of Cyclone separator.
Project Base Learning :	
1	What is surface loading rate explain in brief. The flow into clarifier is 3.2 MGD in tank 80 feet long and 40 feet wide. What is surface loading rate?
2	Research on Recent trends in particle size technology.
3	Watch the NPTEL video on this subject of any TWO modules and summarize it
4	Solve numerical problems asked in previous THREE year question papers.
5	Solve questions asked on filtration in previous THREE year question papers.
6	If your particles are not spherical which equivalent particle size would be suitable to calculate for the purpose of filtration
7	What media are used in filters? What factors affect filter efficiency?
8	How does sedimentation fit in to the waste water treatment process?
9	What zones are present in sedimentation basin?
10	How is sedimentation sludge disposed of?
11	Pilot scale solid-liquid fluidization: Expansion characteristics of solids
12	Estimate power consumption for homogeneous system
13	Industry related unit operation (ANY ONE INDUSTRY) detailing of it.
14	How does filtration fit into the water treatment process?
15	How Does Filtration clean water?

16	What types of filters are used for water treatment? Explain in brief
Text Books/References	
1	McCabe, W. L.; Smith, J. C. and Harriott, P.; Unit Operations of Chemical Engineering, 6^{th} edition, McGraw Hill Publications.
2	Coulson, J.M.; Richardson, J. F.;Backhurst, J. R.; Harker, J. H.; Chemical Engineering Volume 2, 6^{th} edition, Pergamon Press.
3	Badger W. L &Banchero J.T. "Introduction to Chemical Engineering", McGraw Hill
4	Foust A. S "Principles of Unit Operation".
5	George G. Brown, "Unit operations", CBS publishers and distributors.

Syllabus for Unit Test:	
Unit Test -I	UNIT – I ,II,III
Unit Test -II	UNIT – IV,V,VI

MATERIAL SCIENCE AND ENGINEERING		
Designation: Professional Core		
Pre-requisite Courses: Chemistry, Physics and Biology		
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Lectures : 4 Hours/Week	End Semester Examination : 60 Marks	Theory : 04
Total : 4 Hours/Week	Internal Assessment : 40 Marks	Total credits : 04
	Total : 100Marks	

Course Outcomes:

After completion of the course students would be able to:

1	Appraise material properties to choose appropriate material for desired application
2	Compare properties of metals and alloys to select appropriate metal for desired application
3	Analyze properties of hydrocarbon materials and recommend proper material for desired application
4	Define appropriate ceramic material for required applications
5	Assess possibility of material failure by mechanical and chemical failure based upon application and environmental conditions
6	Design appropriate preventive measure to avoid material failure

Topics covered

UNIT-I	**Introduction** Introduction to materials; Bonding between atoms: metallic, ionic, covalent; Van der Waals forces; Role of materials selection in design; Structure-property-processing-performance relationships; Materials and criteria for selection of material in process industries; Material properties: Mechanical, thermal, chemical, electrical, magnetic and technological properties; Modification and control of material properties.	**(08 Hours)**
UNIT-II	**Metal and Their Alloys**	**(08 Hours)**

	Ferrous materials: Pure iron, cast iron, mild steel, stainless steels, special alloy steels, iron and iron carbide; Phase diagram: Heat treatment of carbon steels. ***Nonferrous materials:*** Lead, tin, aluminium, zinc, nickel, copper, magnesium and their alloys; Properties and applications in process industries**.**	
UNIT-III	**Hydrocarbon Materials** ***Polymers:*** Natural and synthetic polymeric materials; Polymer material structure and properties: Deformation, flow and melt characteristics, morphology and order in crystalline polymers, mechanical properties of polymers; Polymer structure and physical properties correlation; Selection of polymeric materials for equipment linings; Fibre reinforced plastic; Application of special polymers like Polyester, Teflon in engineering; Sustainable and biodegradable polymers; Depolymerization; Polymer composites and blends ***Paints, Coatings and Adhesives:*** Compositions, properties and applications	**(08 Hours)**
UNIT-IV	**Ceramic, Glasses and Cement** Definition of ceramics and glasses; Interaction between structure, processing, and properties; Applications of ceramic and glass materials; Crystalline and non-crystalline ceramics: Silicates, refractory, clays, glass, vitreous silica and borosilicate. Cement and its properties: Special cements, cement concrete, RCC- Pre stressed concrete.	**(08 Hours)**
UNIT-V	**Material Failure Analysis** ***Thermal and mechanical failures:*** Creep; Stress; Crystal structure and defects: Vacancies, equilibrium concentration of vacancies, interstitial and substitution impurities in solids, dislocations, types and characteristics of dislocations, interfacial defects, stacking faults ***Chemical failure:*** Acid base environment, water; Corrosion: Theories of corrosion, corrosion attack methods; Types of corrosion: Chemical, biochemical, and electrochemical; Internal and external factors affecting corrosion of chemical equipments; Corrosion charts for process equipment.	**(08 Hours)**
UNIT-VI	**Material failure prevention** Property enhancement by electroplating; Glass and ceramic linings; Polymer lining; Paints; Coatings; Heat treatment techniques; Alloy preparation;	**(08 Hours)**

	Composite and blend formation; Control and prevention of corrosion.	

Text Books/References:

1	Kodgire V. D.: Material Science and Metallurgy for Engineers, 44th Ed. Everest publication India, 2018
2	Gowarikar V. R., Vishwanath N. V., Shreedhar J.: Polymer science, New age International publication, India, 1986
3	Budinsky K. G., Budinsky K. M.: Engineering materials- Properties and Selection, 9th Ed. Prentice Hall of India, 2009.
4	Clauster H. R.: Industrial and Engineering materials, McGraw Hill Book Co. India, 1995
5	Lee J. L. and Evans: Selecting Engineering Materials for Chemical and Process Plants, Business Works, New York, 1974
6	Raghavan V.: Material Science and Engineering, 4th Ed. PHI Learning Private Limited, India, 2015

Project based learning: Below is the list of possible topics, which is for guidance faculty can design and provide relevant topics in addition to these

1	Study and prepare a presentation of different materials, their bonds, bond energy and their effect on material properties
2	Study and prepare a presentation on factors affecting selection of material for any particular engineering application
3	Investigate and prepare the report on cast iron, composition of cast iron and variation in property and application of cast iron based on its composition
4	Investigate and prepare the report on stainless steel and its types, composition of stainless steel based upon its types and variation in property and application of stainless steel based on its composition
5	Investigate and prepare the report on lead and its alloys, composition of alloys and variation in property and application of alloys based on its composition
6	Investigate and prepare the report on Tin and its alloys, composition of alloys and variation in property and application of alloys based on its composition
7	Investigate and prepare the report on Aluminium and its alloys, composition of alloys and variation in property and application of alloys based on its composition

8	Investigate and prepare the report on Nickel and its alloys, composition of alloys and variation in property and application of alloys based on its composition
9	Investigate and prepare the report on Copper and its alloys, composition of alloys and variation in property and application of alloys based on its composition
10	Investigate and prepare the report on Magnesium and its alloys, composition of alloys and variation in property and application of alloys based on its composition
11	Investigate and prepare the report on properties and benefits of polymer, property tuning based upon monomer and composition variation
12	Investigate and prepare the report on properties and benefits of polymer, property tuning based upon monomer and composition variation
13	Investigate and prepare the report on biodegradable polymers and depolymerization, its importance and environmental impact
14	Investigate and prepare the report on surface coating, its importance, and preparation of surface for the same
15	Investigate and prepare the report on effect of composition variation and processing on the properties and applicability of ceramics
16	Investigate and prepare a report on the causes of material failure (chemical or mechanical) bay taking a suitable industrial or real life example

Syllabus for Unit Test:	
Unit Test : I	UNIT: I, II, and III
Unit Test : II	UNIT : IV, V, and VI

PYTHON PROGRAMMING		
Designation: Computational		
Course Pre-requisite: Basic knowledge of computer fundamentals.		
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Practical : 02 Hours/Week	Term-work (TW) : 25 Marks	TW/OR/PR : 01
Total : 02 Hours/Week	Practical/Oral : 25 Marks	Total Credits : 01
	Total : 50 Marks	

Course Outcomes

1	Develop algorithm and explain building blocks of algorithms.
2	Elaborate data type and operators.
3	Elucidate concept of control flow statements and functions
4	Elaborate concept of advanced data types
5	Elucidate concept of data structure
6	Elucidate concept of files, modules, packages.

Topics Covered

UNIT-I	**ALGORITHMIC PROBLEM SOLVING** Algorithms, building blocks of algorithms (statements, state, control flow, functions), notation (pseudo code, flow chart, programming language), algorithmic problem solving, simple strategies for developing algorithms (iteration, recursion). 1. Programs based on arithmetic operations. 2. Programs based on operators. 3. Programs based on areas of different geometrical figures.
UNIT-II	**DATA, EXPRESSIONS, STATEMENTS** Python interpreter and interactive mode; Values and types: int, float, boolean, string, and list; variables, expressions, statements, tuple assignment, precedence of operators, comments, modules and functions, function definition and use, flow of execution, parameters and arguments. 4. Write a program to exchange the values of two variables. 5. Programs based on data types.
UNIT-III	**CONTROL FLOW, FUNCTIONS** Conditionals: Boolean values and operators, conditional (if), alternative (if-else), chained conditional (if-elif-else); Iteration: state, while, for, break, continue, pass; Fruitful functions: return values, parameters, local and global scope, function composition, recursion; Strings: string slices, immutability, string functions and methods, string module. 6. Programs based on conditional statements. 7. Programs based on loop statements. 8. Programs based on functions. 9. Programs based on recursion. 10. Programs based on local and global scope.
UNIT-IV	**LISTS, TUPLES, DICTIONARIES** Lists: list operations, list slices, list methods, list loop, mutability, aliasing, cloning lists, list parameters; Tuples: tuple assignment, tuple as return value; Dictionaries: operations and

	methods; advanced list processing - list comprehension. 11. Programs based on list. 12. Programs based on tuple. 13. Programs based on dictionaries.
UNIT-V	**DATA STRUCTURE** Lists as arrays. OOPs concepts; linear search, binary search, selection sort, insertion sort, mergesort, histogram. 14. Programs based on searching. 15. Programs based on sorting. 16. Programs based on OOPs concept.
UNIT-VI	**FILES, MODULES, PACKAGES** Files and exception: text files, reading and writing files, format operator; command linearguments, errors and exceptions, handling exceptions, modules, packages. Application to Data Science. 17. Programs based on files. 18. Programs based on modules. 19. Programs based on exception handling.

In addition to these above stated programs/practical's concern faculty member may design his/her own programs / practical's.

Term Work

Term work will consist of the programs/practical listed above, out of which any eight programs/practical's are to be performed in laboratory by the students.

Text Books/References

1	A. B. Downey, Think Python: How to Think Like a Computer Scientist, 2nd edition, Updated for Python 3, Shroff/O' Reilly Publishers, 2016 (http://greenteapress.com/wp/thinkpython/).
2	G. Van Rossum, F. L. Drake, An Introduction to Python – Revised and updated for Python 3.2, Network Theory Ltd., 2011.
3	C. Dierbach, Introduction to Computer Science using Python: A Computational Problem-Solving Focus, Wiley India Edition, 2013.
4	J. V Guttag, Introduction to Computation and Programming Using Python, Revised and expanded Edition, MIT Press , 2013.
5	K. A. Lambert, Fundamentals of Python: First Programs, CENGAGE Learning, 2012.
6	P. Gries, J. Campbell, J. Montojo, Practical Programming: An Introduction to Computer Science using Python 3, 2nd edition, Pragmatic Programmers,LLC,2013.
7	R. Sedgewick, K. Wayne, R. Dondero, Introduction to Programming in Python: An Inter-disciplinary Approach, Pearson India Education Services Pvt. Ltd., 2016.

VOCATIONAL COURSE – I: ANALYTICAL TECHNIQUES

Designation: Basic Science

Course Pre-requisites: Basic Chemistry

Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Practical : 02 Hours/Week	Term-work (TW) : 25 Marks	TW/OR/PR : 01
Total : 02 Hours/Week	Practical/Oral : 25 Marks	Total Credits : 01
	Total : 50 Marks	

Course Outcomes

After completion of the course students will be able to

1.	Analyse the samples using HPLC and define its content and concentration
2.	Analyse the samples using GC and define its content and concentration
3.	Analyse the samples using UV and FTIR, and define its content and concentration
4.	Analyse the samples for carbon, fluoride ion content and define its flow properties
5.	Analyse water and fuel samples for properties and composition
6.	Analyse the samples for surface properties and particle size

Topics Covered

Analytical Method - I	**High Precision Liquid Chromatography** Analysis principle; Criteria of selection; Preparation of samples; Selection of eluent and detector; Selection of elution conditions; Standardization and calibration; Sample analysis: Qualitative and quantitative results	**(08 Hours)**
Analytical Method - II	**Gas Chromatography** Analysis principle; Criteria of selection; Preparation of samples; Selection of eluent and detector; Temperature programming; Elution conditions;	**(08 Hours)**

	Standardization and calibration; Sample analysis: Qualitative and quantitative results	
Analytical Method - III	**Spectrographic analysis** Analysis principle and limitations of spectroscopic analysis ***UV-vis spectrophotometry:*** Beart- Lamberts law; Preparation of samples; Dilutions; Standardization and calibration; Sample analysis: Qualitative and quantitative assessment ***Fourier Transfer Infrared Spectroscopy:*** Preparation of samples; KBr palate formation; Film analysis; Powder analysis; Interpretation of data: Sample analysis	**(08 Hours)**
Analytical Method - IV	**Carbon and Fluoride Ion analysis** Selection of methods for analysis; Preparation of samples; Standardization; Analysis and interpretation **Viscometry analysis** Redwood and plate and cone type viscometers: Measurement principle; Sample Analysis;	**(08 Hours)**
Analytical Method– V	**Fuel Analysis:** Bomb calorimetry; Flash point analysis; Fire point analysis; Coal analysis: Ultimate and proximate analysis; Moisture content measurement by Karl Fisher titration: Standardization and data analysis. **Water Analysis:** Concept of Biological oxygen demand (BOD), Chemical oxygen demand (COD), Total Organic Carbon (TOC) and heavy metal content analysis; Sample analysis	**(08 Hours)**
Analytical Method - VI	**Surface and particle analysis:** ***Particle size analysis:*** Principle; Preparation of solution or dispersion; Sample analysis ***Atomic forced microscopic analysis:*** Principle; AFM analysis.	**(08 Hours)**
The analytical methods and their applications would be defined along with background information, principal and application determination, limitation and applications		
Text Books/ References:		

1	I. M. Kolthoff, J. D. Winefordner, M. M. Bursey: Treatise on Analytical Chemistry, Part 1 Vol. 11: Theory and Practice, 2nd Ed., Wiley and Sons, New York, 1989
2	J. A. C. Broekaert: Analytical Atomic Spectrometry withFlames and Plasmas, Wiley-VCH Verlag GmbH & Co. KGaA, New York, 2002
3	G. D. Christian, P. K. Dasgupta, K. A. Schug: Analytical Chemistry, John Wiley & Sons, Inc., Danvers, 2014
4	D. Harvey: Modern Analytical Chemistry, McGraw-Hill Higher Education, Kingsport, 2000
5	J. Mendham, A. Vogel: Vogel's Textbook of Quantitative Chemical Analysis, 6th Ed., Addison Wesley Publishing Co., Boston, 2000

Programme: B. Tech Chemical (2021)

Sem: IV (Chemical)

NUMERICAL METHODS FOR CHEMICAL ENGINEERING					
Designation: Professional Core					
Pre-requisites courses: Basic knowledge of mathematics including derivative, integration etc.					
Teaching Scheme		**Examination Scheme**		**Credits Allotted**	
Lectures	: 04 Hours/Week	End Semester Examination	: 60 Marks	Theory	: 04
Total	: 04 Hours/Week	Internal Assessment	: 40 Marks	Total Credits	: 04
		Total	: 100 Marks		

Course Outcomes	
After completion of the course students will be able to	
1	Estimate the true percent relative error for given problem
2	Compute the roots of the equation using bracketing methods and open methods
3	Solve Chemical Engineering problems using regression analysis
4	Solve Chemical Engineering problems using numerical differentiation methods
5	Evaluate the integral value using Trapezoidal rule, Simpson's $1/3^{rd}$ rule, Simpson's $3/8^{th}$ rule, and Romberg integration
6	Apply finite difference methods to solve boundary value problems

Topics covered		
UNIT-I	**Approximations and Error Analysis** Approximations; Significant figures; Accuracy and precision; Error definitions; Round off error; Truncation error; True percent relative error;	**(08Hours)**

	Prespecified percent tolerance; Total numerical error; Error propagation; Error analysis of numerical differentiation; Root mean square error; Mean square error; Analysis of variance.	
UNIT-II	**Engineering Applications: Roots of equations** Bracketing methods: Bisection method, False position method; Open methods: Secant method, Newton-Rapson method, Modified Newton-Rapson method; Roots of Polynomials: Mueller's method, Bairstow's method, Picard's method; Solve Chemical Engineering problems using above methods.	**(08 Hours)**
UNIT-III	**Regression analysis and Interpolation** Regression analysis: Linear regression, Least square regression, Logistic regression, Polynomial regression, Nonlinear Regression, Curve fitting, Regression Vs Classification. Interpolation: Direct Method, Lagrange interpolating polynomials, Newton's Divided-Difference interpolating polynomials, Sterling's interpolation, Inverse interpolation, Approximation of functions. Solve Chemical Engineering problems using above methods.	**(08 Hours)**
UNIT-IV	**Engineering Applications: Differential Equations** Problems based on Process Calculation, Fluid Flow operation and Heat Transfer to be solved using following methods: Euler's method, Modified Euler's method, 2^{nd} order Runge-Kutta Method, 4^{th} order Runge-Kutta method; Picard's method of successive approximations; Taylor series method; Milne's predictor-corrector method; Richardson Extrapolation; Ordinary Differential Equation: Boundary Value Problems.	**(08 Hours)**
UNIT-V	**Numerical Integration** Solve Chemical Engineering problems using Newton- Cotes integration, Trapezoidal rule, Simpson's $1/3^{rd}$ rule, Simpson's $3/8^{th}$ rule, Romberg integration; Cauchy integral formula; Multiple application of Simpson's $1/3^{rd}$, $3/8^{th}$ rule, Trapezoidal rule.	**(08 Hours)**
UNIT-VI	**Finite Difference Methods** Introduction to finite difference method; Boundary value problems of exact differential equations up to second order; Hyperbolic equations; Finite difference approximations to derivatives; Elliptical Equation; Control Volume Approach; Heat Conduction Equation.	**(08 Hours)**

	Problems based on Process Calculation, Fluid Flow operation and Heat Transfer to be solved using these methods.	

Assignments

There will be six (6) assignments from various units mentioned in the syllabus. Each assignment will carry 10 marks.

1.	Estimate the error and do the error analysis for any chemical Engineering based problem
2.	Find the roots of equations for the problems based on Fluid Mechanics, Heat Transfer
3.	Solve the equations from Heat Transfer, Fluid Mechanics, and Particulate Technology using numerical differentiation methods
4.	Estimate the integral value for the problems based on Heat Transfer, Fluid Mechanics, Chemical Engineering Thermodynamics, and Particulate Technology etc.
5.	Solve Chemical Engineering problems using regression analysis
6.	Solve the boundary value problems using finite difference methods
7.	Solve old (last five years) question papers with reference to particular topic
8.	Solve old (last five years) GATE paper questions of Numerical Methods for Chemical Engineering subject
9.	With suitable case study explain in detail how this subject is prerequisite for Process Modeling of chemical processes
10.	With the help of this subject knowledge, write a guideline report on how you would apply your concepts for industrial practice

Project Based Learning

Students in a group of 3 to 4 shall complete any one project from the below list

1.	Estimate the roots of polymeric equations for fluid flow operations, equations such as buoyancy of any ball, liquid level in manometer etc.
2.	Apply numerical differentiation techniques to solve the case studies of process heat transfer.
3.	Evaluate the integral value/area under the curve for given equations related to any unit

	operation/process.
4.	Apply finite difference method for boundary value problems of exact differential equations up to second order for specific chemical engineering system.
5.	Collect experimental data from open source literature and do the regression analysis.
6.	Apply Sterling's interpolation formula for the given experimental data and calculate the desired results.
7.	Analyze the given experimental data and apply the curve fitting techniques.
8.	Collect experimental data from open source literature, apply regression analysis for prediction and calculate root mean square error (RMSE).
9.	Using Euler's method solve the case study related to transient heat conduction.
10.	Apply the bracketing methods to find the root of equations of fluid flow systems.

Text Books/References

1	S. C. Chapra and R.P. Canale, Numerical Methods for Engineers, 6th Ed., Tata-McGraw Hill Publications, 2015.
2	T. F. Edgar and D. M. Himmblblau, Optimization of Chemical Processes, 2nd Ed., Tata-McGraw Hill Publications, 2001.
3	M. K. Jain, S. R .K. Iyengar and R. K. Jain, Numerical methods for Scientific and Engineering Computational, 5th Ed., New Age International (P) Publishers, 2005.
4	S. S. Sastri , Introductory methods of Numerical analysis, 4th Ed., Prentice-Hall India, 2009.
5	S. Pushpavanam, Mathematical Methods for Chemical Engineering, 1st Ed., Prentice-Hall of India, 2012.
6	E. Balagurusamy, Numerical Methods, McGraw Hill Education (India) Private Limited, 2008.

Syllabus for Unit Tests

Unit Test I	Units I, II, and III
Unit Test II	Units IV, V, and VI

CHEMICAL ENGINEERING THERMODYNAMICS II		
Designation: Professional Core		
Pre-requisite Courses: Basic knowledge of chemistry, physics and mathematics, Chemical engineering thermodynamics, Material and energy balance calculations		
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Lectures : 04Hours/Week	End Semester Examination : 60 Marks	Theory : 04
Tutorial : 01Hours/Week	Internal Assessment : 40 Marks	Tutorial : 01
Total : 05 Hours/Week	Total : 100 Marks	Total Credits : 05

Course Outcomes	
1	Characterize ideality of gaseous mixtures and liquid solutions.
2	Estimate fugacity coefficient to measure the deviation from ideality.
3	Estimate activity coefficient to measure the deviation from ideality.
4	Analyze vapor liquid equilibrium using thermodynamic stability and consistency tests.
5	Estimate partition coefficient for liquid liquid equilibrium and solid liquid equilibrium.
6	Estimate chemical reaction constant and composition of system at thermodynamic equilibrium.

Topics Covered		
UNIT-I	**Thermodynamics of Ideal Solution** Fundamental property relationships for solutions; Concept of chemical potential and partial molar properties; Estimation of partial molar properties; Gibbs-Duhem equation; Ideal gas mixtures: Gibbs theorem; Ideal solution: Characteristics of ideal solution, Lewis Randall law.	**(08 Hours)**
UNIT-II	**Thermodynamics of Non-ideal Gas Mixtures** Concept of non-ideality in gaseous mixtures; Fugacity and fugacity	**(08 Hours)**

	coefficient for non-ideal gas mixtures; Effect of temperature and pressure on fugacity coefficient; Estimation of fugacity coefficient; Concept of residual property; Relation between residual property and fugacity coefficient.	
UNIT-III	**Thermodynamics of Non-ideal Liquid Solution** Concept of non-ideality in liquid solution; Activity and activity coefficient for non-ideal solution; Effect of temperature and pressure on activity coefficient; Estimation of activity coefficient; Excess properties: Gibbs excess energy; Relation between excess property and activity coefficient; Excess properties of mixing and heat effects.	**(08 Hours)**
UNIT-IV	**Vapor-liquid equilibrium (VLE):** Criteria of vapour liquid equilibria and stability; Basic equation for vapor-liquid equilibrium(Raoult'slaw); Qualitative behavior of VLE; Non-ideality in vapour and liquid phases (Modified Raoult's law); Estimation of liquid phase properties from VLE data; Excess Gibbs free energy models; Azeotropic data; Multicomponent VLE; Bubble point and dew point calculations; Thermodynamic consistency test for VLE data.	**(08 Hours)**
UNIT-V	**Liquid-liquid Equilibria (LLE) and Siquid-liquid Equilibria (SLE):** Equilibrium and stability; LLE: Basic equation governing LLE, Distribution coefficient (Partition Coefficient), solubility diagram, Intermolecular interactions; SLE: Basic equation governing SLE, Solid liquid equilibrium models and estimation of design parameters.	**(08 Hours)**
UNIT-VI	**Chemical reaction equilibria** The reaction coordinate; Application of equilibrium criteria to chemical reactions; The standard Gibbs energy change and the equilibrium constant; Effect of temperature on the equilibrium constant; Evaluation of equilibrium constant; Relation of equilibrium constants to composition; Phase rule for reacting systems; Multi-reaction equilibria.	**(08 Hours)**

Project Based Learning

1.	Group discussions on any of the following topics:
2.	Importance of Phase equilibria in chemical industries.
3.	Solving numerical in connection with phase equilibria

4.	Solving numerical based on application of Roult's law for the calculation of dew point and bubble point
5.	Unsolved numerical from the reference books on various topics studied.
6.	Draw P-xy and T-xy diagrams.
7.	Solving numerical based on chemical reaction equilibrium.
8.	Enhancement in collaborative learning is done through, group assignments that will be given to encourage students to work with classmates to discuss and complete homework assignments.
9.	Students have to study any five NPTEL videos related to Chemical Engineering Thermodynamics I and prepare/present power point presentation.
10.	Solving numerical in connection with the solution thermodynamics
a)	Questions involving fugacity and activity for the species in solution.
b)	Thermodynamic properties for pure species and species in solution
11.	Preparation of a brief report on applicability of liquid-liquid equilibrium (LLE) in chemical engineering systems.
12.	Solve question papers of CET II of previous THREE years.
Text Books/References	
1	J. M. Smith and H. C. Van Ness, "Introduction to Chemical Engineering Thermodynamics", McGraw- Hill Publication
2	T. E. Daubert, " Chemical Engineering Thermodynamics", McGraw- Hill Publication
3	K.V. Narayanan," Chemical Engineering Thermodynamics", PHI Learning Pvt. Ltd.
4	B. F. Dodge, "Chemical Engineering Thermodynamics", McGraw- Hill Publication
5	M. D. Koretsky, "Engineering and Chemical Thermodynamics", 2nd Edition, John Wiley & Sons
6	S. I. Sandler, "Chemical Engineering Thermodynamics", McGraw- Hill Publication
7	S. Glasstone, "Thermodynamics for Chemists", Affileated East West Press Pvt.Ltd.

Syllabus for Unit Tests	
Unit Test I	Units I, II, and III
Unit Test II	Units IV, V, and VI

DESIGN OF HEAT TRANSFER EQUIPMENT		
Designation: Professional Core		
Pre-requisite Courses: Basic knowledge of Heat transfer, Particulate technology, Chemical engineering thermodynamics, Material and energy balance calculations		
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Lectures : 04 Hours/Week	End Semester Examination : 60 Marks	Theory : 04
Practical : 02 Hours/Week	Internal Assessment : 40 Marks	TW/OR/PR : 01
Total : 06 Hours/Week	Term-work (TW) : 25 Marks	Total Credits : 05
	Practical/Oral : 25 Marks	
	Total : 150 Marks	

Course Outcomes

1	Design of double pipe heat exchanger
2	Perform process design of shell and tube heat
3	Perform the evaporation calculations and estimate heat transfer area of evaporator.
4	Analyse heat transfer characteristics of mechanically agitated contactors
5	Analyse heat transfer characteristics of fluidised beds
6	Analyse the heat transfer characteristics of furnaces

Topics Covered

UNIT-I	**Double pipe heat exchanger(DPHE)** Selection criteria of DPHE, Heat load calculations; Estimation of physical properties of fluid if any; Material of construction (MOC); Selection of flow arrangements; LMTD calculations; Estimation of film heat transfer coefficient using appropriate empirical correlation; Estimation of overall heat	**(08Hours)**

	transfer coefficient; Heat transfer area; Concept of hydraulic diameter; Pressure drop calculations: Design and working pressure.	
UNIT-II	**Shell and tube heat exchangers** Shell and tube configurations; Heat load calculations; Material of construction (MOC); Estimation of film heat transfer coefficient; Estimation of overall heat transfer coefficient; Heat transfer area and number of tubes; Sizing of shell and tube heat exchanger: Design of baffle, tie rods, tube sheet and nozzles; Pressure drop calculations: Design and working pressure; TEMA standards.	**(08 Hours)**
UNIT-III	**Evaporators** Concept of evaporation; Types of evaporators; Performance parameters of evaporators: capacity, economy and steam consumption; Methods of feeding for evaporators; Material and energy balances; Sizing of evaporators; Design of steam chest: Estimation of heat transfer coefficient and area, boiling point elevation; Factors affecting performance of evaporators; Pressure drop calculations: Design and working pressure.	**(08 Hours)**
UNIT-IV	**Mechanically agitated contactors (MAC)** Heat transfer configurations of MAC; Heat load calculations; Heat transfer calculations for homogeneous and heterogeneous systems: Estimation of film heat transfer coefficient, overall heat transfer coefficient and heat transfer area; Sizing of MAC; Material of construction (MOC); Factors affecting heat transfer characteristics: system and operating parameters; Indian MAC standards.	**(08 Hours)**
UNIT-V	**Fluidised beds** Concept of fluidization; Fluidization regimes; Pressure drop calculations: Effect of superficial velocity and physical properties of solid and fluidising medium; Velocity voidage relationship; Determination of heat transfer rates: Overall heat transfer coefficient calculations; Sizing of fluidised beds based on heat transfer characteristics;	**(08 Hours)**
UNIT-VI	**Furnaces** Components of a furnace; Classification, Performance measures in furnaces: Excess air, heat distribution, temperature control, draft control, waste heat recovery; Heat transfer in furnace. Furnace efficiencycalculations. Lobo and Evans method. Wohlenberg simplified method.	**(08 Hours)**

Project Based Learning:	
1	Visit to any heat transfer equipment fabrication industry and prepare report on internals of heat exchanger.
2	Perform process design for heat exchanger for given application

3	Visit to sugar industry to observe operation of evaporators and prepare report.
4	Enlist TEMA Standards.
5	Make Power point presentation on recent advances in heat transfer characteristics of any one chemical process equipment
6	Write report on heat transfer aspect and any one multiphase reactor based on recent advances.
7	Design experimental methodology to estimate time needed to heat a given fluid to design temperature with a given heat resource.
8	Designed any one heat transfer equipment on laboratory scale and demonstrate its working.
9	Propose suitable heat exchanger for given operation/ process based rational reasoning.
10	Enlist empirical correlations to estimate HTC in heat exchanger and report applicability.
11	Enlist empirical correlations to estimate HTC in mechanically agitator vessel.
12	Demonstrate effect and specific heat of fluid time needed to raise desired temperature by experimental methodology
13	Enlist possible ways to enhance HTC in a given heat exchange system.
Term Work	
Term work will consist of the experiments listed below, which are to be performed in laboratory by the students	
1	To study temperature distribution and overall heat transfer coefficient, in parallel flow finned tube heat exchanger.
2	To study effectiveness and heat transfer rates in counter flow finned tube heat exchanger.
3	To study temperature distribution, effectiveness, overall heat transfer coefficient, heat transfer rates in double pipe heat exchanger.
4	To study Wilson plot in double pipe heat exchanger.
5	To determine overall heat transfer coefficient, effectiveness for shell and tube heat exchanger.
6	To determine number of tubes, pressure drop for shell and tube heat exchanger.
7	Calculation of heat transfer coefficient, rate of heat flow and effectiveness in Double pipe heat exchanger.

8	Detailed flow arrangements, design and drawing of double pipe heat exchanger
9	Detailed design and drawing of shell and tube heat exchanger
10	Detailed design and drawing of evaporator.
11	Calculation of heat transfer coefficient, No of tubes and rate of heat flow in shell and tube heat exchanger
12	Detailed design and drawing of agitated vessel.

Text Books/References

1	Holman, J.P., "Heat Tansfer", 9th edn. The McGraw-Hill Companies, 2008
2	Dutta B. K., "Heat Transfer: Principles and Applications", PHI, 2001
3	Kern D. Q., "Process Heat Transfer", Tata McGraw-Hill Edition, 1997
4	McCabe, W. L., Smith, J. C., and Harriott, P., "Unit Operations of Chemical Engineering", McGraw-Hill, 6th. Ed., 2001
	Richardson, J. F., and J. M. Coulson: “Chemical Engineering,” Butterworth Heinemann, Volume 6.
5	Chapman, A.J. "Heat Transfer", 4th edn. Maxwell Macmillan International Edition, 1984.
6	George E.Totten and M.A.H.Howes: Steel heat treatment handbook
7	P.Mullinger and B. Jenkins: Industrial and process furnaces

Syllabus for Unit Tests

Unit Test I	Units I, II, and III
Unit Test II	Units IV, V, and VI

CHEMICAL TECHNOLOGY				
Designation: Professional Core				
Pre-requisite Courses: Basic knowledge of chemistry				

Teaching Scheme		**Examination Scheme**		**Credits Allotted**	
Lectures	: 04 Hours/Week	End Semester Examination	: 60 Marks	Theory	: 04
Practical	: 02 Hours/Week	Internal Assessment	: 40 Marks	TW/OR/PR	: 01
Total	: 06 Hours/Week	Term-work (TW)	: 25 Marks	Total Credits	: 05
		Practical/Oral	: 25 Marks		
		Total	: 150 Marks		

Course Outcomes	
1	Learn the concept of unit operations and unit processes.
2	Analyze recent methods used in chloro alkali and electrolytic industries.
3	Learn the manufacturing processes used in sulfur and nitrogen industry
4	Learn the recent techniques used in oil industry.
5	Analyze the various processes used in Sugar-Starch industry and fermentation industry.
6	Learn the production methods used in petrochemical industry .

Topics Covered		
UNIT-I	**Unit operations and Unit processes** Unit operations and unit processes; Concept of block diagram; Process flow diagram (ASME guidelines); Major engineering problems; Schematic representation and applications for unit operations and unit processes. **Chlor-alkali industry, sea chemicals**	**(08 Hours)**

	i) Chlor-alkali industry: Recent processes for the production of soda ash, NaOH and Chlorine ii) Sea chemicals: Sodium-Magnesium compounds, methods for salt recovery	
UNIT-II	**Nitro- Phosphorous Industry and Sulphur Industry** i) Nitrogen Industry: Recent processes for the production of Ammonia, Nitric acid, Urea, Ammonium Nitrate ii) Phosphorous Industry: Production of Phosphoric acid, single and triple Super Phosphate, Ammonium Phosphate iii) Sulphur Industry: Production of Sulphur, Sulphuric acid, Ammonium sulphate.	**(08 Hours)**
UNIT-III	**Oils, Fats, Soaps and Detergents** Extraction of oil from seeds, Oil purification, Hydrogenation of oil. Solvent extraction process; Biodiesel production Production of soap, natural glycerine, production of detergents.	**(08 Hours)**
UNIT-IV	**Sugar-Starch Industry and Fermentation industry** i) Sugar-Starch Industry: Production of Sugar, Starch Derivatives ii) Fermentation Industry: production of ethyl alcohol, citric acid and antibiotics.	**(08 Hours)**
UNIT-V	**Natural products** Terpenes, alkaloids, plant pigments, their applications, Methods for extraction, isolation, molecular separation and purification of biomolecules from natural sources.	**(08 Hours)**
UNIT-VI	**Petrochemical Industry** i) C1 Compounds: Production of methanol, formaldehyde, and halogenated hydrocarbons. ii) C2 Compounds: Production of ethylene and acetylene- steam cracking of hydrocarbons, ethylene dichloride, vinyl chloride. iii) C3 Compounds: Production of propylene by indirect hydration, acetone, cumene. iv) Aromatic Compounds: Production of phenol, phthalic anhydride, and styrene.	**(08 Hours)**
***Project Based Learning**		
1	Development of working model of belt conveyor	

2	Development of working model of bucket elevator
3	Prepare prototype of effluent treatment plant with different units like clarifier, bioreactor , pressure sand filter etc. (Activated sludge process: prototype working model)
4	Prepare prototype of any chemical process industry representing the all the unit operations
5	Prepare prototype of any chemical process industry representing the all the unit processes
6	Analyze Safety aspects in Chemical Process industry
7	Prepare working model of cooling tower
8	Prepare prototype of distillation column using packed column/rasching rings
9	Prepare prototype of dryer tray dryer or rotary dryer
10	Analyze Personal protective equipment used in chemical industry
*Students in a group of 3 to 4 shall complete any one project from the above list.	

Term Work	
Term work will consist of the experiments listed below, which are to be performed in laboratory by the students.	
1	Determination of saponification value of oil sample.
2	Application of pH meter to find acidity and alkalinity of a solution.
3	To study the hydrolysis of cane sugar solution in the presence of an acid by Fehling's solution method and find out the reaction constant.
4	Determination of the strength of unknown hydrochloric acid by titrating it against caustic soda by conductometric method.
5	Preparation of laundry soap and to determine its yield.
6	Analysis of acid oils and soap stocks.
7	Analysis of Glycerine (sweet water).
8	Analysis of detergent powders.
9	Preparation of report on industrial visit.

Text Books/References	
1	C.E.Dryden, Outlines of Chemical Technology" (Edited and Revised by M.GopalRao and Sittig .M) 3 rd Ed., East West Press. , New Delhi, 1997.

2	G.T.Austin, Shreve's Chemical Process Industries, 5^{th} Ed., McGraw Hill Education publisher, 2017
3	P.H.Groggins, Unit process in organic synthesis, 5^{th}Ed.Tata McGraw-Hill Edition, 2004.
4	W.L.Faith, D.B. Keyes, R.L. Clark, Industrial Chemicals, John Wiley, 1975.
5	Kirk and Othmer, Encyclopaedia of Chemical Technology, Wiley, 2005
6	G.N.Pandey and S.D.Shukla, Chemical Technology Vol – I,Vikas publication, 2004

Syllabus for Unit Tests

Unit Test I	Units I, II, and III
Unit Test II	Units IV, V, and VI

INDUSTRIAL POLLUTION AND ABATEMENT		
Designation: Professional Core		
Course Pre-requisites:		
Before studying this subject the student should have knowledge of		
1.	Basic fundamentals included in environmental sciences.	
2.	Fundamentals of unit operation.	

Teaching Scheme	**Examination Scheme**	**Credits allotted**
Lectures: 03Hours/Week	End Semester Examination : 60 Marks	Theory : 03
Practical: 02Hours/Week	Internal Assessment : 40 Marks	TW/PR/OR: 01
Total : 05 Hours/Week	Term-work (TW) : 25 Marks	Total Credits 04
	Practical/Oral : 25 Marks	
	Total : 150 Marks	

Course Outcomes:	
1.	Identify and demonstrate the characterization of wastewater with statutory limits for disposal.
2.	To analyze the important parameters of the wastewater such as BOD, COD, DO, etc.
3.	Demonstrate the various physical unit operations used in the treatment.
4.	Define the various treatment methods available for wastewater and solid waste.
5.	Demonstrate the effect of various air pollutants on man and environment.
6.	Demonstrate the operations of various air pollution control equipments.

Topics covered		
UNIT - I	**Introduction** Overview of pollution aspects in Chemical Process Industries (CPI); Types of pollution; Introduction to all prevailing international standards of Health, Safety, and Environment; Environmental laws and regulations; ISO 14000+; Environmental legislation; Air pollution control act; Indian standards for disposal of industrial effluents; Environmental impact assessment; Life cycle assessment.	**(06 Hours)**
UNIT -II	**Air pollution** Air pollutants: sources, classification of air pollutants, air quality, air pollution minimisation and control, source and control of fugitive emissions, Effects of air pollutants, Measurement of air pollutants; Air pollution control: Particulate emission control by mechanical separation and electrostatic precipitation, wet gas scrubbing, gaseous emission control by absorption and adsorption, Design of cyclones, ESP, fabric filters and absorbers.	**(06 Hours)**
UNIT - III	**Water pollution and its control** Groundwater and surface water pollution: types, sources and effects of water pollutants; Physical treatment: solids removal by setting and sedimentation, filtration centrifugation, coagulation and flocculation; Biological Treatment: Anaerobic and aerobic treatment, biochemical kinetics, trickling filter, activated sludge and lagoons, aeration systems, sludge separation and drying; Assessment of water quality through the measurement of: Dissolved oxygen, biological oxygen demand and chemical oxygen demand.	**(06 Hours)**
UNIT IV	**Advanced treatment methods** Advanced oxidation processes viz. Ozonation, Fenton's and photo-Fenton process, electrochemical process, photocatalysis, ultrasound and hydrodynamic cavitation etc. for the treatment of recalcitrant organics and inorganics/metals;	**(06 Hours)**

	Hybrid treatment processes; recent advanced in treatment methods.	
UNIT- V	**Solid waste management** Analysis and quantification of hazardous and non-hazardous wastes; Treatment and disposal of solid wastes; Land filling; Leachate treatment; briquetting / gasification and Incineration.	**(06 Hours)**
UNIT - VI	**Industrial case studies** Concept of zero discharge system; Application of advanced treatment methods for water reclamation and reuse; Study of minimum two case studies for treatment of industrial waste: pesticide industry, textile industry, pharmaceutical industry etc.	**(06 Hours)**
Expert Interaction	Lecture(s) by eminent scholar(s) on the topic(s) mentioned in the syllabus.	**(02 Hours)**

Project based learning

1	Visit to any waste water treatment plant and specify the advanced in the treatment methods
2	Conduct the survey of air quality in Pune city
3	Write a report on concept of zero discharge and its significance
4	Enlist Indian standards for disposal of industrial effluents.
5	Prepare power point presentation on recent advances in waste water treatment
6	Group discussion on health hazards of air and water pollution.
7	Design a novel method for effective solid waste management.
8	Demonstrate the applications of biological processes in waste water treatment.
9	Design the activated sludge process for any particular industrial effluent.
10	Enlist the characteristics of industrial effluent.
11	Prepare the report on primary, secondary and tertiary treatment methods used in industries
12	Visit a pesticide manufacturing industry and prepare a case study for treatment of pesticide industry effluent
13	Prepare a technical report on the effective treatment of pharmaceutical waste.
14	Visit to nearby municipal water treatment plant.

List of Practical:

1.	Determination of pH, color, and turbidity of a given waste water sample.
2.	Inorganic characterization of waste water sample.
3.	Measurement of D. O. of waste water sample.
4.	Measurement of C. O. D. of waste water sample.
5.	Estimation of B. O. D. of waste water sample.
6.	Study of flocculation technique for a given waste water sample.
7.	Study of froth flotation technique for a given waste water sample.
8.	Study of sedimentation method for the treatment of waste water.
9.	Characterization of dairy waste- A report.
10	Characterization of domestic sewage - A report.

Text Books/References:

1.	Theodore L &Bhomlore A.J. “Air Pollution Control Equipments.”
2.	Coulson J. M. Richerdson J.F. Vol.6.Tata McGraw-Hill.

3.	Rao M.N. & H.V.N. Rao. “Air Pollution McGraw-Hill.
4.	S.P. Mahajan “Pollution Controls in process industries.” Tata McGraw-Hill.
5.	C.S.Rao, “Environmental Pollution control Engg.” Willey Estern Ltd.
6.	Noel de Nevers, “Air Pollution control Engg.” McGraw-Hill, Inc, Publication.

Syllabus for Unit Test:	
Unit Test I	Units I, II, and III
Unit Test II	Units IV, V, and VI

MATLAB PROGRAMMING		
Designation: Professional Core		
Pre-requisite Courses: Computer fundamentals		
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Practical : 02 Hours/Week	TW : 25 Marks	TW/OR/PR : 01
	Practical/Oral : 25 Marks	Total Credits : 01
	Total : 50 Marks	

Course Outcomes:

After completion of the course students would be able to:

1	Develop a basic programme applying MATLAB syntax.
2	Design programs involving matrix and publish report.
3	Develop programs involving loops.
4	Apply MATLAB to solve mathematical problems.
5	Design a program to evaluate Thermodynamics, Process calculation problems.
6	Design a program to evaluate Heat transfer and Fluid flow problems.

Topics Covered

UNIT-I	**Getting started with MATLAB** Features of MATLAB window: Command window, current directory pane, workspace, command history window, figure window, editor window, data type, file type; Performing operations: Arithmetic operators, create arrays and vectors, working with arrays of number; File creation: creating, saving and executing a script file and function file.Creating and printing simple plots. 1. Programs based on Fundamentals in MATLAB Programming.
UNIT-II	**Creating files** Programs using Arrays and Matrices; working with anonymous function; symbolic computation; importing and exporting data; publishing reports. 2. Programs based on Matrix calculations. 3. Programs based on function creation and evaluation. 4. Programs based on publishing report.
UNIT-III	**Programming** Creating a script file; creating function file; programs using while, if and for loop. 5. Programs for script and function file. 6. Programs based on loops. 7. Combined program of script file with function and loops.
UNIT-IV	**Applications to Numerical Methods** Programs to solve linear and Nonlinear equations; Curve fitting and interpolation; Numerical Integration; Partial and Ordinary differential equation. 8. Program to solve set of linear equations. 9. Program to solve set of non- linear equations. 10. Program based on curve fitting and interpolation. 11. Program based on partial/ ordinary differential equations.
UNIT-V	**Application to Chemical Engineering** Applications of MATLAB to solve Thermodynamics, physical property estimation and process calculation problems. 12. Vapor pressure estimation of a given component. 13. Estimating bubble point/dew point for a given mixture.

	14. Estimating physical properties of components like humidity, density, viscosity etc.
UNIT-VI	**Application to Chemical Engineering** Applications of MATLAB to solve Heat Transfer and Fluid Mechanics problems. 15.Program based on flow in horizontal pipe (average velocity calculation). 16. Program for estimating pipe diameter/ power requirement. 17. Program for estimating LMTD 18. Estimating heat transfer coefficient for shell and tube heat exchanger.
In addition to these above stated programs/practical's concern faculty member may design his/her own programs / practical's.	
Term Work	
Term work will consist of the programs/practical listed above, out of which any eight programs/practical's are to be performed in laboratory by the students.	
Text Books/References:	
1	Yeong K. Y. , Chemical Engineering Computation with MATLAB, Taylor and Francis Group, CRC Press, Newyork, 2017.
2	Rudra P., Getting Started with MATLAB: A quick introduction for scientist and engineers, Oxford University Press. Reprint India 2011.
3	Gilat A., MATLAB –An introduction with Application, Wiley, India 2012.
4	Jain S. and Kaphse S., Modeling and Simulation using MATLAB Wiley, India 2016.

VOCATIONAL COURSE II: INDUSTRIAL HEATING SYSTEMS		
Designation: Skill Development		
Pre-requisite Courses: Chemical Engineering Thermodynamics, Heat Transfer, Particulate technology		
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Practical : 02 Hours/Week	Term-work (TW) : 25 Marks	TW/OR/PR : 01
Total : 02 Hours/Week	Practical/Oral : 25 Marks	Total Credits : 01
	Total : 50 Marks	

Term Work

Term work will consist of the practicalsbased on the following topics. Any ten practicals are to be performed in laboratory by the students.

Topics Covered

1	**Liquid Fired Thermic Fluid Heaters** Design principle, selection and characterization of liquid fuel and thermic fluid, Efficiency of system, Control system for thermic fluid heaters, Operation and maintenance of liquid fired thermic fluid heaters.
2	**Solid Fired Thermic Fluid Heaters** Design principle, selection and characterization of solid fuel and thermic fluid, Efficiency of system, Control system for solid thermic fluid heaters, Operation and maintenance of solid fired thermic fluid heaters.
3	**Boiler (Fire-Tube Boiler)** Design principle, Construction and working principle, Types of fire tube boilers, Selection criteria, Operation and maintenance of fire tube boilers,
4	**Boiler (Water-Tube Boiler)** Design principle, Construction and working principle, Types of water tube boilers, Selection criteria, Operation and maintenance of water tube boilers
5	**Furnaces** Design principle, Classification and types of furnaces, Construction and working principle, Heating distribution within furnace, selection criteria for furnace. Operation and troubleshooting

	of furnaces.
6	**Selection of Heating System for Industrial Purpose** Selection criteria and factors to be considered, Characteristics of a good heating system, Risk barriers and uncertainty, Case studies.
Text Books/References	
1	Y. V. Deshmukh, "Industrial Heating, Principles, Techniques, Materials, Applications, and Design", 1st edition, CRC Press 2005
2	H. Pfeifer, "Handbook of Heat Processing: Fundamentals - Calculations – Processes" 2nd edition, Vulkan-Verlag(2016)
3	J. G. Wünning, A.Milani,"Handbook of Burner Technology for Industrial Furnaces: Fundamentals - Burner – Applications" 2nd Edition, Vulkan-Verlag(2015)

BharatiVidyapeeth

(Deemed to be University)

Faculty of Engineering and Technology

Programme: B. Tech. (Chemical) (2021Course)

B. Tech. (Chemical) semester V and VI Curriculum Syllabus

Semester-V (Chemical)

MASS TRANSFER OPERATIONS		
Designation: Professional Core		
Pre-requisite Courses: Heat transfer operation and Fluid flow operation		
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Lectures : 04 Hours/Week	End Semester Examination : 60 Marks	Theory : 04
Practical : 02 Hours/Week	Internal Assessment : 40 Marks	Term-work : --
Total : 06 Hours/Week	Term-work (TW) : 25 Marks	Practical/Oral : 01
	Practical/Oral : 25 Marks	Total Credits : 05
	Total : 150 Marks	

Course Outcomes:

After completion of the course students would be able to

1	Evaluate diffusivity and rate of diffusion.
2	Evaluate mass transfer coefficients and understand interphase mass transfer.
3	Calculate the height of transfer unit, number of transfer unit, in absorption column.
4	Calculate rate of mass transfer in humidification.
5	Estimate rate and time of drying.
6	Analyze type of crystallization and estimate yield of crystallization.

Topics Covered

UNIT-I	**Diffusion** Molecular diffusion in fluids: Steady state diffusion in fluids at rest and in laminar flow, Steady state diffusion of A through non-diffusing B, equimolar counter diffusion, steady state diffusion in multicomponent mixture , molecular diffusion in fluids, diffusivity of liquids and gases, effect of temperature and pressure on diffusivity, diffusion in solids. Laws of diffusion and empirical	**(08 Hours)**

	equations – Maxwell’s law, Stefan’s law, Winkle man’s method.	
UNIT-II	**Mass transfer Coefficient and Interphase Mass Transfer:** a) Mass transfer coefficients: Mass transfer coefficient in laminar flow and in turbulent flow. Relation of individual and overall mass transfer coefficient. Theories of mass transfer. Mass, heat and momentum transfer analogies. b) Interphase mass transfer. Equilibrium in mass transfer, two resistance concept. diffusion between phases. Steady state co-current and counter current processes. continuous crosscurrent, counter-current, crosscurrent cascade operations and mass balances.	**(08 Hours)**
UNIT-III	**Absorption:** Introduction to absorption, types of tower packing’s, contact between liquid and gas, pressure drop and limiting flow rates, material balances for each flow , limiting gas-liquid ratio, rate of absorption, calculation of HTU, NTU and HETP. Alternate forms of transfer coefficients and their relations. Tray Efficiencies, absorption in plate columns, absorption with chemical reaction. Equipment for absorption column.	**(08 Hours)**
UNIT-IV	**Humidification** Vapor-liquid equilibrium, enthalpy for pure substances, definitions of humidity terms, adiabatic saturation temperature, wet bulb and dry bulb temperatures, study of humidity charts, Lewis relation, method of adiabatic humidification and dehumidification. Equipment for humidification, cooling tower design.	**(08 Hours)**
UNIT-V	**Drying** Basic principles of drying. equilibrium in drying. definitions of terms in drying, types of moisture binding, rate of drying curve, mechanism of batch drying and continuous drying, time requirement for drying, mechanism of moisture movement in solids. Equipment used for drying: Classification of dryers, solids handling in dryers, equipment for batch and continuous drying processes: working principle of tray driers, tower driers, rotary driers, spray driers. Concept of freeze drying	**(08 Hours)**
UNIT-VI	**Crystallization** Introduction to the process, principal rate of crystallization, Mier's super-saturation theory, growth and properties of crystals, crystallization rate, calculations of yield, mass and enthalpy balances. Equipment used in crystallization.	**(08 Hours)**

Project Based Learning	
1.	Prepare a model for any of the Mass transfer equipment.
2.	Power point presentation (seminar) on any topic of mass transfer and prepare a report.
3.	Evaluate efficiencies of different Gas-liquid contact equipment. .
4.	With the help of this subject knowledge, write a guideline report on how you would apply your concepts in industry.
5.	Compare working and principles for different mass transfer operations.
6.	Solve numerical based on crystallization and humidification.
7.	Write a technical report on your visit to a process industry.
8.	Solve old (last three years) GATE question papers with reference to Mass transfer-I subject.
9.	Group discussion on the recent advances in mass Transfer equipment.
10.	Technical interview based on the knowledge of Mass transfer.
Term Work:	
Term work will consist of the experiments listed below, out of which any eight experiments are to be performed in laboratory by the students.	
1.	To calculate diffusion coefficient in Liquid-Liquid diffusion.
2.	To calculate diffusion coefficient in still air..
3.	To study characteristics of Wetted Wall Column.
4.	To calculate individual and overall interface mass transfer coefficient.
5.	To estimate efficiency of cooling Tower.
6.	To estimate rate of drying in tray drier/rotary drier
7.	To study the crystallization process by air, water cooling and seeding.
8.	Humidification and Dehumidification experiment.
9.	To study agitated batch crystallizer
10.	Study of Spray drier
Text Books/References	

1	Treybal R.E., Mass Transfer Operations, 3rd Ed., McGrawHill, 1981.
2	McCabe, W. L., J. Smith, and Harriot: “Unit operations of chemical engineering,” Tata McGraw Hill.
3	King C. J. “Separation Techniques,” McGraw Hill Publications
4	Richardson, J. F., and J. M. Coulson: “Chemical Engineering,” Butterworth Heinemann, Volume 1.
5	E. L. Cussler, “Diffusion Mass Transfer in fluid systems ” 3rd Ed. Cambridge Series in Chemical Engineering.

Syllabus for Unit Tests	
Unit Test I	Units I, II, and III
Unit Test II	Units IV, V, and VI

HOMOGENEOUS REACTION ENGINEERING		
Designation: Professional Core		
Pre-requisite Courses: Basic knowledge of chemistry, Material and energy balance calculations.		
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Lectures : 04Hours/Week	End Semester Examination : 60 Marks	Theory : 04
Practical : 02Hours/Week	Internal Assessment : 40 Marks	Tutorial : -
Total : 06 Hours/Week	Term-work (TW) : 25 Marks	Practical : 01
	Practical/Oral : 25 Marks	Total Credits : 05
	Total : 150Marks	

Course Outcomes

1	Learn the rates of homogeneous chemical reactions and express the temperature dependent term of a rate equation with Arrhenius' Law and other theories.
2	Study experiments, analyze and interpret data, and apply the results to chemical systems and processes.
3	Design ideal batch reactors, ideal CSTR reactors and ideal plug flow reactors.
4	Analyze multiple reactor system, autocatalytic and recycle reactors.
5	Specify operating conditions to produce desired products from parallel and series chemical reactions.
6	Evaluate effect of temperature on reaction.

Topics Covered

UNIT-I	**Chemical Kinetics** Classification of reactions; rate laws and stoichiometry; relative rates of reaction; reaction order; rate limiting step; half life; concentration-dependent term of a rate equation; temperature-dependent term of a rate equation; Temperature dependency from Arrhenius law; Transition state theory; collision theory; rate equation using partial pressure and concentration; their interrelation; searching for a reaction mechanism.	**(08 Hours)**

UNIT-II	**Interpretation of Batch reactor data** Interpretation of batch experimental kinetics data using integral and differential analysis; constant volume batch reactor system; design equation for zero, first, second and third order irreversible and reversible reactions; graphical interpretation of these equations and their limitations; variable volume batch reactors; design equation for zero, first and second order irreversible and reversible reactions; graphical interpretation of their limitations.	**(08 Hours)**
UNIT-III	**Introduction to Reactor Design** Single ideal reactors under steady state conditions; design equations for batch; mixed flow & plug flow reactor; development of rate expression for mean holding time for a plug flow reactor; space time and space velocity; Introduction to Semi-batch reactor.	**(08 Hours)**
UNIT-IV	**Isothermal flow reactors** Size comparison of reactor performance; sequences of reactors; reactors with recycle; optimum size determination; reactors in series and parallel; performance of infinite number of back mix reactors in series; back mix and plug flow reactors of different sizes in series and their optimum way of staging; optimum recycle ratio for auto –catalytic (recycle) reactors.	**(08 Hours)**
UNIT-V	**Design of reactors for Single and Multiple reactions** Parallel and consecutive reactions in batch; CSTR and PFR; qualitative discussion about product distribution; quantitative treatment of product distribution and reactor size; factors affecting such as choice; optimum yield, conversion, selectivity, reactivity on consecutive and parallel reactions in reactors.	**(08 Hours)**
UNIT-VI	**Non-Isothermal reactor for homogeneous reactor systems** Energy balances in reactors; adiabatic operations; non-adiabatic operations; stability of reactors; non-isothermal homogeneous reactor systems; rates of heat exchanges for different reactors; adiabatic operations for batch and continuous reactors; optimum temperature progression; rate, temperature and conversion profiles for exothermic and endothermic reactions.	**(08 Hours)**

Project Based Learning	
1.	Suggest best suitable reactor arrangement for zero, first and second order reaction.
2.	Derive the rate equations for various combinations of reactors.
3.	Prepare a model for any of the reactor.
4.	Elaborate in detail use of kinetics in equipment/reactor design.

5.	With the help of this subject knowledge, write a guideline report on how you would apply your concepts in industry.
6.	Group discussion on the recent advances in reaction engineering.
7.	Write a report on your visit to research and development laboratory of national/international repute.
8.	Give fifteen minutes presentation (seminar) on particular topic and prepare a report.
9.	Visit chemical industry and prepare a detailed report on reactors used in industry.
10.	Students have to study any five NPTEL videos related to chemical reaction engineering and prepare/present power point presentation.
11.	Explain in detail use of kinetics in equipment/reactor design.
12.	Prepare a report on reactors which are newly introduced in the current year.
*Students in a group of 3 to 4 shall complete any one project from the above list.	
Term Work	
Term work will consist of the experiments listed below, which are to be performed in laboratory by the students.	
1	Study of first order reaction kinetics.
2	Study of PFR & CSTR combination in second order reaction.
3	Rate constant of hydrolysis of methyl acetate by dilute HCl.
4	Hydrolysis of ester (e.g. ethyl acetate) by alkali (NaOH).
5	Study of CSTR .
6	Determination of Arrhenius parameters.
7	Rate constant for saponification of ethyl acetate with NaOH using CSTR
8	Rate constant for saponification of ethyl acetate with NaOH at ambient conditions using PFR
9	Rate constant for saponification of ethyl acetate with NaOH at ambient conditions using (i) Isothermal batch reactor (ii) Isothermal CSTR.
10	Study and operation of an adiabatic batch reactor.
11	Use MATLAB software to simulate Batch / CSTR / Plug flow reactor data
Te1xt Books/References	
1	O. Levenspiel, “Chemical Reaction Engineering”, 3rd Edition, John Wiley and sons, New Delhi, 2007.
2	H.S. Fogler , “Elements of Chemical Reaction Engineering”, 4th Edition, Prentice Hall of India, New Delhi, 2006.
3	K.J. Laidler, “Chemical Kinetics”, 3rd Edition, Pearson Education Inc
4	J.M.Smith, “Chemical Engineering kinetics”, 3rd Edition, McGraw Hill, 1981

Syllabus for Unit Tests	
Unit Test I	Units I, II, and III
Unit Test II	Units IV, V, and VI

BIOCHEMICAL ENGINEERING					
Designation: Professional Core					
Pre-requisite Courses: Basic knowledge of Biology, Chemical Reaction Engineering					
Teaching Scheme		**Examination Scheme**		**Credits Allotted**	
Lectures	: 04Hours/Week	End Semester Examination	: 60 Marks	Theory	: 04
Practical	: 02Hours/Week	Internal Assessment	: 40 Marks	Tutorial	: -
Total	: 06 Hours/Week	Term-work (TW)	: 25 Marks	Practical	: 01
		Practical/Oral	: 25 Marks	Total Credits	: 05
		Total	: 150Marks		

Course Outcomes	
1	Learn bioenergetics principles.
2	Analyze the kinetics of enzyme catalyzed reactions.
3	Analyze the kinetics of substrate utilization.
4	Learn fermentation process in all aspects.
5	Identify the bioremediation processes and learn the mechanism.
6	Design the reactors for biochemical reactions.

Topics Covered		
UNIT-I	**Introduction to Biochemical Engineering** Definition and scope of biochemical engineering; Unit operations in biochemical processes; Introduction to bioenergetics; Batch and continuous culture, Mixed microbial culture , Fed batch culture.	**(08 Hours)**
UNIT-II	**Kinetics of enzyme catalyzed reactions in free and immobilized states**Michaelis-Menten equation and its various modifications; Effects of External mass transfer in immobilized enzyme systems; analysis of	**(08 Hours)**

	intraparticle diffusion and reaction.	
UNIT-III	**Kinetics of substrate utilization, product formation and biomass production** Monod growth model and its various modifications; structured and unstructured kinetic rate models; Thermal death kinetics of cells & spores.	**(08 Hours)**
UNIT-IV	**Fermentation** Modes of bioreactor operation; batch, continuous and fed batch, Mixing and aeration, operation, measurement of parameters and control of bioreactors; Preparation and sterilization of medium for fermentation; study of product formation kinetics in a fermentation process.	**(08 Hours)**
UNIT-V	**Microbial reactors** Different types of microbial reactors; Bioreactor operations for industrial-important biological products; Case studies.	**(08 Hours)**
UNIT-VI	**Introduction to downstream processing** Recovery and the purification of biosynthetic products	**(08 Hours)**

Project Based Learning	
1.	Write a report on the recent advances in Biochemical processes with reference to the current year.
2.	Analyze kinetics of different microorganisms.
3.	Search out some industries related to Biochemical processes.
4.	Write a technical report on your visit to a research laboratory.
5.	List out all the techniques for fermentation.
6.	Perform any one fermentation technique.
7.	Find out different types of microbial reactors.
8.	Prepare a report on downstream processing.
9.	Give fifteen minutes presentation (seminar) on particular topic and prepare a report.
10.	Group discussion on process design for bio products.
*Students in a group of 3 to 4 shall complete any one project from the above list.	
Term Work	
Term work will consist of the experiments listed below, which are to be performed in laboratory by the students.	

1	Media Preparation
2	To study Sterilization techniques
3	Gram strain technique
4	Effect of substrate concentration on enzyme kinetics
5	Effect of temperature on enzyme kinetics
6	Effect of time on enzyme kinetics
7	Effect of pH on enzyme kinetics
8	Study of isolation of chloroplast
9	Study of Urease Test
10	Detection of Adulteration in Milk
11	To study isolation techniques.

Te1xt Books/References

1	R. Dutta, " Fundamental of Biochemical Engineering" Springer , Ann Book India, 2008
2	J.E.Bailey ,D.E.Ollis, "Biochemical Engineering Fundamentals" 2nd Edition,McGraw Hill Education, 2017.
3	M.Doble,A.K.Kruthiventi, V.G.Gaikar, "Bio transformations and Bioprocesses" Marcel Dekker Inc, New York, USA 2004

Syllabus for Unit Tests

Unit Test I	Units I, II, and III
Unit Test II	Units IV, V, and VI

RENEWABLE ENERGY

Designation: Professional Core

Pre-requisite Courses: Basic knowledge of Chemistry, and Physics

Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Lectures : 04Hours/Week	End Semester Examination : 60 Marks	Theory : 04
Total : 04 Hours/Week	Internal Assessment : 40 Marks	Total Credits : 04
	Total : 100 Marks	

Course Outcomes	
Student will be able to	
1	Elaborate the importance of non-conventional energy technologies
2	Apply the solar photovoltaic (PV) technology to harness energy
3	Apply various biomass to bioenergy conversion processes to harness energy
4	Determine the wind turbine performance parameters such as efficiency, energy produced and capacity
5	Elaborate the importance of hydrogen as an alternative fuel
6	Obtain the sustainability of renewable energy technologies

Topics Covered

UNIT-I	**Introduction Renewable Energy** Energy scenario; Role of energy sector in national economy; Energy and environment; Conventional energy resources; Non-conventional energy resources: need and present scenario; Overview and applications of non-conventional energy technologies: Solar, Wind, Hydrogen, Biomass, Hydro etc.	**(08 Hours)**
UNIT-II	**Solar Energy** Basics of solar energy: Physics of sun and its energy transport, Thermal	**(08 Hours)**

	radiation fundamentals, Sun-Earth geometric relationships, Measurement of solar radiation; Solar Thermal collectors: Overall system with details, Concept of aperture area, Sizing of air, Water heating systems, Solar concentrators, Thermal energy Storage systems; Solar photovoltaic (PV) technology: Solar cells, Cell technologies, Characteristics of PV cell, Main elements of PV System for electricity generation, Building integrated PV system and its components, Sizing of solar PV array for a given load, Battery system.	
UNIT-III	**Biomass Energy and Biomass Conversion processes** Biomass Energy: Types, Compositions, Characteristics, Properties, Structural Components; Biomass utilisation through different conversion routes: Introduction to thermochemical and biochemical conversion processes, Kinetics of conversion processes, Types of reactors used, Physico-chemical characterization of products formed, Applications of products formed, Techno-economics of processes.	**(08 Hours)**
UNIT-IV	**Wind Energy** Introduction: Nature and power of the wind, Forces on the blades, Meteorology of wind, Wind speed variation with height, Wind speed statistics, Wind energy conversion principles; Wind measurements: rotational and other anemometers etc.; Wind energy conversion system: Types and classification, power, torque and speed characteristics, Aerodynamic design principles, Aerodynamic theories, Applications; Wind turbine design; Economics of wind energy utilization; Wind energy scenario; Environmental impacts of wind farms.	**(08 Hours)**
UNIT-V	**Hydrogen Energy** Introduction of hydrogen energy; Properties of hydrogen as a fuel;Hydrogen production methods: fossil fuels, electrolysis, thermal decomposition, nuclear, photochemical, photocatalytic, hybrid etc.; Hydrogen storage: Metal hydrides, chemical hydrides, carbon nano-tubes etc. Hydrogen Economy: Hydrogen as an alternative fueland techno-economic aspects.	**(08 Hours)**
UNIT-VI	**Sustainability of Renewable Energy Technologies** Definition of sustainable renewable energy; Systems approach; Indicators of sustainability; Methodologies/tools to measure sustainability: Life cycle assessment (LCA) - introduction to concept; LCA methodology and its application.	**(08 Hours)**

Project Based Learning

1.	Preparation of technical report based on various applications of solar energy

2.	Preparation of power point presentation on any topic related to solar energy utilization- with system sizing calculations considering location, efficiency etc.
3.	Visit to wind mill to understand the actual operation.
4.	Short literature review based on recent trends in the design of wind turbine
5.	Solving numerical based on solar collectors
6.	Group discussions on any of the following topics: d) Importance of renewable energy for society and industries e) Role of renewable energy on Indian and world economy
7.	Read recent research papers related to this subject area and prepare report
8.	Prepare question bank with appropriate answers based on the whole subject renewable energy
9.	Solving numerical based on wind energy calculations
10.	Students have to study any five NPTEL videos related to Renewable energy and prepare/present power point presentation

Text Books/References

1.	Alternative Energy Systems & Applications by B.K.Hodge, Wiley, 2010
2.	Solar Energy (4th Edition) by S. P. Sukhatme and J. K. Nayak. McGraw Hill
3.	Sustainable Energy Systems and Applications, Springer, 2011
4.	Renewable Energy Technologies, by J.C.Sabonnadiere, Wiley, 2009
5.	Hydrogen and Fuel Cells: Emerging Technologies and Applications by Bent Sorenson, Academic Press.
6.	Gupta R. B. (2008); Hydrogen Fuel: Production, Transport and Storage, CRC Press

Syllabus for Unit Tests

Unit Test I	Units I, II, and III
Unit Test II	Units IV, V, and VI

CHEMICAL PROCESS INSTRUMENTATION		
Designation: Professional Core		
Course Pre-requisites:		
Students should have		
	Basic knowledge of Mathematics.	
TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Lectures : 4 Hour/Week	End Semester Examination: 60 Marks	Theory : 04
Practical : 2 Hour /Week	Internal Assessment : 40 Marks	Practical : 01
Total : 6 Hour /Week	Term-work (TW) : 25 Marks	Total Credits : 05
	Practical/Oral : 25 Marks	
	Total : 150 Marks	

Course Outcomes:

After completion of the course students will be able to

1.	To explicate the need of process instrumentation and process control in chemical industries.
2.	To illustrate various pressure and strain measuring instruments.
3.	To elucidate spectrophotometry, colorimetry and conductometry
4.	To describe nephelometry ,turbidiemetry, refractometry and chromatography methods.
5.	To develop an ability to use theorems to compute the Laplace transform, inverse Laplace transforms. To calculate the transfer functions for first order and second order systems.
6.	To give details various control action for first order and second order system.

Topics covered

UNIT-I	**Introduction**: Basic Concepts and characteristics of measurement system; various elements of instrument; performance characteristics. **Temperature measurement**: Introduction, methods of temperature measurement by expansion thermometers, filled system thermometers; electrical temperature instruments; pyrometers; Calibration of Thermometers. **Level measurement**: Displacers; ultrasonic; microwaves; laser light.	**(08 Hours)**
UNIT-II	**Pressure and strain measuring instruments**: Introduction; classification; low, medium, and high pressure measuring instruments, pressure scales (units), manometers, elastic element pressure gauges with pressure equations (using bourdon tube, diaphragms, capsule, and bellows), transduction/ electrical sensors with pressure equations (based on variable capacitance, resistance, and inductance/reluctance-LVDT), force- balance transducers along with mathematical equations, solid-state devices, thin-film transducers, digital transducers, piezoelectric transducers, vibrating element sensors, pressure multiplexer, calibration of pressure sensors using dead- weight tester, Mechanical, optical, and electrical strain gauges.	**(08 Hours)**
UNIT-III	**Introduction to instrumental methods of analysis**: General Introduction; classification of instrumental methods; spectroscopy, properties of electromagnetic radiation, pH metry, Karl Fischer Titration. **Visible Spectrophotometry & Colorimetry**: Deviation from Beer's law; instrumentation applications; Molar compositions of complexes; examples. **Conductometry**: Introduction, laws; conductance; measurements; types of conductometric titrations; applications; advantages and disadvantages.	**(08 Hours)**
UNIT-IV	**Nephelometry and Turbidimetry**: Introduction; theory; comparison with spectrophotometry; applications. **Refractometry:** Introduction; Abbe refractometer; applications.	**(08 Hours)**

	Chromatography: Introduction; types; theoretical principles; theories of chromatography; development of chromatography; qualitative and quantitative analysis; applications. Gas Chromatography; Introduction, principles of gas chromatography, gas liquid chromatography, instrumentation, evaluation, retention volume, resolution. Branches of gas chromatography, applications and numerical. High Performance (Pressure) Liquid Chromatography; Introduction, principles, instrumentation, apparatus & materials, column efficiency and selectivity, applications. **GC-MS; LC-MS.**	
UNIT-V	**Process dynamics:** Introduction; tools of dynamics analysis; ideal forcing function; input output model; transfer function models; proportion of transfer function; poles & zeros of transfer function with qualitative response; dynamic behavior of pure integrator; pure gain; first order & second order systems (with or without dead time); physical example of these systems.	**(08 Hours)**
UNIT-VI	**Introduction to feedback control:** Final Control Elements - Valve characteristics; Instrumentation symbols. Introduction to Process Flow Diagram (PFD) and Piping & Instrumentation Diagram (P&ID). **Control theory basics:** The control loops; process control terms; components of control loops; basic control action i.e. on-off, P, I, D, PI, PD, PID for 1st order process control loops and 2^{nd} order response.	**(08 Hours)**

Project based learning:

1.	Students have to visit chemical industry and prepare a detailed report on various instruments used for process variable measurement.
2.	Students have to visit chemical industry and prepare a detailed report on various instruments used for chemical analysis.
3.	Watch NPTEL video and make report on various instruments used for process variable measurement.
4.	Presentation on instruments used for process variable measurement.
5.	Group discussions on instruments used for process variable measurement.
6.	To find Transfer Function for 1^{st} order and 2^{nd} order Instrument or process.
7.	Draw the Control Loop for HEfor different process variable control.
8.	Draw the Control Loop for Batch Reactor for different process variable control.
9.	Draw the Control Loop for CSTR for different process variable control.

*Students in a group of 3 to 4 shall complete any one or two projects from the above list.

List of Experiments:

Term work will consist of the experiments listed below, of which at least eight should be performed in laboratory by the students.

1.	Calibration of Bimetallic thermometer.
2.	Gas Chromatography.
3.	High Performance Liquid Chromatography.
4.	UV Spectrophotometer.
5.	Dynamic behavior of non interacting system.
6.	Dynamic behavior of interacting system.
7.	Mercury Thermometer With well and Without Well.
8.	To Study the characteristics of On-Off Controller.

9.	Conductivity meter.
10.	PH meter analysis.
11.	Manometer Tuning.
12.	Calibration of RTD.
13.	To Study the Thermocouple.
Text Books/References:	
1	S.K.Singh, “Industrial Instrumentation & Control”, Tata McGraw Hill publishing company ltd, New Delhi, 2000
2	D. Pastranabis, “Principals of industrial instrumentation”, 2nd edition, Tata McGraw 4 Hill publishing company ltd, New Delhi, 2003
3	Eckman D.P. “Industrial Instrumentation”, Willey Eastern Ltd, New Delhi, 1984.
4	A.C. Shrivastav “Techniques in Instrumentation”, New Delhi, 1984.
5	W.Boltan, “Instrumentation and Process Measurement”, Orient Longman Ltd, Hyderabad, 1st Edition, 1993.
6	Willard H.H, “Instrumental methods of analysis”, 6th Edition, CBS Publication New Delhi 1986
7	Galen W. Ewing, “Instrumental Methods of Chemical Analysis”, 5th Edition, McGraw Hill Book Company, Singapore, 1990
8	D. A. Skoog, “Principal of Instrumental Analysis”, Southern Collage Publication, Japan 1984
9	G. R. Chatwal, S.K. Anand, “Instrumental method of chemical analysis”, 5th Edition, Himalaya Publishing House, Mumbai 2002.
10	Ray Choudhuri and Ray Choudhuri “Process Instrumentation, Dynamics and control for Engineers”, 1st Edition, Asian Books Pvt Ltd, New Delhi, 2003.
11	B.G. Liptak, “Instrument Engineers Handbook”, 4thEdition , CRC Press, 2005.

Syllabus for Unit Test:	
Unit Test -I	UNIT – I , II, III
Unit Test -II	UNIT – IV, V, VI

VOCATIONAL COURSE III: FLUID MOVING MACHINERIES		
Designation: Skill Development		
Pre-requisite Courses: Fluid Mechanics		
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Practical : 02 Hours/Week	Term-work (TW) : 25 Marks	Oral : 01
Total : 02 Hours/Week	Oral : 25 Marks	Total Credits : 01
	Total : 50 Marks	

Course Outcomes

After completion of the course students will be able to

1	Select the type of pump according to the requirement and calculate net positive suction head.
2	Obtain the operating parameters affecting the performance of a pump and calculate power requirement.
3	Analyse various types of blowers and obtain the factors affecting the performance of blowers.
4	Calculate the power requirement of blowers.
5	Select the various types of compressors and obtain the factors affecting the performance of compressors
6	Calculate the power requirement of compressors.

Topics Covered

UNIT-I	**Pumps:** Types, selection and specifications, characteristic curves, net positive suction head (NPSH) calculations.
UNIT-II	**Power requirement of pumps:** Operating parameters affecting the performance of a pump, Calculation of power requirement of various types of pumps, Operation and maintenance of pumps.
UNIT-III	**Blowers:**

	Selection and specifications, Factors affecting the performance of blowers.
UNIT-IV	**Power requirement of Blowers:** Operation and maintenance of blowers, Power calculations for given duty.
UNIT-V	**Compressors:** Design principle, Classification and types of compressors, Selection and specifications, Factors affecting the performance of compressors.
UNIT-VI	**Power requirement ofCompressors:** Operation and maintenance of compressors, Power calculations for given duty.

Term Work

Term work will consist of the practical based on the above topics. Any eightpracticals are to be performed in laboratory/industry by the students.

Text Books/References

1	W.L. McCabe, J.C. Smith, and P. Harriott, Unit Operations of Chemical Engineering, 5^{th}edition, McGraw Hill Publications.
2	J.M. Coulson, J.F. Richardson, J.R. Backhurst, J.H. Harker, Chemical Engineering Volume 1, 6^{th}edition, Pergamon Press.
3	S.K.Gupta, Momentum transfer operations, Tata McGraw Hill Publishers.
4	R.K. Bansal, A text book of fluid mechanics and hydraulic machines, Laxmi Publications (P) Ltd, NewDelhi.
5	M.M. Denn, Process fluid mechanics, Prentice Hall Publications.

Semester-VI (Chemical)

SEPARATION TECHNIQUES		
Designation: Professional Core		
Course Pre-requisites:		
Students should have basic knowledge of heat and mass transfer		
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Lectures : 04 Hours/Week	End Semester Examination : 60 Marks	Theory : 04
Practical : 02 Hours/Week	Internal Assessment : 40 Marks	Term-work : --
Total : 06 Hours/Week	Term-work (TW) : 25 Marks	Practical/Oral : 01
	Practical/Oral : 25 Marks	Total Credits : 05
	Total : 150 Marks	

Course Outcomes

1	Apply the basics of distillation for the binary separation of ideal and nonideal mixture and determine the extent of separation obtained.
2	Describe the operation of continuous rectification and determine the number of stages required for distillation.
3	Determine the number of stages required for separation using liquid-liquid extraction and describe the extractors used industrially.
4	Obtain the requirement of solvent in leaching operation and obtain the extent of separation.
5	Plot the adsorption isotherms and estimate the amount of adsorption using single and multistage operations.
6	Explain the operation and applications of novel separation techniques

Topics Covered

UNIT-I	**Introduction:** Review of various separation techniques, Selection of the technique of separation, pros and cons of various methods.	**(08 Hours)**

	Basics of Distillation: Equilibrium of vapor and liquid, relative volatility, Raoult's law, Ideal and Non-ideal behavior study, Azeotropes, positive and negative deviation from ideality, Methods of distillation - simple, flash distillation, Rayleigh's equation, Graphical and analytical method for determination of the compositions, Introduction to reactive distillation, Azeotropic distillation, Molecular or low pressure distillation, Extractive distillation.	
UNIT-II	**Rectification:** Continuous rectification for binary systems, Tray towers, McCabe Thiele's method of calculation of number of trays, Method of PonchonSavarit, Enthalpy concentration diagrams, Tray efficiencies, Concept of reflux, cold reflux, partial and total cold reflux, Effect of feed temperature and q-line equation derivation, Total reflux, Optimum reflux, Fenske Underwood equation, Condenser and reboilers used in distillation, Use of open steam for distillation, Rectification of Azeotropic mixtures. Distillation in packed towers: HETP concept, HTU and NTU calculations, Distillation column internals: Type of trays, Type of packing used.	**(08 Hours)**
UNIT-III	**Adsorption:** Types of adsorption, Nature of adsorbents, Equilibria in adsorption- Single gases and vapors, adsorption hysteresis, Effect of temperature, Heat of adsorption, adsorption of liquids, Langmuir isotherms, Freundlich isotherms, Introduction to pressure swing and temperature swing adsorption, Equipment: Continuous contact, Steady state moving bed absorbers. **Ion exchange process:** Basic principles and chemical reactions, Techniques and applications, Equilibria and rate of ion exchange, Equipment studies.	**(08 Hours)**
UNIT-IV	**Liquid- Liquid Extraction:** Introduction, Choice of solvent, Ternary equilibrium, Binodal solubility curve, Single stage extraction, Multistage crosscurrent and countercurrent extraction, extraction calculations using triangular and rectangular coordinates, Solvent free basis calculations, Nxy diagrams, Material balances, Continuous countercurrent extraction with reflux, stage efficiency. Continuous countercurrent extraction in packed columns: HTU and NTU calculations. Types of extractors: Stage type and differential extractors.	**(08 Hours)**
UNIT-V	**Leaching (Solid Liquid Extraction):**	**(08 Hours)**

	Introduction: Classification of leaching processes, Factors affecting the leaching process, Solid –liquid equilibria. Methods of calculation: Single stage leaching, multistage cross-current leaching, Continuous countercurrent leaching. Leaching Equipment: Unsteady state and steady state equipment.	
UNIT-VI	**Novel separation techniques:** Membrane separation techniques- Ultrafiltration, Nano-filtration, Reverse osmosis process, Electro dialysis, Rate based processes such as diffusion coefficient based inert gas generating from air by carbon molecular sieves.	**(08 Hours)**

Project Based Learning	
1.	Group discussion on the recent advances in Separation Techniques.
2.	Solve previous year GATE question papers with reference to this subject.
3.	Seminar presentation on a particular topic specified in the syllabus and submission of report based on it.
4.	Estimation of composition of vapor and liquid in flash distillation
5.	Technical interview based on the knowledge of various separation techniques studied.
6.	Evaluation of number of stages using McCabe Thiele and PonchonSavarit method.
7.	Group discussion on equipments used for extraction or ion exchange technique and its application. .
8.	Visit to nearby industry to understand various separation techniques
9.	Watch NPTEL videos of distillation and prepare report
10.	Prepare technical report based on advance in novel separation techniques

Term Work:	
Term work will consist of the experiments listed below, out of which any eight experiments are to be performed in laboratory by the students.	
1.	Simple distillation

2.	Distillation with total reflux
3.	Steam distillation
4.	Equilibrium diagrams for liquid -liquid extraction
5.	Cross current multistage extraction
6.	York Schiebel column for extraction
7.	Bubble cap distillation column
8.	Sieve tray distillation column
9.	Vapour liquid equilibria
10.	Solid liquid extraction of oil
11.	Langmuir and Freundlich adsorption isotherm
Text Books/References	
1	Treybal R. E., “Mass Transfer Operation”,McGraw Hill publication.
2	Coulson J. M. Richardson, “Chemical engineering", Vol, I and II, Pergamon Press.
3	King C. J., “Separation Techniques”, McGraw Hill publication.
4	Smith B. D., “Design of Equilibrium stage process”, McGraw Hill publication.
Syllabus for Unit Tests	
Unit Test I	Units I, II, and III
Unit Test II	Units IV, V, and VI

HETEROGENEOUS REACTION ENGINEERING

Designation: Professional Core

Pre-requisite Courses: Material and energy balance calculations, Fluid mechanics, Heat transfer, Mass transfer, Homogeneous reaction engineering

Teaching Scheme		Examination Scheme		Credits Allotted	
Lectures	: 04 Hours/Week	End Semester Examination	: 60 Marks	Theory	: 04
Practical	: 02 Hours/Week	Internal Assessment	: 40 Marks	Practical	: 01
Tutorial	: -	Term work/Practical	: 50	Tutorial	: -
Total	: 06 Hours/Week	Total	: 150 Marks	Total Credits	: 05

Course Outcomes

1	Differentiate between heterogeneous reactions.
2	Estimate heterogeneous reaction rate controlling step and determine overall rate of reaction.
3	Estimate flow structure and phase hold-up of a given multiphase reactor.
4	Estimate flow non-ideality in a given multiphase reactor.
5	Estimate heat and mass transfer coefficient in a given multiphase reactor.
6	Design and scale up a given multiphase system.

Topics Covered

UNIT-I	**Introduction** Classification of heterogeneous reaction; Qualitative description; Examples of industrial importance	**(06 Hours)**
UNIT-II	**Thermodynamics of Heterogeneous Reactions** Criteria of chemical reaction equilibrium; Standard Gibbs free energy change and equilibrium constant; Estimation of equilibrium constant; Effect of temperature and pressure on equilibrium constant; Equilibrium conversions for single and	**(08 Hours)**

	multi-reaction systems.	
UNIT-III	**Kinetics of Heterogeneous Reactions** Mechanisms of heterogeneous reactions; Determination of rate controlling step; Estimation of overall rate of reaction; Factors affecting the rate of reaction; Heterogeneous catalysis: selection of catalyst, external and internal diffusion effects, catalyst deactivation.	**(08 Hours)**
UNIT-IV	**Hydrodynamics and Mixing** Hydrodynamic characteristics of different multiphase reactors: Mechanically Agitated Contactors (MAC), Bubble Columns, Slurry Reactors, Fluidized Beds, Loop Reactors and Modified Versions. Experimental methods to measure phase mixing; Effect of geometrical, system, and operating parameters on phase mixing in multiphase reactors; Quantification of phase mixing; Development of a mathematical model	**(08 Hours)**
UNIT-V	**Heat and mass transfer** Experimental methods to measure heat transfer coefficient; Effect of geometrical, system, and operating parameters on heat transfer coefficient in multiphase reactors; Quantification of heat transfer coefficient; Application of correlations available to different multiphase reactors. Experimental techniques used for estimation of mass transfer coefficient and selection of suitable technique for a multiphase reactor; Effect of geometrical, system, and operating parameters on mass transfer coefficient in multiphase reactors; Quantification of mass transfer coefficient; Application of correlations available to different multiphase reactors.	**(08 Hours)**
UNIT-VI	**Design and scale up of multiphase reactors** Generalized methodology of design and scale up of multiphase reactors; Examples of industrial importance.	**(08 Hours)**

Project Based Learning

1	Elaborate any one heterogeneous system of industrial importance
2	Visit to any one chemical process industry and present a report on any one multiphase reaction system.
3	Study recent advances in measurement of phase hold-up methodologies.
4	Study recent advances in phase flow measurement techniques in multiphase systems.
5	Study any one recent review article on hydrodynamic aspects of any one multiphase system in group

	and make a report.
6	Prepare power point presentation on recent advances hydrodynamic/mixing characteristics of any one multiphase system.
7	Prepare power point presentation on heat/mass transfer measurement methodologies for any one multiphase system.
8	Enlist the steps to standardize any one multiphase reactor.
9	Group discussion on design and scale up aspects of multiphase reactors.
10	Present techno-economic analysis of any one multiphase reactor.
Practicals	
1	Estimation of kinetics parameters for any two heterogeneous system
2	Estimation of thermodynamic parameters for any two heterogeneous system
3	Estimation of hydrodynamic parameters of any two heterogeneous system
4	Estimation of dispersion coefficient of any two heterogeneous system
5	Estimation of mass transfer coefficient of any two heterogeneous system
Text Books/References	
1	V. G. Pangarkar, "Design of multiphase reactors", 1st Edition, Wiley, 2015
2	L. K. Doraiswamy and M. M. Sharma, "Heterogeneous Reactions", 2nd Edition, Volume I and II.
3	G. B. Tatterson, "Fluid Mixing and Gas Dispersion in Stirred Reactors", 10th Edition, Academic Press, London, 1994
4	W. D. Deckwer, "Bubble Column Reactors", Cambridge University Press, New York, 2000.
5	Diazo Kunji and O. Levenspiel, "Fluidization Engineering", 2nd Edition, Butterworth Heinemann, 1991
6	J. F. Devidson and Harrison, " Fluidization", 10th Edition, Academic Press, London, 1994.
7	J. M. Smith, H. C. Van Ness and M. M. Abbott, "Introduction to Chemical Engineering Thermodynamics", 5th Edition, McGraw Hill International, Singapore, 1996.

Syllabus for Unit Tests	
Unit Test I	Units I, II, and III
Unit Test II	Units IV, V, and VI

PROCESS DEVELOPMENT AND ENGINEERING					
Designation: Professional Core					
Pre-requisite Courses: Chemical engineering core courses					
Teaching Scheme		**Examination Scheme**		**Credits Allotted**	
Lectures	: 04 Hours/Week	End Semester Examination	: 60 Marks	Theory	: 04
Practical	: 02 Hours/Week	Internal Assessment	: 40 Marks	Practical	: 01
Tutorial	: -	Term work/Practical	: 50	Tutorial	: -
Total	: 06 Hours/Week	Total	: 150 Marks	Total Credits	: 05

Course Outcomes

1	Analyze synthesis routes of a given compound and select techno-economically feasible route.
2	Design and scale up chemical process equipment
3	Select material of construction for chemical process equipment
4	Calculate cost per unit amount of product for utilities
5	Propose equipment support system for a given plant
6	Differentiate between conventional and green approaches on economic basis

Topics Covered

UNIT-I	**Preliminary process development** Multiple process synthesis; Selection of process; Basic economic evaluation; Development of a preliminary process system: Modular approach; Sequencing of operations and integration in processes.	**(08 Hours)**
UNIT-II	**Design and scale-up** Identification of rate controlling steps of processes; Batch, semi- batch and/or continuous mode of operation/process; Concept of dedicated and multiproduct plant facilities, pilot plant, mini plants; Design and scale up	**(08 Hours)**

	aspects	
UNIT-III	**Material science** Selection of material of construction for chemical process equipment; Operating condition; Techno-economic analysis	**(06 Hours)**
UNIT-IV	**Utilities** Utilization of energy; Selection of utility; Cost of utilities: water, air, steam, etc.; Heat exchange networks; Process intensification.	**(08 Hours)**
UNIT-V	**Process Engineering** Preparation of Conceptual process and instrumentation diagrams; Preparation of process specifications for typical equipment; Equipment support system: Load calculations and commissioning of equipments; Labeling of process equipment and piping system.	**(08 Hours)**
UNIT-VI	**Green approach and process safety** Energy conservation: solar and wind energy; Green synthesis routes; Minimization of waste; Waste treatment by green route; Process hazards and process safety	**(08 Hours)**

Project Based Learning	
1	Analyze possible synthesis rout for a given compound on economic platform.
2	Visit to any one chemical process industry and present a report on equipment support system.
3	Study recent advances in material science and engineering.
4	Study recent advances in waste water treatment and waste minimization.
5	Study any one recent review article on process development of any one synthetic route in group and make a report.
6	Prepare power point presentation on green approaches and process safety.
7	Prepare power point presentation on hazardous waste management.
8	Prepare a report on recent development in solar and wind energy sectors

9	Group discussion on design and scale up aspects of chemical process equipment
10	Present techno-economic analysis of any one multiphase reactor.
Term work	
1	Term work will be based on the assignments given. Assignments will be based the content covered in the course. Minimum six assignments can be given for a course
Text Books/References	
1	D. L. Erwine, “Industrial Chemical Process Design”, 2nd Edition, 2013
2	P. Groggins, “Unit Processes in Organic Synthesis”, 5th Edition, Tata McGraw Hill, 2001
3	Chandalia S. B., “Handbook of Chemical Process Development”, 1st Edition, 2002
4	Silla H., “Chemical Process Engineering: Design and Economics”, 1st Edition, CRC Press, 2003
Syllabus for Unit Tests	
Unit Test I	Units I, II, and III
Unit Test II	Units IV, V, and VI

QUANTITATIVE TECHNIQUES, COMMUNICATION AND VALUES		
TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS:**
Theory: 03Hours / Week Tutorial: 01Hour / Week	Semester End Examination: 60 Marks Internal Assessment: 40 Marks	Credits:4

Course Pre-requisites: The students should have knowledge of	
1	Basic math's and reasoning, and comprehensive ability
2	Basic knowledge of communication process, soft skills
3	Basic knowledge and idea about leaders and leadership qualities, ethics, etiquettes and values
Course Objective:	
	The **Quantitative Techniques, Communication and Values**aims to augment students to face the campus recruitment test and train them on applying short techniques/ tricks to solve questions of Maths, reasoning and English in very less amount of time. The communication and values section focuses on the aspects of communication and soft skills such as grooming personality for leading team, presentation, business communication which would enable graduates to project themselves as a professionals in the corporate sector and/or otherwise.
Course Outcomes: The student will be able to	
1	Solve the aptitude test in the recruitment and competitive exam by applying short techniques and solve the question in less amount of time
2	Apply the short mnemonics and techniques to solve the questions of logical reasoning in the placement and competitive exam in lesser time.
3	Develop the verbal ability to communicate effectively using suitable vocabulary and proper sentence pattern
4	Understand the concept of soft skills and its implication at workplace
5	Build up the ability to study employment business correspondences and its proper implications
6	Understand business ethics, etiquettes and values and apply them in the professional ventures.

Course Content:

Unit-I	**QUANTITATIVE APTITUDE** :Number system, Percentage, profit and loss, Simple Interest and Compound Interest, Ratio, Proportion and Average, Mixture and Allegation, Time, Speed & Distance, Time & Work , Permutation	**(8 Hrs)**

	& Combination, Probability, Pipes and Cisterns	
Unit-II	**NON-VERBAL REASONING :** Coding, Decoding, Number series, Blood relation Directions, cubes & dices , Data Interpretation, Data Sufficiency, Set Theory & Syllogisms, Matching, Selection & Arrangement, Clocks & Calendars, Visual Reasoning, Input, Output & Flow Chart.	**(8 Hrs)**
Unit-III	**VERBAL REASONING:** Sentence Patterns, Sentence correction and spotting errors, Vocabulary, antonyms and synonyms and analogy, Phrasal Verbs, idiomatic expressions, reading comprehension, closest, sentence rearrangement and theme detection	**(8 Hrs)**
Unit-IV	**SELF AWARENESS AND SOFT SKILLS DEVELOPMENT:** Concept of SWOT, Importance of SWOT, Individual & Organizational SWOT Analysis, Soft skills, meaning, need and importance, difference between soft skills and hard skills, life skills and personal skills, Leadership skills,-Importance ,Types, Attributes of good leader Motivational theories and leadership ,Emotional intelligence in personal and professional lives its importance need and application, Team Building and conflict resolution Skills ,Problem solving skills, Time Management and Stress Management Skills Pareto Principle(80/20) Rule in time management, Time management matrix, creativity and result orientation, working under pressure, stress management	**(8 Hrs)**
Unit-V	**COMMUNICATION AND HONING EMPLOYMENT SKILLS:** Communication process, Non-verbal codes in communication, importance of LSRW in communication, Barriers to communication, Principles of effective Technical writing, Email writing and Netiquettes, **Letter writing** – formal letters, job application letter, cover letter, structure of technical report writing, Building Resume and CV, Tips to build an effective Resume Group discussion, Skills required for Group Discussion Interview skills, Ways of handling telephonic interviews, Importance of body language, grooming &etiquettes for getting right impression in PI&GD , Extempore, Introduction to PowerPoint presentation, ,Structure & flow of presentation,	**(8 Hrs)**
Unit-VI	**BUSINESS ETHICS ,ETIQUETTES AND VALUES:** The Importance of Ethics and Values in Business World, Respect for Individuality and diversity at workplace values of a good manager Key features of corporate etiquette, Corporate grooming & dressing, etiquettes in social & office Setting-Understand the importanceof professional behaviour at the work place, Corporate social responsibility (CSR) its importance and need.	**(8 Hrs)**
Internal Assessment:		

	Unit Test -1	UNIT – I, II, III	
	Unit Test -2	UNIT – IV, V, VI	

Reference Books:	
1	Quantitative Aptitude by R. S. Agarwal published by S. Chand
2	The Book of Numbers by Shakuntala Devi
3	A Modern Approach To Logical Reasoning by R. S. Agarwal published by S. Chand
4	A New Approach to Reasoning Verbal & Non-Verbal by InduSijwali
5	Business Communication by Meenakshi Raman, Prakash Singh published by Oxford University press, second edition
6	Communication Skills by Sanjay Kumar, PushpLata, published by Oxford University press, second edition
7	Technical Communication by Meenakshi Raman, Sangeeta Sharma published by Oxford University press
8	Developing Communication Skills by Krishna Mohan, Meera Banerji published by Macmillan India Pvt Ltd
9	Soft Skills by Meenkashi Raman, published by Cengage publishers
10	Soft Skills by Dr. K Alex published by Oxford University press
11	Soft skills for Managers by Dr. T. KalyanaChakravarthi and Dr. T. LathaChakravarthi published by biztantra
Project Based Learning Topics:	
1	Prepare mock Tests on Unit –I and solve it in given time(use of PSD lab manual)
2	Prepare mock Tests on Unit –I and solve it in given time(use of PSD lab manual)
3	Prepare online model test based on Unit-II and solve it in specific time(use of PSD lab manual)
4	Prepare online model test based on Unit-II and solve it in specific time(use of PSD lab manual)
5	Form a model for spoken and written communication skills which avoid grammar mistakes and common errors
6	Develop various activity models for enriching and developing vocabulary

7	Preparing strategies by using SWOT and TWOS analysis
8	Analysing differences between Soft Skills, Hard skills, and Personal skills
9	Develop Bruce Tuchman's Team Building Models with classmates/Teammates
10	To study different personalities of Leaders from various sectors and find out their attributes and success stories
11	Preparing a model for Time Management Skills and Stress Management and conduct activities for effective implementation of it.
12	Form a model to develop LSRW and communication Skills
13	Conduct mock interview and practice GD activities to build competencies for actual selection process
14	Preparing a model for evaluating Values and Ethics of Good Managers
15	Preparing a model of dress codes and attire for different professional situations Corporate etiquettes and its implications
16	Develop some good activities to understand the importance and need of Corporate social responsibility (CSR)

CHEMICAL PROCESS MODELLING AND SIMULATION

Designation: Professional Core

Pre-requisite Courses: Students should have basic knowledge of

1. Heat transfer, Mass transfer, Thermodynamics and Chemical reaction engineering
2. Process Calculation
3. Mathematics

Teaching Scheme		Examination Scheme		Credits Allotted	
Lectures	: 04 Hours/Week	End Semester Examination	: 60 Marks	Theory	: 04
Practical	: 02 Hours/Week	Internal Assessment	: 40 Marks	Practical	: 01
Total	: 06 Hours/Week	Term work / practical	: 50 Marks	Total Credits	: 05
		Total	: 150 Marks		

Course Outcomes

1	Express mass balance, energy balance and momentum balance equation for various chemical process systems.
2	Express models for heat transfer equipment such as double pipe heat exchangers, shell and tube heat exchanger, etc.
3	Develop models for separation equipments.
4	Develop models for reaction equipment such as batch reactor, CSTR, etc.
5	Recognize simulation approaches.
6	Simulate model equations using numerical methods.

Topics Covered

UNIT-I	**Introduction to Modelling** Introduction: Definition of modelling, different types of models, applications of mathematical modelling, principles of formulation and degree of freedom analysis; Types of models: lumped model, distributed parameter model; Fundamental laws: continuity equation, energy equation, equations of	**(08 Hours)**

	motions, transport equations, equations of state, chemical kinetics.	
UNIT-II	**Modelling of Heat transfer equipment** Double pipe heat exchanger; Shell and tube heat exchanger; Two heated tanks; Single component vaporizer; Steady-state heat Conduction through a hollow cylindrical pipe; Heat transfer with coil; Single and multiple effect evaporators.	**(08 Hours)**
UNIT-III	**Modelling of Separation equipments** Ideal binary distillation column; Multi component non-ideal distillation column; Batch distillation with holdup; Flash distillation; Packed column design; Extraction column, Absorption and stripping column	**(08 Hours)**
UNIT-IV	**Modelling of reactors** CSTR Modelling: Two phase CSTR with heat removal, series of isothermal constant holdup CSTRs, CSTRs with variable holdups, Gas phase-pressurized CSTR, non–Isothermal CSTR; Batch reactor; Gas liquid bubble reactor; Semi-batch reactor, Fixed bed reactor.	**(08 Hours)**
UNIT-V	**Introduction to simulation** Introduction to simulation: Definition of simulation, need of simulation; Approaches of simulation: modular approach, equation-solving approach; decomposition of networks: tearing algorithms, algorithms based on the signal flow graph, algorithms based on reduced digraph; Simulation tools: design specification, sensitivity analysis and optimization.	**(08 Hours)**
UNIT-VI	**Simulations using numerical methods** Numerical methods to solve mathematical model equations and estimate parameters of gravity flow tank, three CSTRs in series, non-isothermal CSTR, binary distillation column, multi-component distillation column and batch reactor.	**(08 Hours)**

Project Based Learning	
1.	Draw a flow diagram to build a simulation of any specific product.
2.	Write a mathematical model for unit operation and processes involved in any specific chemical industry.
3.	Prepare a report on modelling and simulation of different chemicals reactors.

4.	Students have to study any five NPTEL videos related to Chemical Process Modelling and Simulation and prepare/present power point presentation.
5.	Collect experimental data from literature and estimate unknown parameters for chemical reactors/heat exchanger/distillation unit.
6.	Literature search for any industrial data for modelling and simulation.
7.	Solving numerical based on heat transfer using modelling and simulation concept.
8.	Solving numerical based on distillation using modelling and simulation concept.
9.	Solve assignments allotted with group discussion and problem solving.
10.	Preparation of a brief report on chemical engineering systems.
	Term Work:
	Term work will consist of the practical's listed below, out of which any eight practicals are to be performed in laboratory by the students.
1	Study of gravity flow tank.
2	Study of Batch reactor.
3	Simulation of CSTR.
4	Simulation of bubble point temperature.
5	Simulation of distillation column.
6	Simulation of heat exchanger.
7	Simulation of first order reaction system in batch reactor.
8	Simulation of first order reaction system in CSTR
9	Study of a reversible reaction in a batch reactor.
10	Simulation of any model equation.
11	Study of CSTR combination in first order reactions.
12	For simulation, faculty member may use any suitable simulation software like MATLAB, ASPEN, CHEMCAD, etc. In addition to these above stated practicals concerned faculty member may design his/her own practicals.
Text Books/References	

1	W. L. Luyben, “Process Modeling Simulation and Control for Chemical Engineers”, McGraw Hill, 1990.
2	S. C. Chapra, R. P. Canale, “Numerical Methods for Engineers”, 6th Edition, Tata-McGraw Hill, 2012.
3	R. E. G. Franks, “Modeling and Simulation in Chemical Engineering”, WielyIntrscience, NY, 1972.
4	B.V. Babu, “Process Plant Simulation”, Oxford University Press, NY 2004.
5	D. Himmelblau, K.B. Bischoff, “Process Analysis and Simulation”, John Wiley & Sons, 1968

Syllabus for Unit Tests	
Unit Test I	Units I, II, and III
Unit Test II	Units IV, V, and VI

Vocational Course IV: Piping Design					
Designation: Professional Core					
Pre-requisite Courses: Chemical engineering core courses					
Teaching Scheme		**Examination Scheme**		**Credits Allotted**	
Lectures	:	End Semester Examination	: -	Theory	: -
Practical	: 02 Hours/week	TW Assessment	: 25 Marks	Practical	: 01
Tutorial	: -	Oral/Practical	: 25 Marks	Tutorial	: -
Total	: 02 Hours/Week	Total	: 50 Marks	Total Credits	: 01

Course Outcomes	
1	Define the material for piping in given process
2	Select the type of fitting and define valves for given process
3	Design piping for heat treatment systems
4	Establish the PFD and arrange the piping accordingly
5	Define the P&ID and select the controls for given process
6	Select the proper code for design of piping requirement for given process

Topics Covered		
UNIT-I	**Introduction to piping designing & engineering** Need for piping and its design requirements, Piping materials and selection, Pipe dimensioning, Schedule numbers, Common piping abbreviations, Common abbreviations etc.	**(04 Hours)**
UNIT-II	**Basic Piping components required** Type of Fittings - elbows, weld tee, stub in, couplings, reducers, weld cap, screwed and socket welded fittings, Pipe nipples, flanged fittings and use of	**(04 Hours)**

	fittings Type Flange -Types, P-T ratings and facings, Gaskets, bolts and nuts. Major Valves - Types, Materials operations, applicability, codes and specifications.	
UNIT-III	**Piping Equipment** Horizontal vessels/accumulators, fractionation columns, pumps, heat exchangers, re-boiler, air cooled heat exchanger, heaters / boilers, storage tanks, fractional distillation process	**(04 Hours)**
UNIT-IV	**Piping Engineering flow diagram and its concept** Uses of flow diagrams, process flow diagrams, mechanical flow diagrams, utility flow diagrams, piping symbols, line symbols, valve symbols piping isometrics, general arrangement drawings- sections/elevations/ detail drawings	**(04 Hours)**
UNIT-V	**P&IDs** Purpose of P&ID'S, study of P&ID'S, stages of development of P&ID'S, process and instrumentation diagrams, process equipments, symbols usage according to industrial practices, Purpose of P&ID in process industrial/plants.	**(04 Hours)**
UNIT-VI	**Basic knowledge of applicable standards** ASME/ANSI Codes & Specification, Specification classes, Piping abbreviations, General abbreviations	**(04 Hours)**

Term work: Following are few practicals to be performed as a part of termwork. These are just for guidelines concerned faculty or course coordinator can design own term work

1.	Case study on piping material selection based upon process condition and fluids involved
2.	Prepare a study report on schedule number, its application in piping design and piping abbreviations.
3.	Define selection of fitting based upon process requirements and conditions
4.	Define selection of valves based upon process requirements
5.	Design piping requirements for heat exchange equipments
6.	Design the piping requirement for reboiler and other equipments involving phase change

7.	Define about the concept of flow diagram and its importance in piping design factors involved in designing flow diagram
8.	Prepare the general arrangement drawing for given plant case study
9.	Prepare report on formation of P&ID for given plant case study
10.	Prepare the P&ID for given plant case study and define its components and importance
11.	Prepare the report on ASME codes their classes and usability along with standard mentioned
12.	Prepare the report on ANSI codes their classes and usability along with standard mentioned
13.	Piping and its structural design would be defined considering suitable case study
14.	Industrial visit to study actual life piping design and
Text Books/References	

1	RutgerBotermans and Peter Smith, "Process Piping Design Handbook– Vol II: Advanced Piping Design", 2008, Gulf publishing Company, Houston, Texas
2	Peter Smith, "Process Piping Design Handbook– Vol I: The Fundamentals of Piping Design Drafting and Design Methods for Process Applications", 2007, Gulf publishing Company, Houston, Texas
3	AlirezaBahadori, "Oil and Gas Pipelines and Piping Systems Design, Construction, Management, and Inspection", 2017, Gulf publishing Company, Elsevier Inc.
4	J. Phillip Ellenberger, "Piping and Pipeline Calculations Manual Construction, Design Fabrication and Examination", 2nd Edition, 2014, Butterworth-Heinemann, Elsevier Inc.
5	Geoff Barker, "The Engineers Guide for Plant Layout and Piping Design for the Oil Gas Industries", 2018, Gulf publishing Company, Elsevier Inc.

Programme: B. Tech Chemical (2021)
Semester- VIII (Chemical)

ELECTIVE-II: Nanomaterials Synthesis and Applications

Designation: Elective

Pre-requisite Courses: Basic chemistry, Physical chemistry, Mass transfer, Fluid flow operations, Chemical Engineering Thermodynamics

Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Lectures : 4 Hours/Week	End Semester Examination : 60 Marks	Theory : 04
Practical : 2 Hour /Week	Continuous Assessment : 40 Marks	TW/Practical : 01
	Term-work (TW) : 50 Marks	Tutorial :
	Total : 150Marks	Total credits : 05

Course Outcomes:

After completion of the course students would be able to:

1	Define the importance of nanotechnology and their property optimization
2	Design the methodology for synthesis of nanomaterials
3	Determine suitable process for analysis of nanomaterials and evaluate their properties
4	Define the applications of nanomaterials and their property requirements for desired applications
5	Explain environmental issues and risks involved during nanomaterial applications and design safe pathway
6	Define suitable methodology for design of product from nanomaterials

Topics covered

UNIT-I	**Introduction toNano-Materials** Importance of Nanotechnology, opportunity at the nano scale, length and time scale in structures, energy landscapes, interdynamic aspects of inter molecular forces, classification based on the dimensionality, nanoparticles, nanoclusters, nanotubes, nanowires and nanodots, semiconductor nanocrystals carbon	**(08 Hours)**

	nanotubes, influence of nano structuring on mechanical, optical, electronic, magnetic and chemical properties	
UNIT-II	**Nanomaterials synthesis** Synthesis and processing, method of nanostructured material preparation – mechanical grinding, wet chemical synthesis, sol-gel processing, gasphase synthesis, gas condensation processing, chemical vapor condensation, nano compositesynthesis – processing Biological methods of synthesis: Use of bacteria, fungi, Actinomycetes for nanoparticlesynthesis, Magnetotactic bacteria for natural synthesis of magnetic nanoparticles; S-layerproteins, Viruses as components for the formation of nanostructured materials; Synthesis processand application, Role of plants in nanoparticle synthesis	**(08 Hours)**
UNIT-III	**Analysis of nanomaterial properties** X-ray Diffraction, Thermal Analysis Methods, Differential Thermal Analysis and Differential scanning calorimetry, Spectroscopic techniques, UV-Visible Spectroscopy, IR Spectroscopy, Microwave Spectroscopy, Raman Spectroscopy, Electron Spin Resonance Spectroscopy, NMR Spectroscopy-Particle size characterization: Zeta Potential Measurement, Particle size Analysis, X-ray Photoelectron spectroscopy, Optical microscopy, Scanning Electron Microscopy, Transmission Electron Microscopy, Atomic Force Microscopy, Scanning Tunneling Microscopy	**(08 Hours)**
UNIT-IV	**Applications of nanonaterials** Industrial applications of nanomaterials, in the areas of electronics, photonics, biology, health and environment, medicine, defence, chemicals, catalysts, textiles, etc. Application of nanotechnology in remediation of pollution, photocatalysis and other nano-catalysts, greenhouse gases, global warming.	**(08 Hours)**
UNIT-V	**Environmental aspects and risk analysis of nanomaterials** Identification of Nano-specific risks, responding to the challenge, human health hazard, risk reduction, standards, safety, transportation of nanoparticles, emergency responders. Riskassessment, environmental impact, predicting hazard, environmental and policy making, ecotoxicitymeasurement of nanomaterials, vacuum packaging under inert gas atmosphere, methodology for stabilization, human safety in nanomaterial processing area.	**(08 Hours)**
UNIT-VI	**Product Development with Nanomaterials**	**(08 Hours)**

	Criteria for selection of product, product development process, design for manufacture,estimate the manufacturing cost, reduce the support cost, prototyping, economics of product development projects, elements of economic analysis, financial models, sensitive analysis and influence of the quantitative factors	
Text Books/References:		
1	P.P. Simeonova, N. Opopol and M.I. Luster, Nanotechnology - Toxicological Issues andEnvironmental Safety, Springer USA 2006.	
2	Mick Wilson, KamaliKannangara, Geoff Smith, Michelle Simmons, BurkarRaguse,Nanotechnology:Basic sciences and emerging technologies, Overseas Press, 2005	
3	Charles P. Poole, Frank J. Owens, Introduction to Nanotechnology‖, Wiley Interscience, USA 2003.	
4	Mark A. Ratner, Daniel Ratner, Nanotechnology: A gentle introduction to the next Big Idea‖, 1st Ed. Prentice Hall P7R:USA, 2002	
5	G. Cao and Y.Wang, Nanostructures and Nanomaterials: synthesis, properties and applications, 2nd Ed., World Scientific, Singapore, 2011	
6	H. S. Nalwa, Encyclopedia of nanoscience and nanotechnology, American ScientificPublishers, USA 2007	
7	Willard, H. H, Merritt Jr., L. L, Dean, J. A., Settle Jr., F. A, Instrumental methods of analysis, Van NostrandNew York, N.Y. USA, 2014	
Project based learning: Below is the list of possible topics, which is for guidance faculty can design and provide relevant topics in addition to these		
1	Prepare a report on detail of Nano material, preparation, characterization, module and process design for anyone application	
2	Technical interview based on knowledge of Nano technology.	
3	Students have to study any five NPTEL/you-tube videos related to Nano technology and prepare/present power point presentation.	
4	Group discussions on Nano science and technology related topics.	
5	Prepare a report on innovations in Nano technology and their practical importance.	

6	Students have to study any five research papers related to specific topic and prepare/present power point presentation
7	With the help of this subject knowledge, write a report on how you would apply your concepts in industry.
8	Case study on emerging trends in process/product innovation considering nano-technology.
9	Students have to visit chemical industry and make a detailed report on nano-technologies used in the process.
10	Write a report on your visit to research and development laboratory of national/international repute.
11	Write a report on nano-technologies for addressing the problems of Water and Energy.

Syllabus for Unit Test:	
Unit Test : I	Units : I, II, and III
Unit Test : II	UNIT : IV, V, and VI

ELECTIVE-II: MEMBRANE SEPARATION		
Designation: Elective		
Pre-requisite Courses: Basic chemistry, Physical chemistry, Mass transfer, Fluid flow operations, Chemical Engineering Thermodynamics		
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Lectures : 4 Hours/Week	End Semester Examination : 60 Marks	Theory : 04
Practical : 2 Hour /Week	Continuous Assessment : 40 Marks	TW/Practical : 01
	Term-work (TW) : 50 Marks	Tutorial :
	Total : 150 Marks	Total credits : 05

Course Outcomes:

After completion of the course students would be able to:

1	Explain basics of membrane and select proper material depending upon application
2	Explain the methods of membrane preparation and characterization
3	Determine suitable process for size based separation and explain its transport mechanism
4	Define the transport through non-porous membranes and define membranes for desired application
5	Explain basics and preparation of membrane for other specialized membrane processes
6	Design suitable module and parameters for the desired application

Topics covered

UNIT-I	**Introduction and Membrane Materials** Introduction, historical development of membrane processes, definition of membrane, permeation, retention and selectivity, membrane processes, their categorization, material for membrane preparation, polymeric material, inorganic materials, mechanical, thermal and chemical stability of membrane based on material, choice of polymer for membrane preparation based on application	**(08 Hours)**

UNIT-II	**Membrane Preparation and Characterizations** Preparation of synthetic membranes: phase inversion membranes, preparation of composite membranes, preparation of inorganic membranes Characterization: Porous membranes – electron microscopy, atomic force microscopy, mercury intrusion, bubble point method, permeability method, solute rejection characteristic; non-porous membranes – permeability, surface analysis, wide angle X-ray, DCS/DTA, density measurement	**(08 Hours)**
UNIT-III	**Processes using porous membranes** Transport mechanism in porous membranes – Knudsen flow, friction model, sieving mechanism Processes: Microfiltration – membranes details, characteristics, industrial applications; Ultrafiltration - membranes details, characteristics, industrial applications; Nano-filtration - membranes details, characteristics, industrial applications.	**(08 Hours)**
UNIT-IV	**Solution-diffusion based membrane processes** Transport mechanism – Solution-diffusion mechanism, solubility, diffusivity, effect of temperature, interaction polymer crystallinity of solubility and diffusivity; Free volume theory Processes: Reverse osmosis - membranes details, characteristics, industrial applications; Gas separation - membranes details, characteristics, industrial applications; Pervaporation - membranes details, characteristics, industrial applications	**(08 Hours)**
UNIT-V	**Other membrane processes** Dialysis - membranes details, their preparation, characteristics, transport mechanism, industrial applications; Electrodialysis - membranes details, their preparation, characteristics, industrial applications; Membrane distillation - membranes details, their preparation, characteristics, industrial applications; Membrane bioreactor - membranes details, their preparation, characteristics, industrial applications; Liquid membranes - membranes details, ionic liquids, their preparation, characteristics, industrial applications; ion exchange - membranes details, their preparation, characteristics, industrial applications	**(08 Hours)**
UNIT-VI	**Membrane modules and process design** Selection of process depending upon applications, plate and frame module, spiral wound module, tubular module, capillary module, hollow fiber module, comparison between module configuration, system design, cross flow operations, hybrid dead end/cross flow operations, cascade operations, Process	**(08 Hours)**

	parameters, Energy requirements	

Text Books/References:	
1	Mulder M.: Basic Principle of Membrane Technology, Kluwer Academic Press Springer Nature Switzerland AG, 1996
2	Baker R. W.: Membrane Technology and Applications, John Wiley and Sons, Ltd. USA, 2004
3	Porter M. C.: Handbook of Industrial Membrane Technology, Noyes Publications, Switzerland, 1991
4	Baker R. W., Cussler E. L., Eykamp W., Koros W. J., Riley R. L., Strathman H.: Membrane Separation Systems – Recent Developments and Future Directions, Noyes Data Corporation, USA, 1991
5	Nunes S. P., Peinemann K.-V., Membrane Technology in the Chemical Industry, Wiley-VCH Verlag GMBH Germany, 2001

Project based learning: Below is the list of possible topics, which is for guidance faculty can design and provide relevant topics in addition to these	
1	Prepare a report on detail of membrane material, preparation, characterization, module and process design for anyone application
2	Technical interview based on knowledge of membrane technology.
3	Students have to study any five NPTEL/you-tube videos related to membrane technology and prepare/present power point presentation.
4	Group discussions on membrane science and technology related topics.
5	Prepare a report on innovations in membrane technology and their practical importance.
6	Students have to study any five research papers related to specific topic and prepare/present power point presentation
7	With the help of this subject knowledge, write a report on how you would apply your concepts in industry.
8	Case study on emerging trends in process/product innovation considering membrane technology.
9	Students have to visit chemical industry and make a detailed report on membrane technologies used in the process.
10	Write a report on your visit to research and development laboratory of national/international

	repute.
11	Write a report on membrane technologies for addressing the problems of Water and Energy.
Syllabus for Unit Test:	
Unit Test : I	Units : I, II, and III
Unit Test : II	UNIT : IV, V, and VI

Artificial Intelligence		
Designation: Professional Elective		
Pre-requisite Courses: Basic knowledge of Engineering Mathematics, Computer Programming		
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Lectures : 04 Hours/Week	End Semester Examination : 60 Marks	Theory : 04
Practical : 02 Hours/Week	Internal Assessment : 40 Marks	TW/OR : 01
Total : 06 Hours/Week	Termwork : 25 Marks	Total Credits : 05
	Termwork and Oral : 25 Marks	
	Total : 150 Marks	

Course Outcomes

After completion of the course students would be able to

1	Formulate problem statement of chemical engineering process using artificial intelligence.
2	Apply formalisms of artificial intelligence to chemical engineering processes.
3	Estimate artificial neural network modeling parameters for chemical process.
4	Estimate genetic programming modeling parameters for chemical process.
5	Estimate principle components for a given system/process data.
6	Estimate economic artificial intelligence based optimization procedure for chemical process.

Topics Covered

UNIT-I	**Introduction** Introduction to Artificial Intelligence (AI); Applications of AI to Chemical Engineering; Introduction to various AI- based formalisms; Principal component analysis; Cause and effect relationships. Black box modelling.	**(08 Hours)**

UNIT-II	**AI-based Modelling Formalisms** Introduction to various AI- based modelling formalisms; Artificial Neural Networks (ANNs); Genetic Programming (GP); Support Vector Regression; Fuzzy Logic (FL); Applications of these formalisms to Chemical engineering.	**(08 Hours)**
UNIT-III	**Artificial Neural Networks (ANNs)** Biological background; ANN classification; Computational properties of ANNs; Modelling a single neuron; Building blocks of feed-forward neural network: Bias, Processing elements, Input layer, hidden layer, Output layer, Learning rate, Momentum, Transfer function; Error back propagation.	**(08 Hours)**
UNIT-IV	**Genetic Programming (GP)** Introduction to evolutionary algorithms; Dependent variables; Independent variables; Mathematical operators; Initial population; Candidate solution; Tree structure; Initialization; Fitness evaluation and selection; Crossover; Mutation.	**(08 Hours)**
UNIT-V	**Evolutionary Algorithms (EA)** Introduction to stochastic evolutionary algorithms; Applications; Genetic algorithms; Particle Swarm method; Ant Colony method.	**(08 Hours)**
UNIT-VI	**Applications and Case Studies** Chemical Engineering based different case studies solution using AI-based modelling and optimization formalisms	**(08 Hours)**

***Project Based Learning**	
1.	Group discussions on any of the following topics: a) Role of Artificial Intelligence in Chemical Engineering b) Phenomenological, empirical and AI-based modelling c) Artificial Intelligence and Chemical Industries
2.	Make a complete chart of various AI based modeling formalisms with suitable schematics.
3.	Preparation of seminar report and oral presentation based on recent advances in Chemical Engineering with Artificial Intelligence.
4.	Students have to study any five NPTEL videos related to Artificial Intelligence and prepare/present power point presentation.
5.	Solving numerical based on core chemical engineering process problems using AI formalisms.

6.	Collect and read recent research papers on Artificial Neural Network and chemical process modelling and prepare summery report.
7.	Collect and read recent research papers on Genetic Programming and chemical process modelling and prepare summery report.
8.	Analyse the results for case study with Principal Component Analysis and interpret the results.
9.	Prepare question bank with appropriate answers based on the whole subject renewable energy.
10.	Enhancement in collaborative learning is done through, group assignments that will be given to encourage students to work with classmates to discuss and complete homework assignments.
*Students in a group of 3 to 4 shall complete any one project from the above list.	
Termwork:	
Oral examination will be based on the assessment of the term-work (duly certified by the teacher and HOD). The term-work shall consist of case study solved using AI-based formalisms mentioned in the syllabus OR term-work shall be based on the technical report/seminar based AI-based studies carried out by individual or small group of students.	
Text Books/References	
1	C.M. Bishop, Neural Networks for Pattern Recognition, Oxford University Press, Oxford, 1995.
2	S.S. Tambe, P.B. Deshpande, B.D. Kulkarni, Elements of Artificial Neural Networks with Selected Applications in Chemical Engineering, and Chemical & Biological Sciences, Simulation & Advanced Controls, Inc., Louisville, 1996.
3	J. Koza, Genetic Programming: On the Programming of Computers by Means of Natural Selection, MIT Press, Cambridge, M.A, 1992.
4	V. Vapnik, The Nature of Statistical Learning Theory, Springer-Verlag, New York, 1995.
5	K. Deb, Optimization for Engineering Design: Algorithms and Examples, Prentice-Hall, New Delhi, 1995.
6	D.E. Goldberg, Genetic Algorithms in Search, Optimization, and Machine Learning, Addison-Wesley, Reading, MA, 1989.
Syllabus for Unit Tests	

Unit Test I	Units I, II, and III
Unit Test II	Units IV, V, and VI

ELECTIVE-II : BIO-SEPARATIONS		
Designation: Professional Core		
Pre-requisite Courses: Basic knowledge of Biology, Analytical chemistry and techniques.		
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Lectures : 04Hours/Week	End Semester Examination : 60 Marks	Theory : 04
Practical : 02Hours/Week	Internal Assessment : 40 Marks	Tutorial : -
Total : 06 Hours/Week	Term-work (TW) : 25 Marks	Practical : 01
	Practical/Oral : 25 Marks	Total Credits : 05
	Total : 150Marks	

Course Outcomes

1	Define concept of bio-separation, physico-chemical basis of bio-separation.
2	Learn low resolution bio-separation techniques.
3	Analyze high resolution bio-separation techniques.
4	Learn separation techniques like precipitation, crystallization, etc.
5	Identify the emerging bio-separation techniques like expanded-bed chromatography, hybrid bioseparations, etc.
6	Apply bio-separation knowledge for purification of β amylase, aspartic acid, etc.

Topics Covered

UNIT-I	**Introduction to Bio-separation** An overview of bio-separation; Separation of cells and other insolubles from fermented broth; bioproduct purification; characteristics of biological mixtures; Broad categories of bioproducts; essential stages in downstream processing; basic unit operations in downstream processing; physico-chemical basis of bio-separation.	**(08 Hours)**

UNIT-II	**Low resolution Bio-separation techniques** Cell disruption, Centrifugation; Liquid-liquid extraction; Leaching; Filtration; Supercritical fluid extraction; Micro-filtration; Ultra-filtration; Adsorption; Sedimentation	**(08 Hours)**
UNIT-III	**High resolution Bio-separation techniques** Ultra-centrifugation**;** Different electrophoresis techniques viz. Isoelectric focusing; Affinity separation; Chromatographic techniques viz. Paper, Gel; Ion exchange; Affinity; GLC; HPLC; Dialysis.	**(08 Hours)**
UNIT-IV	**Other separation techniques** Zone refining; Molecular sieves; Adductive crystallization; Reactive extraction; Precipitation method using ammonium sulfate; organic solvents; high molecular weight polymers; Reverse osmosis; Foam separation; Aqueous two phase systems.	**(08 Hours)**
UNIT-V	**Emerging bio-separation techniques** Membrane and monolith chromatography; Expanded-bed chromatography; High-resolution ultrafiltration; Hybrid bio-separations; Introduction to SEP box and Hyphenated techniques.	**(08 Hours)**
UNIT-VI	**Applications of Bio-separation -case studies** Purification of β amylase; aspartic acid; insulin; Food and Beverages; Beer; Citric acid; Bio-chemicals: Butanol.	**(08 Hours)**

Project Based Learning	
1.	Write a report on the recent advances in chromatographic processes with reference to the current year.
2.	Evaluate efficiencies of different chromatographic techniques.
3.	Search out some industries related to bio-separation.
4.	Write a technical report on your visit to a process industry.
5.	List out all the principles of the analytical techniques.
6.	Perform any one chromatographic technique.
7.	Find out different types of proteins with structure.

8.	Prepare a report on downstream processing.
9.	Give fifteen minutes presentation (seminar) on particular topic and prepare a report.
10.	Group discussion on merits and de-merits of bio-separation.
*Students in a group of 3 to 4 shall complete any one project from the above list.	
Term Work	
Term work will consist of the seminars on the following topics.	
1	Gas chromatography.
2	Membrane separation and its application in industry.
3	Sedimentation and its application in industry.
4	Reactive extraction.
5	Material analysis using paper chromatography
6	High-resolution ultrafiltration.
7	Gel electrophoresis
8	Molecular sieves.
9	Centrifugation.
10	Adductive crystallization
Te1xt Books/References	
1	P.A.Belter, E.L. Cussler and S.H.Wei, “Bio-separation–Downstream Processing for Biotechnology”, Wiley India Pvt. Ltd., 2011.
2	N.K.Prasad, “Downstream Process Technology-A New Horizon in Biotechnology”, Prentice Hall of India, New Delhi, 2012.
3	M.D.Pauline, “Bioprocess Engineering Principles”, Academic Press, London, USA, 2012.
4	B Sivasankar, “Bio-separations: Principles and Techniques”, Phi Learning Pvt. Ltd., 2009.
5	A. Kumar, A. Awasthi , “Bio-separation Engineering: Comprehensive DSP Volumen” I.K International Publishing House Pvt. Ltd., New Delhi, 2009.
Syllabus for Unit Tests	
Unit Test I	Units I, II, and III
Unit Test II	Units IV, V, and VI

Chemical Project Engineering and Economics

Designation: Professional Core

Pre-requisite Courses: Basic knowledge of engineering mathematics, core Chemical Engineering subjects, and process modeling

Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Lectures : 04 Hours/Week	End Semester Examination : 60 Marks	Theory : 04
Drawings : 02 Hours/Week	Internal Assessment : 40 Marks	Practical : 01
Total : 06 Hours/Week	Term-work : 25 Marks	Total Credits : 05
	Oral : 25 Marks	
	Total : 150 Marks	

Course Outcomes

After completion of the course students would be able to

1	Formulate preliminary techno economic feasibility report.
2	Elaborate the criteria for process selection and justification of the selected chemical process.
3	Estimate the total product cost.
4	Estimate the depreciation charges for various assets.
5	Evaluate the break even chart and its significance.
6	Estimate the critical path method (CPM) for project planning of given chemical process.

Topics Covered

UNIT-I	**Introduction** Plant design and development : Design basis, process selection, material of construction, plant location, plant layout and installation, plant operation and control, safety, start up, shut down and operating guidelines; Preliminary techno economic feasibility report.	**(08 Hours)**
UNIT-II	**Optimization and feasibility of plant design**	**(08 Hours)**

	Preliminary design: Design and selection of process equipments, standard versus special equipment selection criteria, specification sheets; Comparison of different processes; Importance of laboratory development and pilot plant; utilities; Complete engineering flow sheet drawing; Flow diagrams: Process flow diagram, qualitative flow diagram, quantitative flow diagram.	
UNIT-III	**Cost estimation** Cash flow and cumulative cash position for industrial operations; Factors affecting investment and production cost; Capital investments: Fixed capital investment, working capital, method for estimating capital investment; Estimation of total product cost: Direct production cost, fixed charges, plant overhead costs, administrative expenses, distribution and marketing expenses; Cost indexes.	**(08 Hours)**
UNIT-IV	**Depreciation** Introduction; Basic terminologies related to depreciation; Types of depreciation: Functional depreciation, physical depreciation; Methods for determining depreciation: Straight line method, Declining balance method, Double declining balance method, Sum of the years digits method, Sinking fund method.	**(08 Hours)**
UNIT-V	**Interest and investment costs** Types of interest; Present worth and discount; Annuities: Relation between amount of ordinary annuity and the periodic payments, present worth of an annuity; Balance sheet; Evaluation of break-even point and its significance; Profitability, Alternative investments and replacement: Methods for profitability evaluation, % rate of return, practical factors in alternative investment and replacement studies	**(08 Hours)**
UNIT-VI	**CPM and PERT** Bar charts; Milestone charts; Introduction to Critical Path Method (CPM) and Project Evaluation and Review Technique (PERT); Applications of CPM and PERT; Basic Steps in PERT / CPM: Planning, scheduling, allocation of resources, controlling; Network Diagram Representation: Activity, classification of activities, event, classification of events, sequencing; Rules for drawing network diagram; Common errors in drawing networks; Advantages of CPM and PERT project planning; Detail calculation procedure of CPM and PERT project planning.	**(08 Hours)**
***Project Based Learning**		

1.	Preparation of quantitative flow diagram for any process plant
2.	Preparation of feasibility report for any chemical product/process
3.	Preparation of critical path network for specific case study/chemical process
4.	Preparation of project evaluation and review technique for specific case study/chemical process
5.	Students have to study any five NPTEL videos related to Chemical Project Engineering and Economics and prepare/present power point presentation.
6.	Group discussions on any of the following topics: a) Importance of project engineering techniques in chemical industries. b) Critical path method and project evaluation and review technique c) Role of economics in chemical process design
7.	Read recent research papers related to this subject area and prepare report
8.	Prepare question bank with appropriate answers based on Chemical Project Engineering and Economics
9.	Solving numerical based on core chemical engineering using optimization methods
10.	Enhancement in collaborative learning is done through, group assignments that will be given to encourage students to work with classmates to discuss and complete homework assignments.
*Students in a group of 3 to 4 shall complete any one project from the above list.	
Termwork	
Term work will consist of any six drawings of following:	
1	Process flow diagram
2	Plant layout and elevations
3	Utility Diagram
4	Cumulative cash position for industrial operations
5	Break Even Chart
6	Critical Path Method (CPM)

7	Project Evaluation and Review Technique (PERT)
Text Books/References	
1	T. F. Edgar and D. M. Himmblblau, Optimization of Chemical Processes, 2nd Ed., Tata-McGraw Hill Publications, 2001.
2	S. C. Chapra and R.P. Canale, Numerical Methods for Engineers, 6th Ed., Tata-McGraw Hill Publications, 2015.
3	A. Ravindran, K. M. Ragsdell, and G. V. Reklaitis, Engineering Optimization: Methods and Applications, 2nd Ed., Wiley India, 2006.
4	S. S. Rao, Engineering Optimization: Theory and Practice, 4th Ed., John Wiley & Sons, Inc, 2009.
5	M. S. Peters and K. D. Timmerhaus, Plant Design and economics for chemical engineers, Mc Graw Hill Publications, 2002.
Syllabus for Unit Tests	
Unit Test I	Units I, II, and III
Unit Test II	Units IV, V, and VI

Optimization Techniques in Chemical Engineering		
Designation: Professional Core		
Pre-requisite Courses: Basic knowledge of engineering mathematics, core Chemical Engineering subjects, and process modeling		
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Lectures : 04 Hours/Week	End Semester Examination : 60 Marks	Theory : 04
Total : 04 Hours/Week	Internal Assessment : 40 Marks	Total Credits : 04
	Total : 100 Marks	

Course Outcomes	
After completion of the course students would be able to	
1	Formulate statement of optimization problem
2	Apply methods for unconstrained single variable optimization
3	Apply methods for unconstrained multivariable optimization
4	Elaborate economic optimization procedure for chemical engineering problems
5	Estimate optimum design procedure for chemical engineering problems
6	Estimate economic optimization procedure for process equipments

Topics Covered		
UNIT-I	**Introduction** Introduction to Optimization; Statement of optimization problems; Classification of optimization problems; Examples from engineering	**(08 Hours)**

	applications; Review of linear algebra	
UNIT-II	**Unconstrained Single Variable Optimization** Methods and Applications: Region elimination methods; Methods requiring derivatives: Newton-Raphson method, Bisection method, Secant method	**(08 Hours)**
UNIT-III	**Unconstrained Multivariable Optimization** Gradient Based Methods: Cauchy's method, Newton's method, Marquardt method	**(08 Hours)**
UNIT-IV	**Numerical Methods for Optimizing a Function of One Variable:** Core Chemical Engineering problem solution using following methods: Unconstraint One Dimension Methods: Newton's Method, Quadratic Interpolation, Cubic Interpolation; Unconstraint Multiple Variable: Random search, Grid search, Simplex search, Quasi Newton method	
UNIT-V	**Economic Optimization and Optimum Design** Nature of optimization; Uni-variable and multivariable systems; Analytical, graphical and incremental methods of solution; Lagrange multiplier method; Linear programming; Other techniques and strategies establishing optimum conditions; Break even chart for production schedule; Optimum production rates in plant operation; Optimum conditions in batch and cyclic operation; Critical path method; Project evaluation and review technique.	**(08 Hours)**
UNIT-VI	**Optimisation of Different Process Equipment** Transportation systems; Heat exchangers; Evaporators; Mass transfer equipments and reactors; Determination of height and diameter of different process equipments at conditions of optimum cost; Pinch technology analysis; Preparation of techno-economic feasibility report.	**(08 Hours)**

***Project Based Learning**	
1.	Determination of height and diameter of different process equipments for optimum cost
2.	Preparation of feasibility report for any chemical product/process
3.	Preparation of critical path network for specific case study/chemical process
4.	Preparation of project evaluation and review technique for specific case study/chemical process

5.	Students have to study any five NPTEL videos related to Optimization in Chemical Engineering and prepare/present power point presentation.
6.	Group discussions on any of the following topics: a) Importance of optimization technique in chemical industries. b) Critical path method and project evaluation and review technique c) Role of optimization in process design
7.	Read recent research papers related to this subject area and prepare report
8.	Prepare question bank with appropriate answers based on optimization techniques in chemical engineering
9.	Solving numerical based on core chemical engineering using optimization methods
10.	Enhancement in collaborative learning is done through, group assignments that will be given to encourage students to work with classmates to discuss and complete homework assignments.

*Students in a group of 3 to 4 shall complete any one project from the above list.

Text Books/References

1	T. F. Edgar and D. M. Himmblblau, Optimization of Chemical Processes, 2nd Ed., Tata-McGraw Hill Publications, 2001.
2	S. C. Chapra and R.P. Canale, Numerical Methods for Engineers, 6th Ed., Tata-McGraw Hill Publications, 2015.
3	A. Ravindran, K. M. Ragsdell, and G. V. Reklaitis, Engineering Optimization: Methods and Applications, 2nd Ed., Wiley India, 2006.
4	S. S. Rao, Engineering Optimization: Theory and Practice, 4th Ed., John Wiley & Sons, Inc, 2009.
5	M. S. Peters and K. D. Timmerhaus, Plant Design and economics for chemical engineers, Mc Graw Hill Publications, 2002.

Syllabus for Unit Tests

Unit Test I	Units I, II, and III
Unit Test II	Units IV, V, and VI

Industrial Management		
Designation: Professional Core		
Pre-requisite Courses: Concept of Management		
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Lectures : 04 Hours/Week	End Semester Examination : 60 Marks	Theory : 04
Total : 04 Hours/Week	Internal Assessment : 40 Marks	Total Credits : 04
	Total : 100 Marks	

Course Outcomes	
After completion of the course students would be able to	
1	Know the types of business.
2	Understand the types of organization
3	Understand the forms of ownership.
4	Know the concepts of material management.
5	Know the concepts quality management.
6	Know the various acts

Topics Covered		
UNIT-I	**Outline of Business** Types of Business, Industrial sectors Globalization Management Process, Principles of Management, Functions of Management Types of organization, Departmentation, Principles of Organization, Forms of ownership	**(08 Hours)**
UNIT-II	**Financial Management** Objectives & Functions, Capital Generation & (06 Hours) Management, Budgets and accounts, Taxation (Excise Tax, Service Tax, Income Tax, Value Added Tax and	**(08 Hours)**

	Custom Duty)	
UNIT-III	**Material management** Definition, functions, importance, relationship with other departments, purchasing systems, purchase procedure, Storekeeping , classification of stores as centralized and decentralized with their advantages, disadvantages and application in actual practice, Material Resource Planning (MRP)	**(08 Hours)**
UNIT-IV	**Quality Management** Quality Control, Quality Circle, Quality Assurance, Total Quality and TQM, Kaizen,5'S',6 Sigma	**(08 Hours)**
UNIT-V	**Production planning and Control** Need and importance. Scheduling- meaning and need for productivity and utilization. Gantt chart- Format and method to prepare. Critical ratio scheduling-method.	**(08 Hours)**
UNIT-VI	**Recent Trends in IM** ERP (Enterprise resource planning) - concept, features and applications, Important features of MS Project. Logistics- concept need and benefits. Just in Time (JIT)-concept and benefits. Supply chain management-concept and benefits.	**(08 Hours)**

***Project Based Learning**	
1.	Given the data, prepare the network diagram and determine critical path
2.	Given the data, prepare the scheduling using Gantt chart
3.	Perform value analysis for given case
4.	Globalization in India
5.	Different principals of management.
6.	Various types of organization
7.	Various forms of ownership
8.	Capital Generation for an organization.

9.	ABC Analysis. 8. Standard purchase
10.	Material Resource Planning (MRP), Enterprise Resource Planning (ERP)
*Students in a group of 3 to 4 shall complete any one project from the above list.	
Text Books/References	
1	CPM & PERT principles and Applications. L.S.Srinath.
2	Modern Production Management. Buffa.
3	Materials Management. N. Nair. iv. Industrial Engineering & Management. O. P. Khanna. v. Value Analysis. Mikes.
4	Khanna. O.P., "Industrial Engineering & Management" Dhanpat Rai & Sons New Delhi.
5	Banga T. R. and Sharma S.C. "Industrial Engineering & Management" Khanna Publication
6	Saxena, S.C." Business Administration & Management" SahityaBhavan Agra
7	Newman W.H., Warren E. K. and McGil A. R., "The process of Management" Prentice- Hall
Syllabus for Unit Tests	
Unit Test I	Units I, II, and III
Unit Test II	Units IV, V, and VI

Chemical Process Simulation II		
Designation: Professional Core		
Pre-requisite Courses: Fundamentals ofComputer, Mechanical operations, Heat Transfer, Fluid Flow, Mass Transfer, Thermodynamics and Chemical reaction engineering.		
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Practical : 02Hours/Week	TW :25Marks	
	Practical/Oral :25 Marks	Practical/Oral : 01
	Total : 50 Marks	Total Credits : 01

Course Outcomes:

After completion of the course students would be able to:

1	Develop a process flow diagram for a given system.
2	Design simulation programs involving small unit operations.
3	Simulate reactors and estimate parameters.
4	Design and simulate heat exchangers
5	Develop a simulation model for separation of binary/ternary components.
6	Apply all fundamental knowledge to build a simulation environment for a given problem.

Topics Covered

UNIT-I	**VLE data estimation** Estimation of VLE data for different binary mixtures at isothermal and isobaric conditions 1. Program/ simulation applying different activity Coefficient models 2. Estimation of binary interaction parameters
UNIT-II	**Simulation of Separation Units** 3. Process, design of absorption/ Distillation column 4. Estimating HTU, NTU, HETP absorption column 5. Estimating design parameters of distillation column
UNIT-III	**Simulation of Reactors** Simulation of batch, semi-batch and continuous stirred reactors. 6.Estimating conversion/purity/selectivity in batch reactor 7. Case study selecting any example
UNIT-IV	**Simulation of Reactor + Separator unit** Theoretical calculation for reactor separator unit, variable selection for design. 8. Optimization of the reactor + Separator unit.
UNIT-V	**Application to Chemical Engineering** Solving real case studies in chemical engineering. 9. Simulation of any case study involving all unit operations and processes. 10. Optimizing the variables.
UNIT-VI	**Computational Fluid Dynamics Basics** Introduction to CFD approach, advantages of CFD, applications, equation structure overview. Governing equations of fluid dynamics, mass, energy and momentum, boundary conditions, time-averaged equations for turbulent Flow, partial differential equations on CFD, elliptic, parabolic and hyperbolic equations. 11. Programs based on Fundamentals in CFD Programming. 12. Programs based on governing equations

Term Work

Term work will consist of the programs/practical's listed above, out of which any eight programs/practical's are to be performed in laboratory by the students.

Text Books/References:	
1	A. Finlayson, Introduction to chemical engineering computing. John Wiley & Sons, 2012
2	W. L. Luyben, Process Modeling Simulation and Control for Chemical Engineers,McGraw Hill, 1990.
3	J. Haydary, Chemical Process Design and Simulation, Wiley, 2019.
4	A. Jana, Amiya K. Chemical process modelling and computer simulation. PHI Learning Pvt. Ltd. 2011.
5.	D. Himmelblau, K.B. Bischoff, Process Analysis and Simulation, John Wiley & Sons, 1968

PROJECT: STAGE-II		
Designation: Professional Core		
Pre-requisite Courses: Knowledge of chemistry, Material and energy balance calculations, Mass transfer, and Chemical reaction engineering, Equipment design, etc.		
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Practical : 04 Hours/Week	Term-work (TW) : 100 Marks	TW/Oral : 06
Total : 04 Hours/Week	Practical/Oral : 100 Marks	Total Credits : 06
	Total : 200 Marks	

Course Outcomes

1	Fabrication of the experimental setup/new system and/or purchase of standard components
2	Pilot run and/or validation of new system for its performance
3	Modifying the system if required to improve its performance
4	Detailed parametric studies of the modified system and analyzing the results
5	Writing technical report, research article and/or filing a patent

Course Contents

Students need to approach to the guide after guide allotment using standard procedure. Guide will elaborate the project to students and decide the objectives and the plan of work.

Minimum number of in-sem. project presentations: 03

Parameters for evaluation of project in University examination

Idea of Project/Topic, Technical content, Innovation, Experinnentation/Model development/Software development/Simulation development, etc., Participation as an Individual, Research Potential, Project Hardware/Software, Fabrication/Model/Equipment development, Data Analysis, Attendance, Timely completion, Report writing, Presentation

Progress report card will be issued to each student to monitor the progress of work.

Assessment and progressive evaluation of the project will be done by the committee consisting of senior faculty members. The record of progressive evaluation shall be submitted in the department at the end of the semester and made available at time of university examination.

BHARATI VIDYAPEETH
(DEEMED TO BE UNIVERSITY), PUNE

Faculty of Science
B. Tech. Chemical
Old Syllabus

College Information

Bharati Vidyapeeth University college of Engineering, Pune continued to take new strides towards evolving directions to further the growth and dissemination of scientific and technological knowledge.

The college established in 1983, is one of the oldest and largest Engineering Colleges in the state of Maharashtra. The college has well defined goals which are intensely practised and followed.

Their implementation encompass multi-faceted activities in the form of recruiting experienced faculty, organizing faculty development program, Identifying socio-economically relevant areas and emerging technologies. Constant review and upgradation of curricula, Upgradation of Laboratories, library and communication facilities, Collaboration with industries and research and development organizations, Sharing of knowledge, infrastructure and resources, training extension, testing and consultancy services and Promoting Interdisciplinary research.

The college has been ranked as 'A' grade Engineering college by the Government of Maharashtra. Meeting quality standards in education such as is been a motto of this institute. As a pedagogical effect, out of ten under graduate programmes being conducted, seven programmes eligible for accreditation are accredited by National Board of Accreditation(NBA).

The DATAQUEST - CMR conducts an annual survey of technical schools of India and publishes the list of best 100 technical schools in India. In the surveys, for the past seven years, the college has been consistently ranked among top 50 technical schools.

Another feather in Institute's cap is its selection for the grant of Rs. 4.0 Crore under Technical Education Quality Improvement Programme - II(TEQIP-II) by Ministry of Human Resource Development (MHRD) of Government of India supported by World Bank.

This Institute has been ranked to 45th position at all India level and 5th at the Western Region of AICTE in 2012.The Institute has been very sensitive to the human resource development and continues initiating new academic programmes. Presently it offers 09 undergraduate programmes in the field of Civil Engineering, Chemical Engineering, Computer Engineering, Information Technology, Electrical Engineering, Electronics Engineering, Electronics and Telecommunication Engineering, Mechanical Engineering and Production Engineering.

The college offers 08 postgraduate programmes in the field of Civil Engineering,Chemical Engineering, Computer Engineering, Information Technology, Electrical Engineering, Electronics Engineering, Mechanical Engineering and NanoTechnology.

Salient Features

The Department of Chemical Engineering offers undergraduate, postgraduate and doctorate degree courses. The department offers a broad spectrum of educational and research opportunities supported by state-of-the-art facilities. The curriculum is designed along with participants from the industry. The department also organizes expert lectures for students, by inviting experienced leaders from the industry. At the end of the third year, each student is sent for a six weeks internship at various companies across India to gain hands-on experience and recieve on-the-job training in the industry. When the students return for the final year, they are better prepared to graduate and face the challenge as offered by the outside world. Upon graduation, the 'Bharati Chemical Engineer' has recieved well-rounded education, exposure to live research projects and an extensive industry internship. The in-depth training ensure that our students hit-the-ground-running when they join the industry.

Chemical Engineering involve the design, erection, commisioning, and maintenance of the processes incorporating chemical or biological transformations for large scale manufacture. It has wide application in industries like dyestuff, pharmaceuticals, fertilizer, food, speciality chemicals, paints, steel, etc. Chemical Engineers play a vital role in various emerging areas with special references to Nanotechnology/ Science, Green Energy, Water, etc.

The scope for individual engineers in the field of chemical engineering is bound to grow with time. This is mainly because of rapid industrial growth and also scarcity of related resources which are necessary for the future. Chemical Engineers will be needed to develop alternative technologies for those resources which will be depleted in the near future.

Research Initiatives:

- Development of continuous fixed bed adsorption column towards the removal of fluoride and trace organics from ground water. Research grant worth Rs. 5.75 lacs has been recieved by AICTE under Research Promotion Scheme.
- Phase equillibrium studies to generate Vapour Liquid Equillibrium data for multi component system. Research grant worth Rs. 10.5 lacs has been recieved by AICTE under Career Award for Young Teachers.
- Developing ultrasound cavitation based techniques for degradation of organic pollutants. Bharati Vidyapeeth University has given grant of 2.66 lacs for establishing this facility.
- Studies of adsorption of gases, specially CO2 using innovative adsorbents. Research grant worth Rs. 5.45 lacs has been recieved by AICTE under Research Promotion Scheme.

Research Facilities Developed:

- Process Dynamics and Controla, Chemical Reaction Engineering, Unit Operation and Mass Transfer Laboratories are modernized utilizing the grant of AICTE (MODROBS) worth Rs.12 lacs
- Analytical facilities like Gas Chromatograph, UV spectrophotometer, HPLC, Karl Fisher Titrater, etc.
- Software facilities like ChemCAD, TK solver, gProms software, Dynochem are made available for carrying out research in the field of modeling and simulation.
- Design and development & solid-liquid circulating fluidized bed. Research grant worth Rs. 30 lacs has been recieved from DST-SERB.
- Membrane based separation. Research grant worth Rs. 1.2 lacs has been recieved from Bharati Vidyapeeth University, Pune.
- Process development and intemsification. Research grant worth Rs. 5 lacs has been recieved under TEQIP-II
- Bio-processing of Bio-fuel. Research grant worth Rs. 35 lacs has been recieved from DST-INSPIRE.

Total Research Grants Recieved from Academic Year 2004-05 to 2013-14: Rs 95.56 lacs

Research Publications from Academic Year 2010-11 to 2014-15:

Type of Publication	No of Publication
International Journal	62
National Journal	09
International Conference	06
National Conference	02
Total	79

Program Educational Objectives:

- Practice chemical engineering in conventional, multidisciplinary and emerging fields.
- Pursue advanced studies or other forms of continuing education.
- Demonstrate professionalism, ethical and social responsibility and desire for lifelonglearning.

Programme Outcomes:

- Apply knowledge of mathematics, science and engineering principles to solve wide range of open ended chemical engineering problems.
- Analyze the problem and give feasible solutions using fundamentals of mathematics,basic sciences and engineering sciences.
- Design chemical process equipments and processes to meet desired needs with realistic constraints.
- Conduct engineering experiments to analyze and interpret the information obtained from the experiment to synthesis and design valid conclusions.
- Utilize the techniques, analytical skills and modern computational tools necessary for successful chemical engineering practice.
- Develop the culture of health and safety in chemical engineering practice by adhering to statutory regulations.
- Understand the impact of chemical engineering solution in a techno-economic, environmental and societal context for sustainable development.
- Understand the need for ethical decision making in engineering practice.
- Function effectively as an individual and as a member or leader within multi disciplinary teams.
- Express ideas and position clearly and concisely in both oral and in written communication.
- Understand the fundamental precept of effective project management and finance.
- Appreciate the need for and engage in lifelong learning to maintain and enhance the practice of chemical engineering.
- Acquire entrepreneurship skills and business insight.

Sr. no.	Subject	Teaching Scheme (Hours / Week)			Examination Scheme (Marks)						Credits		
		L	P / D	T	End Semester Exami-nation	Continuous Assessment			TW	Total	Theory	P/D	Total
						Unit test	Atten-dance	Assign-ments					
1	Engineering Mathematics- I	3	-	1	60	20	10	10	-	100	4	-	4
2	Fundamental of Civil Engineering	3	2	-	60	20	10	10	25	125	3	1	4
3	Engineering Graphics*	4	2	-	60	20	10	10	25	125	4	1	5
4	Engineering Physics	4	2	-	60	20	10	10	25	125	4	1	5
5	Chemical Engineering Materials	3	-	1	60	20	10	10	25	125	4	-	4
6	Professional Skill Development- I	2	-	-	50	-	-	-	-	50	2	-	2
7	Workshop Technology	-	2	-	-	-	-	-	50	50	-	1	1
	Total	19	8	2	350	100	50	50	150	700	21	4	25

* End semester examination duration of 4 hours

Sr. no.	Subject	Teaching Scheme (Hours / Week)			Examination Scheme Marks						Credits		
		L	P / D	T	End Semester Exami-nation	Continuous Assessment			TW	Total	Theory	P/D	Total
						Unit test	Atten-dance	Assign-ments					
1.	Engineering Mathematics- II	3	-	1	60	20	10	10	-	100	4	-	4
2.	Fundamental of Mechanical Engineering	3	2	-	60	20	10	10	25	125	3	1	4
3.	Engineering Mechanics	4	2	-	60	20	10	10	25	125	4	1	5
4.	Engineering Chemistry	4	2	-	60	20	10	10	25	125	4	1	5
5.	Fundamental of Electrical Engineering	3	2	-	60	20	10	10	25	125	3	1	4
6.	Professional Skill Development- II	2	-	-	50	-	-	-	-	50	2	-	2
7.	Analytical Techniques in Chemical Engineering	-	2	-	-	-	-	-	50	50	-	1	1
	Total	19	10	1	350	100	50	50	150	700	20	5	25

Total Credits

Sem - I = 25

Sem - II = 25

Grand Total = 50

ENGINEERING MATHEMATICS – I

TEACHING SCHEME

Lectures	:3 Hrs/week
Tutorial	:1 Hrs/week
Total	:4 Hrs/week
CREDIT	
Theory	:3
Tutorial	:1
Total	:4

EXAMINATION SCHEME

Theory	: 60 Marks
Unit Test	: 20 Marks
Attendance	: 10 Marks
Assignments	: 10 Marks
Total	: 100 Marks

Course Prerequisite

Students should have knowledge about

1. Matrix
2. Complex Numbers
3. Derivatives

Course Objectives

To develop an ability to use the mathematical techniques, skills and tools necessary for engineering practice.

Course Outcomes

At the end of this course, a student will be able to

1. solve the consistency of any type of system.
2. find the roots of equation, using DeMoivre's Theorem and to locate imaginary points using Argand Diagram.
3. apply Leibnitz rule to find n^{th} Derivative.
4. test Convergence and Divergence of infinite series.
5. compute a total derivative.
6. compute Maxima and Mininma of any functiion of two variables.

Unit-I
(8 Hours)

Matrices

Rank, Normal form, System of Linear Equations, Linear Dependence and Independence, Linear and Orthogonal Transformations, Eigen values, Eigen Vectors, Cayley – Hamilton Theorem, Application to problems in Engineering .

Unit-II
(8 Hours)

Complex Numbers and Applications

Definition, Cartesian, Polar and Exponential Forms ,Argand's Diagram, De'Moivre's theorem and its application to find roots of algebraic equations, Hyperbolic Functions, Logarithm of Complex Numbers, Separation into Real and Imaginary parts, Application to problems in Engineering.

Unit-III
(8 Hours)

Expansion of Functions and Differential Calculus

Differential Calculus : Successive Differentiation, n^{th} Derivatives of Standard Functions, Leibnitz's Theorem.

Expansion of Functions : Taylor's Series and Maclaurin's Series.

Unit-IV
(8 Hours)

Differential Calculus

Indeterminate Forms, L' Hospital's Rule, Evaluation of Limits.

Infinite Series

Infinite Sequences, Infinite Series, Alternating Series, Tests for Convergence, Absolute and Conditional Convergence, Power series, Range of Convergence.

Unit-V
(8 Hours)

Partial Differentiation and Applications

Partial Derivatives, Euler's Theorem on Homogeneous Functions, Implicit functions, Total Derivatives, Change of Independent Variables.

Errors and Approximations.

Unit-VI

(8 Hours)

Jacobian

Jacobians and their applications, Chain Rule, Functional Dependence.

Maxima and Minima

Maxima and Minima of Functions of two variables, Lagrange's method of undetermined multipliers.

Text Books

Applied Mathematics (Volumes I and II) by P.N. Wartikar and J.N. Wartikar, Pune Vidhyarthi Griha Prakashan, Pune 7th edition(1988).

Assignments

1. Rank , System of linear equations.
2. Complex Numbers.
3. Differential calculus and expansion of functions.
4. Indeterminate forms and infinite series.
5. Partial Derivatives, Euler's theorem on homogeneous functions.
6. Jacobians, Maxima and Minima of functions of two variables.

Reference Books

Advanced Engineering Mathematics by Peter V. O'Neil ,(Thomson Learning) 6th Edition (2007).

Advanced Engineering Mathematics, by M. D. Greenberg, (Pearson Education) 2nd Edition (2002).

Advanced Engineering Mathematics, by Erwin Kreyszig ,Wiley Eastern Ltd. 8th Edition (1999).

Higher Engineering Mathematics ,by B. S. Grewal ,(Khanna Publication, Delhi) 42nd Edition(2012).

Higher Engineering Mathematics , by B. V. Ramana, Tata McGraw- Hill, Edition(2012).

Syllabus for Unit Tests

Unit Test I	Unit I ,II & III
Unit Test II	Unit IV, V &VI

FUNDAMENTALS OF CIVIL ENGINEERING

TEACHING SCHEME

Lectures	: 3 Hrs/week
Practicals	: 2 Hrs/week
Total	: 5 Hrs/week

CREDITS

Theory	: 3
Practicals	: 1
Total	: 4

EXAMINATION SCHEME

Theory	: 60 Marks
Unit Test	: 20 Marks
Attendance	: 10 Marks
Assignments	: 10 Marks
Term work	: 25 Marks
Total	: 125Marks

Course Prerequisite

The Students should have the knowledge of

1.Concepts of units and conversions of units.
2.Basic knowledge of Chemistry
3.Basic knowledge of geography, concept of latitude and longitude.

Course Objective

To make students understand the scope and application of Civil Engineering

Course Outcomes

Students will be able to

1. Describe the scope of Civil Engineering and role of Civil Engineer in Construction project.
2. Explain use of surveying instruments for land survey .
3. Explain principles of building planning and bye laws.
4. Describe types of foundations and their stability.
5. Explain methods of irrigation, types of dams, canals, and water and sewage treatment process.
6. Describe the components of infrastructure like roads, railways, bridges and airports.

Unit-I
(6 Hours)

Civil Engineering scope and applications

Civil Engineering scope, importance and applications to other disciplines of Engineering; Civil Engineering construction process and role of Civil engineer; Government authorities related to Civil Engineering; Types of structures based on loading , material and configuration; Building components and their functions; Civil Engineering materials: concrete, construction steel, bricks, flooring material and tiles, paints, plywood , glass and aluminum.

Unit-II
(6 Hours)

Surveying

Objectives , Principles and Classification of Surveying; Linear ,angular ,Vertical and area Measurements and related instruments.

Unit-III
(6 Hours)

Building planning and Bye laws

Site selection for residential building; Principles of building planning; Building bye laws-necessity, Floor Space Index, Heights , open space requirements, set back distance , ventilation and lighting, concept of carpet and built up area, minimum areas and sizes for residential buildings ; Concept of Eco friendly structures and Intelligent buildings.

Unit-IV
(6 Hours)

Foundations and Earthquakes

Function of foundation, concept of bearing capacity and its estimation, types of foundation and its suitability, causes of failure of foundation.
Earthquakes causes, effects and guidelines for earthquake resistant design, earthquake zones .

Unit-IV
(6 Hours)

Foundations and Earthquakes

Function of foundation, concept of bearing capacity and its estimation, types of foundation and its suitability, causes of failure of foundation.
Earthquakes causes, effects and guidelines for earthquake resistant design, earthquake zones .

Unit-V
(6 Hours)

Irrigation and Water Supply

Rainfall measurement and its use in design of dams; Types of dams, canals, methods of irrigation and their merits and demerits; hydropower structures ;Water supply, drinking water requirements and its quality, water and sewage treatment flow chart.

Unit-VI
(6 Hours)

Jacobian

Roads- types of roads and their suitability, cross section of roads, meaning of terms ; width of roads, super elevation, camber, gradient ,sight distance, materials used for construction of roads.
Railways- Types of gauges, section of railway track, components of railway track, advantages.
Bridges : Components - Foundation , Piers, Bearings, Deck.
Airways- Components -Runway , Taxiway and Hangers.
Waterways: components- port, jetty, breakwater.

Practicals

(Following Exercises should be carried out.)

1. Study and use of prismatic compass and measurement of bearings.
2. Study and use of Dumpy level and reduction of levels by collimation plane method.
3. Area measurement by Digital Planimeter.
4. Drawing- plan and elevation of a residential bungalow.
5. Study of features of topographical maps.
6. Assignment on collection of information on Civil Engineering materials.
7. Assignment on types of foundations.
8. Assignment on unit 6.

Reference Books

1. Surveying Vol I - S.K. Duggal , Tata Mc Graw Hill Publication.
2. Built Environment – Shah , Kale, Patki, , Tata Mc Graw Hill Publication
3. Building Construction – Dr. B.C. punmia , Laxmi Publication
4. Irrigation and water Power Engineering , Dr. P.N. modi
5. Text book of transportation Engineering- Arora, Charotar Publishers.
6. Water supply and sanitary engineering-Rangawala, Charotar Publishers.
7. Assignment on types of foundations.
8. Assignment on unit 6.

Syllabus for Unit Tests

Unit Test I	Unit I ,II & III
Unit Test II	Unit IV, V &VI

ENGINEERING GRAPHICS

TEACHING SCHEME

Lectures	: 4 Hrs/week
Practicals	: 2 Hrs/week
Total	: 6 Hrs/week

CREDIT

Theory	: 4
Practical	: 1
Total	: 5

EXAMINATION SCHEME

Theory	: 60 Marks
Unit Test	: 20 Marks
Attendance	: 10 Marks
Assignment	: 10 Marks
Term Work	: 25 Marks
Total	: 125 Marks

Course Prerequisites

Students should have basic knowledge of fundamentals of drawing.

Course Objectives

To apply fundamental principles of Engineering Graphics.

Course Outcomes

At the end of this course, a student will be able to understand

1. Different engineering curves and dimensions.
2. Differentiate first angle and third angle projection method in orthographic.
3. To interpret views of object and to draw by using Isometric Projection Method.
4. Projection of lines and its traces.
5. Projection of different planes
6. Projection of solids and its sections.

Unit-I
(6 Hours)

Lines and Dimensioning in Engineering Drawing

Different types of lines used in drawing practice, Dimensioning – linear, angular, aligned system, unidirectional system, parallel dimensioning, chain dimensioning, location dimension and size dimension.

Unit-II
(6 Hours)

Curves used in Engineering Practice

Ellipse by Directrix-Focus method, Arcs of Circle method, Concentric circle method and Oblong method. Involute of a circle, Cycloid, Archimedean Spiral, Helix on cone, Loci of points- Slider Crank mechanisms.

Projections of Points and Lines and planes

Projections of points, projections of lines, lines inclined to one reference plane, Lines inclined to both reference planes. (Lines in First Quadrant Only) Traces of lines, Projections of Planes, Angle between two planes, Distance of a point from a given plane, Inclination of the plane with HP, VP.

Unit-III
(6 Hours)

Projection of Solids

Projection of prism, pyramid, cone and cylinder by rotation method.

Unit-IV
(6 Hours)

Section of Solids

Types of section planes, projections of solids cut by different sections of prism, pyramid, cone and cylinder.

Unit-V
(6 Hours)

Orthographic Projection

Basic principles of orthographic projection (First and Third angle method) . Orthographic projection of objects by first angle projection method only. Procedure for preparing scaled drawing, sectional views and types of cutting planes and their representation, hatching of sections.

Unit-VI
(6 Hours)

Isometric Projections

Isometric view, Isometric scale to draw Isometric projection, Non-Isometric lines, and construction of Isometric view from given orthographic views and to construct Isometric view of a Pyramid, Cone, Sphere.

Term work

- Term work shall consist of Seven half-imperial size or A2 size (594 mm x 420 mm) sheets.
- Assignment 05 Problems on each unit in A3 size Drawing Book.

Sheets

- Types of lines, Dimensioning practice, Free hand lettering, 1nd and 3rd angle methods symbol.
- Curves and loci of points
- Projections of Points and Lines and planes
- Projection of Solids
- Section of solids
- Orthographic Projections
- Isometric views

Text Books

1. "Elementary Engineering Drawing", N.D. Bhatt, Charotar Publishing house, Anand India
2. "Text Book on Engineering Drawing", K.L.Narayana&P.Kannaiah, Scitech Publications, Chennai.
3. "Fundamentals of Engineering Drawing", Warren J. Luzzader, Prentice Hall of India, New Delhi.
4. "Engineering Drawing and Graphics", Venugopal K., New Age International Publishers.
5. M. B. Shah and B. C. Rana, "Engineering Drawing", 1st Ed, Pearson Education, 2005
6. P. S. Gill, "Engineering Drawing (Geometrical Drawing)", 10 Edition, S. K. Kataria and Sons, 2005.
7. P. J. Shah, "Engineering Drawing", C. Jamnadas and Co., 1 Edition, 1988.

Syllabus For Unit Tests

Unit Test I	Unit I ,II & III
Unit Test II	Unit IV, V &VI

ENGINEERING PHYSICS

TEACHING SCHEME		EXAMINATION SCHEME	
Lectures	: 4 Hrs/week	Paper	: 60 Marks
Practicals	: 2 Hrs/week	Unit Test	: 20 Marks
Total	: 6 Hrs/week	Assignment	: 10 Marks
CREDITS		Attendance	: 10 Marks
Theory	: 4	Term Work	: 25 Marks
Practicals	: 1	Total	: 125 Marks
Total	: 5		

Course Prerequisite

The Student should have basic knowledge of kinematics, electrostatic, wave mechanics and dimensions along with good knowledge of calculus of Higher Secondary level of schooling.

Course Objective

After completing this course the students will able to apply knowledge of Engineering Physics to different branches of engineering for better conceptual clarity and exploring emerging fields of technology and research.

Course Outcomes

1. To use the properties of charged particles to develop modern instruments and explain the mechanism of fusion and fission.
2. To understand the basics of semiconductor and its uses to develop devices such as diode.
3. Students will be capable of applying knowledge of nanoscience to develop new electronic devices.
4. Students will be able to associate the wave nature of light and apply it to measure stress, pressure and dimension etc..
5. To discuss the concept of transverse waves.
6. To judge the problems associated with architectural acoustics and give their remedies and use ultrasonic as a tool in industry for Non Destructive Testing.
7. To understand the behavior of quantum particles in different types of potentials.

Unit-I
(8 Hours)

Modern Physics

Motion of a charged particle in electric and magnetic fields, Electrostatic and Magnetostatic focussing, Wavelength and resolution, Specimen limitation, Depth of field and focus, Electron microscope, Positive rays, Separation of isotopes by Bainbridge mass spectrograph.

Nuclear Physics

Nuclear fission, Liquid drop model of nucleus, Nuclear fission in natural uranium, Fission energy, Critical mass and size, Reproduction factor, Chain reaction and four factor formula, Nuclear fuel and power reactor, Nuclear fusion and thermonuclear reactions, Merits and demerits of nuclear energy, Particle accelerators, Cyclotron, Betatron.

Unit-II
(8 Hours)

Solid State Physics

Band theory of solids, Free electron theory, Fermi-Dirac probability function and position of Fermi level in intrinsic semi-conductors and in extrinsic semi-conductors (with derivation), Band structure of p-n junction diode under forward and reverse biasing, Conductivity in conductor and semi-conductor, Hall effect and Hall coefficient, Photovoltaic effect, Solar cell and its characteristics.

Superconductivity

Introduction, Properties of a super conductor, Meissner's effect, Critical field, Types of superconductors, BCS theory, High temperature superconductors, Application of superconductors.

Unit-III
(8 Hours)

Thermodynamics

Zeroth law of thermodynamics, first law of thermodynamics, determination of j by Joule's method, Applications of first law, heat engines, Carnot's cycle and Carnot's engine, second law of thermodynamics, entropy, change in entropy in reversible and irreversible processes, third law of thermodynamics.

Nanoscience

Introductions of nanoparticals, properties of nanoparticals (Optical, electrical, Magnetic, structural, mechanical), synthesis of nanoparticals(Physical and chemical), synthesis of colloids, growth of nanoparticals, synthesis of nanoparticals by colloidal route, applications.

Unit-IV (8 Hours)

Optics - I

Interference

Interference of waves, Visibility of fringes, interference due to thin film of uniform and non-uniform thickness, Newton's rings, Engineering applications of interference (optical flatness, non-reflecting coatings, multi-layer ARC).

Diffraction

Classes of diffraction, Diffraction at a single slit (Geometrical method), Conditions for maximum and minimum, Diffraction at a circular aperture (Result only), Plane diffraction grating, Conditions for principal maxima and minima, Rayleigh's criterion for resolution, Resolving power of grating and telescope.

Unit-V (8 Hours)

Polarisation

Introduction, Double refraction and Huygen's theory, Positive and negative crystals, Nicol prism, Dichroism, Polaroids, Elliptical and circular polarisation, Quarter and half wave plates, Production of polarised light, Analysis of polarised light, half shade polarimeter, LCD.

Lasers

Spontaneous and stimulated emission, Population inversion, Ruby laser, Helium-Neon laser, Semiconductor laser, Properties of lasers, Applications of lasers (Engineering/ industry, medicine, communication, Computers), Holography.

Unit-VI (8 Hours)

Architectural Acoustics

Elementary acoustics, Limits of audibility, Reverberation and reverberation time, Sabine's formula, Intensity level, Sound intensity level, Sound absorption, Sound absorption coefficient, different types of noise and their remedies, basic requirement for acoustically good hall, factors affecting the architectural acoustics and their remedies.

Quantum Mechanics

Wave nature of matter, De-Broglie waves, Wavelength of matter waves, Electron diffraction, Davisson and Germer's experiment, Physical significance of wave function, Schrodinger's time dependant and time independent wave equation, Application of Schrodinger's time independent wave equation to the problems of Particle in a rigid box and non rigid box.

Term-work :

Experiments

Any eight experiments from the following

1. Determination of band gap of semi-conductor.
2. Solar cell characteristics.
3. e/m by Thomson's method.
4. Uses of CRO for measurement of phase difference and Lissajous figures.
5. Hall effect and Hall coefficient.
6. Conductivity by four probe method.
7. Diode characteristics (Zener diode, Photo diode, LED, Ge/Si diode).
8. Plank's constant by photodiode.
9. Wavelength by diffraction grating.
10. Newton's rings.
11. Ultrasonic interferometer.
12. Sound intensity level measurement.
13. Wavelength of laser by diffraction.
14. Determination of refractive index for O-ray and E-ray.
15. Brewester's law.

Assignments

1. Recent advances in Nanotechnology
2. Nuclear radiation detectors.
3. Atomic force microscope (AFM).
4. Advanced opto-electronic devices.
5. Laser in Industry.
6. Different spectroscopic methods – a comparison (Raman, IR, UVR, etc.).

Text Books

1. Engineering Physics –Gaur and Gupta, Dhanpat Rai Publication
2. A text Book of Engineering Physics- M.N. Avadhanulu, P.G. Kshirsagar, S. Chand Technical

Reference Books

1. Physics for Engineers – Srinivasan M.R., New Age International Publication
2. Engineering Physics- K. Rajagopal, PHI
3. Electronics Principles – A.P.Molvino, Tata McGraw Hill
4. Fundamentals of Optics – Jenkins and White, McGraw Hill

Syllabus for Unit Tests

Unit Test I	Unit I ,II & III
Unit Test II	Unit IV, V &VI

CHEMICAL ENGINEERING MATERIALS

TEACHING SCHEME

Lectures	: 3Hrs/week
Total	: 3Hrs/week

CREDIT

Theory	:4
Total	:4

EXAMINATION SCHEME

Theory	: 60 Marks
Unit Test	: 20 Marks
Attendance	: 10 Marks
Assignment	: 10 Marks
Term Work	: 25 Marks
Total	: 125 Marks

Unit-I
(6 Hours)

Introduction

Materials and criteria for selection of material in process industries. Material properties: Mechanical, thermal, chemical, electrical, magnetic and technological properties, modification and control of material properties.

Unit-II
(6 Hours)

Metal and their alloys

A. Ferrous materials: Pure iron, cast iron, mild steel, stainless steels, special alloy steels- iron and iron carbide, phase diagram-heat treatment of plain-carbon steels.

B. Nonferrous materials: Lead, Tin, aluminium, zinc, nickel, copper , Magnesium and their alloys. Properties and applications in process industries.

Unit-III
(6 Hours)

Hydrocarbon materials

Natural & synthetic polymeric materials

Selection of polymeric materials for equipment linings, fiber reinforced plastic, application of special polymers like Nylon 66, Teflon in engineering. Polymer Composites and blends.

Paints, coatings and adhesives

Unit-III
(6 Hours)

Ceramic, glasses and cement

Definition of ceramics and glasses; interaction between structure, processing, and properties; Applications of ceramic and glass materials; Crystalline and non-crystalline ceramics, silicates, refractories, clays, glass vitreous silica, and borosilicate

Cement and its properties- special cements, cement concrete, RCC- Pre stressed concrete.

Unit-V (6 Hours)

Material failure analysis

Thermal and mechanical failures : Creep, stress, crystal structure and defects.
Chemical failure : Acid base environment, water, Corrosion: Corrosion attack methods, Different types of corrosion: chemical, biochemical, and electrochemical; Internal and external factors affecting corrosion of chemical equipments; corrosion charts for process equipments.

Unit-VI (6 Hours)

Material failure prevention

Property enhancement by electroplating, glass and ceramic linings, polymer lining, paints, coatings, alloy preparation, composite and blend formation.

Note : Term work comprises tutorials based on each unit

Text Books/ References

1. Budinsky K G and Budinsky K M "Engineering materials- Properties and Selection" Prentice Hall of India.
2. Henry R Clauster, "Industrial and Engineering materials" McGraw Hill Book Co.
3. James F. Shacketford, Introduction to Material Science, Mc-Millan Publishing Company, New-York.
4. D. Z. Jestrazebaski, Properties of Engineering Materials, 3rd Ed. Toppers. Co. Ltd.
5. J. L. Lee and Evans, Selecting Engineering Materials for Chemical and Process Plants, Business Works.

Syllabus For Unit Tests

Unit Test I	Unit I ,II & III
Unit Test II	Unit IV, V &VI

PROFESSIONAL SKILL DEVELOPMENT - I
ENGLISH COMMUNICATION

TEACHING SCHEME

Lectures	: 2 Hrs/week
Total	: 2 Hrs/week

CREDITS

Theory	: 2
Total	: 2

EXAMINATION SCHEME

Theory	: 50 Marks
Total	: 50 Marks

Unit I: (5 hours)

Essential Grammar

Tenses: Basic forms and use, sentence formation (general & Technical), Common errors, Parts of speech through context, Direct and reported speech structures and voices.

Unit II: (2 hours)

Vocabulary Enrichment

Exposure to words from General Service List (GSL) by West, Academic word list (AWL) specific technical terms related to the field of technology. Phrases, idioms, significant abbreviations, formal (business) vocabulary.

Unit III: (3 hours)

Written Communication I

Letter Writing – Formal and Informal letter writing, Application letters, Report Writing-Academic and Business reports, Job application letter.

Unit IV: (2 hours)

Phonetics

Pronunciation, Reduction of MTI in spoken English, Question formation with emphasis on common errors made during conversation.

SOFT SKILLS

Unit I: (3 hours)

Communication Skill

a) Importance of effective communication, types of communication- verbal and non verbal, barriers of communication, effective communication

b) Listening Skills: Law of nature- Importance of listening skills, difference between listening and hearing, Types of listening.

Unit II: (3 hours)

Self Awareness & Self Development

a) Self Assessment, Self Appraisal, SWOT, Goal setting - Personal & career - Self-Assessment, Self-Awareness, Perceptions and Attitudes, Positive Attitude, Values and Belief Systems, Self-Esteem, Self appraisal, Personal Goal setting,

b) Career Planning, Personal success factors, Handling failure, Depression and Habit, relating SWOT analysis & goal setting, prioritization.

Unit III: (4 hours)

Interpersonal Relationship

Team work, Team effectiveness, Group discussion, Decision making - Team Communication. Team, Conflict Resolution, Team Goal Setting, Team Motivation Understanding Team Development, Team Problem Solving, Building the team dynamics. Multicultural team activity.

Unit IV: (2 hours)

Time Management

The Time management matrix, apply the Pareto Principle (80/20 Rule) to time management issues, to prioritize using decision matrices, to beat the most common time wasters, how to plan ahead, how to handle interruptions , to maximize your personal effectiveness, how to say “no” to Time wasters.

WORKSHOP TECHNOLOGY

TEACHING SCHEME

Practicals	: 2 Hrs/week
Total	: 2 Hrs/week

CREDITS

Practical	: 1
Total	: 1

EXAMINATION SCHEME

Term Work	: 50 Marks
Total	: 50 Marks

Course Objectives

Introduction to different materials in engineering practices with respect to their workability, formability & machinability with hand tools & power tools and to develop skills through hands on experience. Special; emphasis shall be given to Safety in Workshop - Fire hazards, electric short circuit –causes and remedies, Machine protection, Human protection, Accident prevention methods, developing ability to observe safe working habits.

Term work shall consist of any three jobs, demonstrations on rest of the trades and journal consisting of six assignments one on each of the following topics.

Course Outcomes

At the end of this course, students should be able to understand

1. Basic Manufacturing Processes used in the industry,
2. Importance of safety.
3. Electrical circuit making.

Carpentry

Introduction to wood working, kinds of woods, hand tools & machines, Types of joints, wood turning. Pattern making, types of patterns, contraction, draft & machining allowances Term work includes one job involving joint and woodturning.

Fitting

Types of Fits, concepts of interchangeability, datum selection, location layout, marking, cutting, shearing, chipping, sizing of metals, drilling and tapping. Term work to include one job involving fitting to size, male-female fitting with drilling and tapping.

Sheet Metal Practice

Introduction to primary technology processes involving bending, punching and drawing various sheet metal joints, development of joints.

Joining

Includes making temporary and permanent joints between similar and dissimilar material by processes of chemical bonding, mechanical fasteners and fusion technologies. Term work includes one job involving various joining processes like riveting, joining of plastics, welding, brazing, etc.

Forging

Hot working, cold working processes, forging materials, hand tools & appliances, Hand forging, Power Forging.

Moulding

Principles of moulding, methods, core & core boxes, preparation of foundry sand, casting, Plastic moulding.

Electrical Board Wiring
(Demonstration Common for Electrical & Non electrical Group)

Electric power utilization, energy audit, Types of wiring - House wiring, stair case wiring, two-way switch wiring, Types of fuses and their uses, circuit breaker, Three phase wiring for electrical motors, earthing, minor fault finding.

Plumbing (Demonstration Common for Electrical & Non electrical Group)

Types of pipe joints, threading dies, Pipe fittings.

ENGINEERING MATHEMATICS – II

TEACHING SCHEME

Lectures	:3 Hrs/week
Tutorial	:1 Hrs/week
Total	:4 Hrs/week

CREDIT

Theory	:3
Tutorial	:1
Total	:4

EXAMINATION SCHEME

Theory	: 60 Marks
Unit Test	: 20 Marks
Attendance	: 10 Marks
Assignment	: 10 Marks
Total	: 100 Marks

Course Prerequisite

Students should have basic knowledge about

1. Derivatives
2. Integration

Course Objectives

To develop an ability to use the mathematical techniques, skills and tools necessary for engineering practice.

Course Outcomes

At the end of this course, a student will be able to

1. solve the differential equations of first order and first degree.
2. form mathemtical model of rectilinear motion , electric circuit , fourier heat conduction, newton's law of cooling.
3. represent periodic function as fourier series.
4. evaluate definite Integral by DUIS Rule and to trace cartesian and polar curves.
5. transform the cartesian coordinates into spherical polar and cylindrical coordinate systems.
6. apply methods to find area and volume by double and triple integration.

Unit-I (8 Hours)

Differential Equations (DE)

Definition, Order and Degree of DE, Formation of DE, Solutions of Variable Separable DE, Exact DE, Linear DE and reducible to these types

Unit-II (8 Hours)

Application of Differential Equations

Applications of DE to Orthogonal Trajectories, Newton's Law of Cooling, Kirchoff's Law of Electrical Circuits, Motion under Gravity, Rectilinear Motion, Simple Harmonic Motion, One–Dimensional Conduction of Heat, Chemical engineering problems

Unit-III (8 Hours)

Fourier Series

Definition, Dirichlet's conditions, Fourier Series and Half Range Fourier Series, Harmonic Analysis.

Integral Calculus

Reduction formulae, Beta and Gamma functions.

Unit-IV (8 Hours)

Integral Calculus

Differentiation Under the Integral Sign, Error functions

Curve Tracing

Tracing of Curves, Cartesian, Polar and Parametric Curves. Rectification of Curves.

Unit-V (8 Hours)

Solid Geometry

Cartesian, Spherical Polar and Cylindrical Coordinate Systems. Sphere, Cone and

Unit-VI (8 Hours)

Multiple Integrals and their Applications

Double and Triple integrations, Applications to Area, Volume, Mean and Root Mean Square Values.

Assignments

1.Differential equations.
2.Aplication of differential equations.
3.Fourier series and Integral calculus.
4.DUIS and curve tracing.
5.Solid geometry.
6.Double and triple integrations, area and volume.

Text Books

Applied Mathematics (Volumes I and II) by P.N. Wartikar and J.N. Wartikar, Pune Vidhyarthi Griha Prakashan, Pune 7th edition(1988).

Reference Books

Higher Engineering Mathematics ,by B. S. Grewal ,(Khanna Publication, Delhi) 42nd Edition(2012).
Higher Engineering Mathematics , by B. V. Ramana, Tata McGraw- Hill, Edition(2012).
Advanced Engineering Mathematics by Peter V. O'Neil ,(Thomson Learning) 6th Edition (2007).
Advanced Engineering Mathematics, by M. D. Greenberg, (Pearson Education) 2nd Edition (2002).
Advanced Engineering Mathematics, by Erwin Kreyszig ,Wiley Eastern Ltd. 8th Edition (1999).

Syllabus for Unit Tests

Unit Test I	Unit I ,II & III
Unit Test II	Unit IV, V &VI

FUNDAMENTALS OF MECHANICAL ENGINEERING

TEACHING SCHEME

Lectures	: 3 Hrs/week
Practicals	: 2 Hrs/week
Total	: 5 Hrs/week

CREDIT

Theory	: 3
Practical	: 1
Total	: 4

EXAMINATION SCHEME

Theory	: 60 Marks
Unit Test	: 20 Marks
Attendance	: 10 Marks
Assignment	: 10 Marks
Term Work	: 25 Marks
Total	: 125 Marks

Course Prerequisites

Students should have the basic knowledge of Thermal Science.

Course Objectives

Students will get the basic knowledge of Mechanical Engineering systems.

Course Outcomes

At the end of this course, a student will be able to understand

1. the fundamentals of thermal engineering.
2. working of power producing and absorbing devices.
3. different energy sources and fundamental laws of heat transfer.
4. the basic properties of fluids and materials.
5. the different mechanical devices and mechanisms.
6. machine tools and manufacturing processes.

Unit-I

(8 Hours)

Thermodynamics

Heat, work and Internal Energy, Thermodynamic State, Process, Cycle, Thermodynamic System, First Law of Thermodynamics, Application of First Law to steady Flow and Non Flow processes, Limitations of First Law, PMM of first kind (Numerical Treatment), Second Law of Thermodynamics – Statements, Carnot Engine and Carnot Refrigerator, PMM of Second Kind (Elementary treatment only).

Unit-II

(8 Hours)

Introduction to I.C. Engines and turbines

Two stroke, Four Stroke Cycles, Construction and Working of C.I. and S.I. Engines, Hydraulic turbines, steam turbines, gas turbines.(Theoretical study using schematic diagrams)

Introduction to refrigeration, compressors & pumps

Vapor compression and vapor absorption system, house hold refrigerator, window air conditioner. Reciprocating and rotary compressor, Reciprocating and centrifugal pump. (Theoretical study using schematic diagrams)

Unit-III

(8 Hours)

Energy Sources

Renewable and nonrenewable, solar flat plate collector, Wind, Geothermal, Wave, Tidal, Hydro power, Bio-gas, Bio-Diesel, Nuclear power.

Heat transfer

Statement and explanation of Fourier's law of heat conduction, Newton's law of cooling, Stefan Boltzmann's law. Conducting and insulating materials and their properties, types of heat exchangers and their applications.

Unit-IV (8 Hours)

Properties of fluids

Introduction, Units of measurements, mass density, specific weight, specific volume and relative density, viscosity, pressure, compressibility and elasticity, gas laws, vapor pressure, surface tension and capillarity, regimes in fluid mechanics, fluid properties and analysis of fluid flow.

Properties of Materials and their Applications

Metals – Ferrous and Non-Ferrous, Nonmetallic materials, smart materials, Material selection criteria.

Unit-V (8 Hours)

Mechanical devices

Types of Belts and belt drives, Chain drive, Types of gears, Types of Couplings, friction clutch (cone and plate), brakes, Power transmission shafts, axles, keys, bush and ball bearings.

Mechanisms

Slider crank mechanism, Four bar chain mechanism, List of various inversions of Four bar chain mechanism, Geneva mechanism, Ratchet and Paul mechanism.

Unit-VI (8 Hours)

Machine Tools

Lathe Machine – Centre Lathe, Drilling Machine – Study of Pillar drilling machine, Introduction to NC and CNC machines, Grinding machine, Power saw, Milling Machine.

Introduction to manufacturing processes and Their Applications

Casting, Sheet metal forming, Sheet metal cutting, Forging, Fabrication, Metal joining processes

List of experiments:

The Term Work shall consist of any Eight experiments of following list

1 Measurement of viscosity using Redwood viscometer.
2 Assembly and working of 4-bar, 6-bar, 8-bar planer mechanisms
3 Finding relation between input angle and output angle for various link lengths.
4 Study of domestic refrigerator & window air-conditioner
5 Demonstration of operations of centre lathe
6 Demonstration of operations on drilling machines
7 Demonstration of Two stroke and four stroke engine
8 Study of power transmitting elements: Coupling, Gears and bearings
9 Demonstration of pumps and compressor
10 Study and demonstration of different types of clutches.

References

1 Thermodynamics An Engineering Approach: Yunus A. Cengel and Michael A. Boles,McGraw-Hill, Inc,2005,6th edition.
2 Applied Thermodynamics for Engineering Technologists: T. D. Eastop and A. McConkey, 5th Edition, Prentice Hall.
3. I.C. Engines Fundamentals: J. B. Heywood, McGraw Hill, 3rd Edition, MacMillian
4 I.C.Engine : V.Ganeshan,Tata McGraw-Hill, 3rd edition.
5 Strength of Materials: H. Ryder, Macmillians, London, 1969, 3rd edition.
6 Mechanics of Materials: Johston and Beer TMH, 5th edition
7 Mechanisms and Machine Theory: Ambekar A.G., Prentice-Hall of India, 2007.
8 Theory of Machines: S S Rattan, Tata McGraw- Hill, 2nd edition.
9 A Textbook of production engineering: P.C. Sharma, S. Chand Publication, New Delhi, 2nd edition.
10 Fluid Mechanics & Fluid Power: D.S. Kumar, Katson Publishing Engineering House, Ludhiana. 8th edition

Syllabus for Unit Tests

Unit Test I	Unit I ,II & III
Unit Test II	Unit IV, V &VI

ENGINEERING MECHANICS

TEACHING SCHEME		**EXAMINATION SCHEME**	
Lectures	: 4 Hrs/week	Theory	: 60 Marks
Practicals	: 2 Hrs/week	Unit Test	: 20 Marks
Total	: 6 Hrs/week	Attendance	: 10 Marks
CREDIT		Assignment	: 10 Marks
Theory	: 4	Term Work	: 25 Marks
Practical	: 1	Total	: 125 Marks
Total	: 5		

Course Prerequisites

The Students should have knowledge of

1. Scalar and Vector
2. Newton's law of motion
3. Law of friction
4. Concept of physical quantities, their units and conversion of units
5. Concept of differentiation and integration

Course Objectives

To develop and apply the concept of resultant and equilibrium for various static and dynamic engineering problems.

Course Outcomes

At the end of this course, a student will be able to understand

1. calculate resultant and apply conditions of equilibrium.
2. analyze the truss and calculate friction force.
3. calculate centroid and moment of inertia.
4. solve problem on rectilinear motion.
5. solve problems on curvilinear motion.
6. use D'Alembert's principle, Work Energy principle and Impulse Momentum principle for particle.

Unit-I
(8 Hours)

Resultant and Equilibrium

Types and Resolution of forces, Moment and Couple, Free Body Diagram, Types of Supports, Classification and Resultant of a force system in a Plane - Analytical and Graphical approach..
Equilibrant, Conditions of Equilibrium, Equilibrium of a force system in a Plane, Force and Couple system about a point.

Unit-II
(8 Hours)

Truss and Friction

Coefficient of Static Friction, Impending motion of Blocks, Ladders and Belts.
Analysis of Perfect Trusses - Method of Joint, Method of Section and Graphical Method.

Unit-III
(8 Hours)

Centroid and Moment of Inertia

Centroid of line and plane areas, Moment of Inertia of plane areas, parallel and perpendicular axis theorem, radius of gyration, least moment of inertia.

Unit-IV
(8 Hours)

Kinematics of Rectilinear motion of a Particle

Equations of motion, Constant and variable acceleration, Motion Curves, Relative motion, Dependent motion.
Farady's law of electromagnetic induction, statically and dynamically induced emf, self inductance, mutual inductance, coefficient of coupling,
Single phase transformer construction, principle of operation, EMF equation, voltage ratio, current ratio, kVA rating, losses in transformer, Determination of Efficiency & Regulation by direct load test.

Unit-V
(8 Hours)

Kinematics of Curvilinear motion of a Particle

Motion of a Projectile, Cartesian components, Normal and Tangential components of a curvilinear motion.
Farady's law of electromagnetic induction, statically and dynamically induced emf, self inductance, mutual inductance, coefficient of coupling,
Single phase transformer construction, principle of operation, EMF equation, voltage ratio, current ratio, kVA rating, losses in transformer, Determination of Efficiency & Regulation by direct load test.

Unit-VI

(8 Hours)

Kinetics of a Particle

D'Alemberts Principle, Work-Energy Principle and Impulse-Momentum Principle, Coefficient of Restitution, Direct Central Impact.

Practicals

A) The term-work shall consist of minimum Five experiments from list below.

1. Determination of reactions of Simple and Compound beam.
2. Study of equilibrium of concurrent force system in a plane.
3. Determination of coefficient of friction for Flat Belt.
4. Determination of coefficient of friction for Rope.
5. Study of Curvilinear motion.
6. Determination of Coefficient of Restitution.

B)The term-work shall also consist of minimum Five graphical solutions of the problems on different topics.

Reference Books

1. Beer F.P. and Johnston E.R., "Vector Mechanics for Engineers-Vol.-I and Vol.-II (Statics and Dynamics)", Tata McGraw Hill Publication.
2. Hibbeler R.C., "Engineering Mechanics (Statics and Dynamics)", McMillan Publication.
3. Shames I.H., "Engineering Mechanics (Statics and Dynamics)", Prentice Hall of India (P) Ltd.
4. Singer F.L., "Engineering Mechanics (Statics and Dynamics)", Harper and Row Publication.
5. Meriam J.L. and Kraige L.G., "Engineering Mechanics (Statics and Dynamics)", John Wiley and Sons Publication.
6. Timoshenko S.P. and Young D.H., "Engineering Mechanics (Statics and Dynamics)", McGraw Hill Publication.
7. Bhavikatti S.S. and Rajashekarappa K.G., "Engineering Mechanics", New Age International (P) Ltd.
8. Tayal A.K., "Engineering Mechanics (Statics and Dynamics)", Umesh Publication.
9. Mokashi V.S., "Engineering Mechanics-I and II (Statics and Dynamics)", Tata McGraw Hill Publication.

Syllabus for Unit Tests

Unit Test I	Unit I ,II & III
Unit Test II	Unit IV, V &VI

ENGINEERING CHEMISTRY

TEACHING SCHEME

Theory	:	4 Hrs/week
Practicals	:	2 Hrs/week
Total	:	6 Hrs/week

CREDITS

Theory	: 4
Practical	: 1
Total	: 5

EXAMINATION SCHEME

Theory	:	60 Marks
Term Work	:	25 Marks
Unit Test	:	20 Marks
Assignments	:	10 Marks
Attendance	:	10 Marks
Total	:	125 Marks

Course Prerequisites

Students should have basic knowledge of

Industrial use of water, crystal structure, fuels, corrosion, electrochemical cell and structure of organic molecules at Higher Secondary level of schooling.

Course Objectives

After completing this course the students will able to apply knowledge of Engineering Chemistry to different branches of engineering for better conceptual clarity and exploring emerging fields of technology and research.

Course Outcomes

At the end of this course, a student will be able to

1. Analyze the methods involved in improving quality of water for domestic and industrial purposes.
2. Express the crystal structure through X-ray diffraction technique to examine the internal structure of crystal.
3. Demonstrate the properties and applications of fossil fuels and derived fuels.
4. Define the fundamental principles of corrosion and methods used for minimizing corrosion.
5. Interpret the basic concepts of electrochemical techniques and its applications in society.
6. Develop the skills for correct stereo chemical assignment and interpretation in complex organic molecules.

Unit-I (8 Hours)

Water

Introduction, Hardness of water, Effect of hard water on boilers and heat exchangers: a) boiler corrosion b) caustic embrittlement c) scales and sludges d) priming and foaming Water softening methods for industrial purposes :a) Zeolite process b) Phosphate conditioning , Numerical based on the zeolite process.

Unit-II (8 Hours)

Material Chemistry

Crystallography

Unit cell, Laws of crystallography, Weiss indices and Miller indices, Crystal defects (point and line defects), X-ray diffraction – Bragg's Law and numericals.

Cement

Introduction of cement, Hydraulic/ Non-hydraulic cementing materials, classification of cement, chemistry of portland cement, chemical composition and compound constituents of portland cement, properties of cement and its applications.

Unit-III (8 Hours)

Fuels

Introduction, classification of fuels, calorific value of fuels, NCV and GCV, Determination of calorific values using Bomb calorimeter and Boys' gas calorimeter.
Theoretical calculation of calorific value of a fuel, Analysis of coal a) Proximate b) Ultimate analysis of coal, Numericals based on NCV, GCV.

Unit-IV (8 Hours)

Corrosion and its Prevention

Corrosion : Definition, atmospheric corrosion-mechanism, Wet corrosion-mechanism, Electrochemical and galvanic series, Factors affecting corrosion-nature of metal, nature of environment.
Methods of prevention of corrosion : Cathodic and Anodic protection, Metallic coatings, Electroplating, Hot dipping.

Unit-V

(8 Hours)

Electrochemistry

Introduction, Arrhenius Ionic theory, Kohlrausch's law of independent migration of ions Laws of electrolysis: Faradays Laws, Ostwald's dilution law, Acids and Bases, concept of pH and pOH, Buffer solutions, Solubility Product, Redox Reactions.
Electrode Potential, electrochemical cell, concentration cell, reference Electrodes, Overvoltage, Conductometric Titrations, Fuel cells, Lead Acid Storage Cell and numericals based on the above articles.

Unit-VI

(8 Hours)

Stereochemistry

Introduction, chirality, optical activity, Enantiomers, Diastereomers, projection formula of tetrahedral carbon- Newman projection, Wedge projection, Fischer projection,
Geometrical isomerism : cis and trans isomerism, E and Z isomers
Optical isomerism : Mesoform, the number of optical isomers for chiral molecules,
Conformations : conformations of ethane, conformations of n-butane

Term work

Practicals

Any Eight experiments from the following

1. Estimation of hardness of water by EDTA method.
2. Estimation of chlorine by Mohr's method.
3. Determination of percentage of Ca in given cement sample
4. Determination of coefficient of viscosity by Ostwald's viscometer.
5. Study of Bomb calorimeter for determination of calorific value.
6. Determination of calorific value of gas fuel by using Boy's gas calorimeter.
7. Determination of dissolved oxygen in a water sample.
8. To determine the Molecular Weight of polymer.
9. Estimation of Copper from brass sample solution by Iodometrically.
10. Estimation of percentage of Iron in Plain Carbon Steel by Volumetric Method.
11. To standardize NaOH solution and hence find out the strength of given hydrochloric Acid solution .
12. To determine Surface Tension of given liquid by Stalagmometer.
13. Study of corrosion of metals in medium of different pH.
14. To set up Daniel cell.
15. To determine pH of soil .
16. To determine Acidity of soil.

Assignments

1. Effect of hard water on boilers and heat exchangers
2. Hydraulic/ Non-hydraulic cementing materials
3. Analysis of coal a) Proximate b) ultimate analysis of coal
4. Wet corrosion-mechanism, Electroplating, Hot dipping
5. Geometrical isomerism :- cis and trans isomerism, E and Z isomers
6. Fuel cells

References / Text Books

1. Engineering Chemistry by Jain and Jain, Dhanpat Rai Company (P) Ltd, New Delhi.
2. Chemistry of Engineering Materials, Agarwal C.V, Rata Publication Varanasi, 6th edition (1979)
3. Chemistry in Engineering and Technology, Volume W, Tata McGraw Hill Publishing Company Ltd, New Delhi (1988)
4. Applied Chemistry, O. P. Vidyankar, J. Publications, Madurai, (1955)
5. Engineering Chemistry, S. N. Chand and Co., Jalandhar, 31st Edition (1990)
6. Engineering Chemistry by Dara S. S. Chand Publications
7. Fundamentals of Electrochemistry, V. S. Bagotsky (Ed) Wiley NY (2006)

Syllabus for Unit Tests

Unit Test I	Unit I ,II & III
Unit Test II	Unit IV, V &VI

FUNDAMENTALS OF ELECTRICAL ENGINEERING

TEACHING SCHEME

Lectures	: 3 Hrs/week
Practicals	: 2 Hrs/week
Total	: 5 Hrs/week

CREDITS

Theory	: 3
Term Work	: 1
Total	: 4

EXAMINATION SCHEME

Theory	: 60 Marks
Unit Test	: 20 Marks
Attendance	: 10 Marks
Assignments	: 10 Marks
Term work	: 25 Marks
Total	:125 Marks

Course Pre-requisites :

The Students should have basic knowledge about

1. Mathematics
2. Physics

Course Objectives :

The course introduces fundamental concepts of DC and AC circuits, electromagnetism, transformer and measuring instruments to all first year Engineering students.

Course Outcomes:

1. Understand and apply knowledge of basic concepts of work, power, energy for electrical, mechanical and thermal systems.
2. Understand and apply knowledge of Kirchoff's laws and network theorems to solve electrical networks.
3. Describe construction, principle of operation, specifications and applications of capacitors and batteries.
4. Describe and apply fundamental concepts of magnetic and electromagnetic circuits for operation of single phase transformer.
5. Define basic terms of single phase and three phase ac circuits and supply systems.
6. Know and use electrical safety rules.

Unit-I
(6 Hours)

Basic concepts

Concept of EMF, Potential Difference, current, resistance, Ohms law, resistance temperature coefficient, SI units of Work, power, energy. Conversion of energy from one form to another in electrical, mechanical and thermal systems

Unit-II
(6 Hours)

Network Theorem

Voltage source and current sources, ideal and practical, Kirchoff's laws and applications to network solutions using mesh analysis, Simplifications of networks using series-parallel, Star/Delta transformation. Superposition theorem, Thevenin's theorem, Max Power Transfer theorem.

Unit-III
(6 Hours)

Electrostatics

Electrostatic field, electric field intensity, electric field strength, absolute permittivity, relative permittivity, capacitor composite, dielectric capacitors, capacitors in series& parallel, energy stored in capacitors, charging and discharging of capacitors, Batteries-Types, Construction& working.

Unit-IV
(6 Hours)

Magnetic Circuit & Transformer

Magnetic effect of electric current, cross and dot convention, right hand thumb rule, concept of flux, flux linkages, Flux Density, Magnetic field, magnetic field strength, magnetic field intensity, absolute permeability, relative permeability, B-H curve, hysteresis loop, series-parallel magnetic circuit, composite magnetic circuit, Comparison of electrical and magnetic circuit

Farady's law of electromagnetic induction, statically and dynamically induced emf, self inductance, mutual inductance, coefficient of coupling,

Single phase transformer construction, principle of operation, EMF equation, voltage ratio, current ratio, kVA rating, losses in transformer, Determination of Efficiency & Regulation by direct load test.

Unit-V (6 Hours)

AC Fundamentals & AC Circuits

AC waveform definitions , form factor, peak factor, study of R-L, R-C, RLC series circuit, R-L-C parallel circuit, phasor representation in polar & rectangular form, concept of impedance, admittance, active, reactive, apparent and complex power, power factor, 3-ph AC Circuits.

Unit-VI (6 Hours)

Electrical Wiring and Illumination system

Basic layout of distribution system, Types of Wiring System & Wiring Accessories, Necessity of earthing, Types of earthing, Different types of lamps (Incandescent, Fluorescent, Sodium Vapour, Mercury Vapour, Metal Halide, CFL, LED) , Study of Electricity bill.

Term-work :

The term work shall consist of record of minimum eight exercises / experiments.

List of Experiments

1. Determination of resistance temperature coefficient
2. Verification of Superposition Theorem
3. Verification of Thevenin's Theorem
4. Verification of Kirchoff's Laws
5. Verification of Maximum power transfer Theorem
6. Time response of RC circuit
7. Study of R-L-C series circuits for XL> XC , XL< XC & XL= XC
8. Verification of current relations in three phase balanced star and delta connected loads.
9. Direct loading test on Single phase transformer
   a)Voltage and current ratios.
   b) Efficiency and regulations .
10. Study of a Residential (L.T.) Bill

Reference Books

1. A Textbook of Electrical Technology Volume- I – B.L.Theraja, S.Chand and Company Ltd., New Delhi.
2. . Basic Electrical Engineering, V. K. Mehta, S. Chand and Company Ltd., New Delhi.
3. Electrical Engineering- G. K. Mittal
4. Theory and problems of Basic Electrical Engineering- I. J. Nagrath and Kothari, Prentice Hall of India Pvt. Ltd.
5. Electrical Technology- Edward Hughes, Seventh Edition, Pearson Education
6. Elements of Electrical Technology- H. Cotton, C.B.S. Publications
7. Basic circuits analysis by John Omalley Shawn Mc Graw Hill.
8. Principles of Electrical Engineering by Del. Toro, PHI

Syllabus for Unit Tests

Unit Test I	Unit I ,II & III
Unit Test II	Unit IV, V &VI

PROFESSIONAL SKILL DEVELOPMENT - II

ENGLISH COMMUNICATION

TEACHING SCHEME

Lectures	: 2 Hrs/week
Total	: 2 Hrs/week

EXAMINATION SCHEME

Theory	: 50 Marks
Total	: 50 Marks

CREDITS

Theory	: 2
Total	: 2

Unit I: (4 hours)

Essential Grammar II

Application of tenses, Auxiliaries- correct usage and importance in formal communication, Business Vocabulary - Vocabulary exercises through web-based applications

Unit II: (4 hours)

Written Communication II

Email writing- Formal and Informal email writing structure, Inquiry letters, Instruction letters, complaint letters, Routine business letters, Sales Letters etc. Technical writing, Essay writing, Paragraph writing.

Unit III: (2 hours)

Vocabulary Application

Vocabulary exercises through web-based applications, Usage and application through

Unit IV: (2 hours)

Situational Conversation

Application of grammar and correct spoken English according to context/ situation and application in business scenario.

SOFT SKILLS

Unit I: (3 hours)

Fundamentals Of Effective Communication

Public Speaking: fundamentals of effective public speaking, types- Extempore speech, manuscript speech, and ways to enhance public speaking skills, storytelling, oral review

Unit II: (3 hours)

Presentation Skills

PowerPoint presentations, Effective ways to structure the presentation, importance of body language.

Unit III: (3 hours)

Leadership Skills, Leader's Role, Responsibilities And Skill Required

Understanding good Leadership behaviors, Learning the difference between Leadership and Management, Gaining insight into your Patterns, Beliefs and Rules, Defining Qualities and Strengths of leadership, Determining how well you perceive what's going on around you, interpersonal Skills and Communication Skills, Learning about Commitment and How to Move Things Forward, Making Key Decisions, Handling Your and Other People's Stress, Empowering, Motivating and Inspiring Others, Leading by example, effective feedback.

Unit VI: (2 hours)

Problem Solving Skill

Problem solving skill, Confidence building

Unit V:

(4 hours)

Corporate / Business Etiquettes

Corporate grooming & dressing, etiquettes in social & office setting-Understand the importance of professional behavior at the work place, Understand and Implement etiquettes in workplace, presenting oneself with finesse and making others comfortable in a business setting. Importance of first impression, Grooming, Wardrobe, Introduction to Ethics in engineering and ethical reasoning, rights and responsibilities

ANALYTICAL TECHNIQUES IN CHEMICAL ENGINEERING

TEACHING SCHEME

Practicals	: 2 Hrs/week
Total	: 2 Hrs/week
CREDITS	
Practical	: 1
Total	: 1

EXAMINATION SCHEME

Term Work	: 50 Marks
Total	: 50 Marks

Minimum eight practicals should be conducted from the list given below

I. Standardization

1. To prepare standard alkaline and acidic solutions.

II. Normality/ Molarity/ Molality Concepts

1. Find the strength of given alkaline solution using acidic solution or vice versa.
2. Preparation of solutions for given normality/ molarity/ molality

III. Water Analysis

1. To determine free CO2 in the given water Sample.
2. Determination of Dissolved oxygen in the given water sample.
3. To determine Acidity of a given water sample.
4. To determine alkalinity of a given water sample.

IV. Fuel Analysis

1. Determination of octane/cetane number
2. Determination of kinematic viscosity
3. Determination of calorific value
4. Determination of moisture content
5. Ultimate/proximate analysis of solid fuel

References

1. Practical organic chemistry, Arthur I. Vogel, Longman publication
2. Experiments in applied chemistry, Sunita Rattan, S. K. Kataria & Sons

RULES REGARDING ATKT, CONTINUOUS ASSESSMENT AND AWARD OF CLASS

Standards of Passing and ATKT Rules:

1. For all courses, both UE(University Evaluation) and IA(Internal Assesment) constitue 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 course is atleast 6.0 (50 % of aggregate). The GPA for a course will be calculated only if the learner passes at the UE.
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 backlog candidate and clear the HoP.

Rules of ATKT:

1. A student is allowed to carry backlog of courses prescribed for B. Tech. Sem - I, III , V , VII to B.Tech. Sem-II, IV , VI , VIII respectively.
2. A student is allowed to keep term of Sem-III , if he/she is failing in any number of subjects of Sem - I & II.
3. A student is allowed to keep term of Sem-V , if he/she is failing in any number of subjects of Sem - III & IV but passed in all subjects of Sem- I & II.
4. A student is allowed to keep term of Sem-VII , if he/she is failing in any number of subjects of Sem - V & VI but passed in all subjects of Sem-III & IV.

Award of Class for the Degree Considering CGPA:

Award of Honours:

A student who has completed the minimum credits specified for the programme 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 at the End of the Programme are as given below.

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

Vision

To provide quality chemical engineers for the growth and development of the nation.

Mission

Nurture students into dynamic chemical engineers for societal progress

Programme Educational Objectives (PEOs)

A. Practice chemical engineering in conventional, multidisciplinary and emerging fields.

B. Pursue advanced studies or other forms of continuing education.

C. Demonstrate professionalism, ethical and social responsibility and desire for lifelong learning.

Programme outcomes (POs)

A chemical engineering graduate will be able to

1. Apply knowledge of mathematics, science and engineering principles to solve wide range of open ended chemical engineering problems.
2. Analyze the problem and give feasible solutions using fundamentals of mathematics, basic sciences and engineering sciences.
3. Design chemical process equipments and processes to meet desired needs with realistic constraints.
4. Conduct engineering experiments to analyze and interpret the information obtained from the experiment to synthesis and design valid conclusions.
5. Utilize the techniques, analytical skills and modern computational tools necessary for successful chemical engineering practice.
6. Develop the culture of health and safety in chemical engineering practice by adhering to statutory regulations.
7. Understand the impact of chemical engineering solution in a techno-economic, environmental and societal context for sustainable development.

8. Understand the need for ethical decision making in engineering practice.
9. Function effectively as an individual and as a member or leader within multi disciplinary teams.
10. Express ideas and position clearly and concisely in both oral and in written communication.
11. Understand the fundamental precept of effective project management and finance.
12. Appreciate the need for and engage in lifelong learning to maintain and enhance the practice of chemical engineering.
13. Acquire entrepreneurship skills and business insight.

B.TECH (CHEMICAL) SEM :- III

Sr. No.	Subject	Teaching Scheme (Hours/week)			Examination Scheme (Marks)							Credit		
		L	P/D	T	End Semester Examination	Continuous Assessment: Unit Test	Continuous Assessment: Attendance	Continuous Assessment: Assignments	TW/O	TW/P	Total	Theory	P/D	Total
1	Chemical Engineering Thermodynamics I	3	-	1	60	20	10	10	25	-	**125**	4	-	**4**
2	Strength of Material	3	2	-	60	20	10	10	25	-	**125**	3	1	**4**
3	Physical Chemistry	3	2	-	60	20	10	10	**-**	50	**150**	3	1	**4**
4	Chemical Process Calculations	3	-	1	60	20	10	10	50	-	**150**	4	-	**4**
5	Mechanical Operation	4	2	-	60	20	10	10	-	50	**150**	4	1	**5**
6	Professional Skill Development Structure - III	4	-	-	100	-	-	-	-	-	**100**	4	-	**4**
Total		**20**	**6**	**2**	**400**	**100**	**50**	**50**	**100**	**100**	**800**	22	3	**25**

Sr. No.	Subject	Teaching Scheme (Hours/week)			Examination Scheme (Marks)							Credit		
		L	P/D	T	End Semester Examination	Continuous Assessment: Unit Test	Continuous Assessment: Attendance	Continuous Assessment: Assignments	TW/O	TW/P	Total	Theory	P/D	Total
7	Engineering Mathematics III	3	-	1	60	20	10	10	-	-	**100**	4	-	**4**
8	Fluid Flow Operations	4	2	-	60	20	10	10	**-**	50	**150**	4	1	**5**
9	Process Heat Transfer	4	2	-	60	20	10	10	-	50	**150**	4	1	**5**
10	Chemical Engineering Thermodynamics II	3	-	1	60	20	10	10	50	-	**150**	4	-	**4**
11	Chemical Process Industries	2	-	1	60	20	10	10	50	**-**	**150**	3	-	**3**
12	Professional Skill Development-IV	4	-	-	100	-	-	-	-	-	**100**	4	-	**4**
Total		**20**	**4**	**3**	**400**	**100**	**50**	**50**	**100**	**100**	**800**	23	2	**25**

Total Credits

Semester III : 25

Semester IV : 25

Grand Total : 50

CHEMICAL ENGINEERING THERMODYNAMICS-I

Designation : Professional Core

Course Pre-requisites : Students should have knowledge of

1. Mathematics
2. Physics
3. Chemistry

TEACHING SCHEME		CREDITS ALLOTTED	
Lectures	: 3 Hours/Week	Theory	: 03
Tutorial	: 1 Hour /Week	Tutorial	: 01
Total	: 4 Hour /Week	Total credits	: 04

Course Outcomes

After completion of the course students will be able to

1. (a) Estimate energy requirement for a system
2. (a) Understand second law of thermodynamics and the concept of entropy
   (b) Calculate efficiency of heat engines and refrigerator, and calculate change in entropy for ideal gas.
3. (a) Understand P-T and P-V diagrams for pure fluids
   (b) Select appropriate equation of state for representing P-V-T behavior of gases and/or liquids.
4. (a) Calculate changes in internal energy, enthalpy, and entropy for ideal gases, and also for non- ideal gases through use of residual properties
   (b) Understand the criterion of phase equilibrium for a pure substance and use it to relate the enthalpy of phase change to the saturation pressure curve via Clausius- Clapeyron equation
5. (a) Understand refrigeration and liquefaction cycles.
6. (a) Estimate deviation from ideality for real gaseous mixtures and liquid solutions

<u>Topics covered</u>

<u>UNIT - I</u> (06 Hours)

First Law of Thermodynamics

Preliminary concepts of thermodynamics; Statement of first law of thermodynamics; Joules experiment and internal energy; Mathematical form of first law of thermodynamics; State function and path function; Intensive and extensive properties; Enthalpy; Steady state steady flow process; Equilibrium; Phase rule; Reversible and irreversible processes; Constant volume and constant pressure processes.

<u>UNIT - II</u> (06 Hours)

Second Law of Thermodynamics

Necessity of second law of thermodynamics; Statements of second law of thermodynamics; Heat engine: Carnot approach; Kelvin-Plank statements; Thermodynamic temperature scale; Thermodynamic temperature and the ideal gas scale; Entropy: Clausius approach; Entropy change of ideal gas; Mathematical statement of second law of thermodynamics; Third law of thermodynamics and its mathematical statement

<u>UNIT - III</u>

Volumetric Properties of Pure Fluids (06 Hours)

PVT behavior of pure substance; Basic equation of state; Difference between Ideal gas and real gas; Equation governing PVT behavior of ideal gas; Development of thermodynamic relations for ideal gas for isochoric, isobaric, isothermal, adiabatic, and polytropic processes; Equations governing PVT behavior of real gas: (i) the viral equations, (ii) two parameter equations (van der Waal, and RedlichKwong equations), (iii) compressibility factor: two parameter theorem of corresponding state and three parameter theorem of corresponding state.

<u>UNIT - IV</u> (06 Hours)

Thermodynamic properties of Fluids

Property relations for homogeneous phases: (i) Thermodynamic relations derived from laws of thermodynamics, Helmholtz energy, and Gibbs energy, (ii) Maxwell relationships; Two-phase systems: Clausius - Clapeyron equation and Antoine equation; Thermodynamic diagrams: (i) temperature-entropy, (ii) pressure-enthalpy, and (iii) enthalpy-entropy (the Mollier diagram).

UNIT - V (06 Hours)

Refrigeration and Liquefaction

The Carnot Cycle; The vapor- compression cycle; Comparison of refrigeration cycle; The Choice of refrigerant; Absorption refrigeration and power cycle; Organic Rankine cycle; Liquefaction processes

UNIT - VI (06 Hours)

Introduction to Thermodynamics

Fundamental property relation; Concept of chemical potential, Partial molar properties; Ideal gas mixtures and ideal solutions; Concept of fugacity and activity; Effect of temperature and pressure on fugacity and activity; Determination of fugacity of pure species; Concept of residual and excess properties.

Tutorials / Team work

Tutorials will be based on the theoretical and/or numerical covered in six units

Assignments

1 Solving numerical in connection with the basic principles of thermodynamics
2 Questions involving first law applied to pure component systems.
3 Solving numerical in connection with entropy changes of ideal gas for various thermodynamic processes.
4 Draw P-T and P-V diagrams for pure substances.
5 Solving numerical based on application of thermodynamics to transient open and closed systems
6 Numerical involving Pure Fluid Properties Coupled to 1st and 2nd Laws.
7 Conducting surprise MCQ test for students
8 Solving numerical based on Refrigeration and Liquefaction.

9 Enhancement in collaborative learning is done through, group assignments that will be given to encourage students to work with classmates to discuss and complete homework assignments.

10 Students have to study any five NPTEL videos related to Chemical Engineering Thermodynamics I and prepare/present power point presentation.

11 Group discussions on any of the following topics:

a) Importance of Chemical Engineering Thermodynamics in chemical industries.

b) Practical applications involving various thermodynamic processes.

c) Ideal Gas, Real Gas, Ideal gas mixture, Ideal solution.

12 Preparation of a brief report on applicability of equations of states (EOS) in chemical engineering systems.

13 Solve question papers of CET I of previous THREE years.

14 Unsolved numerical from the reference books on various topics studied

Text Books/ References

1. J. M. Smith and H. C. Van Ness, "Introduction to Chemical Engineering Thermodynamics", McGraw- Hill Publication
2. T. E. Daubert, " Chemical Engineering Thermodynamics", McGraw- Hill Publication
3. B. F. Dodge, "Chemical Engineering Thermodynamics", McGraw- Hill Publication
4. S. I. Sandler, "Chemical Engineering Thermodynamics", McGraw- Hill Publication

Syllabus for Unit Test

Unit Test - I	UNIT– I, II, and III
Unit Test - II	UNIT– IV, V, and VI

STRENGTH OF MATERIAL

Designation : Breath

Course Pre-requisites : Students should have

1. Basic knowledge of Engineering Mechanics

TEACHING SCHEME		CREDITS ALLOTTED	
Lectures	: 3Hours/Week	Theory	: 03
Practical	: 2 Hour /Week	Practical	: 01
Total	: 5 Hours/Week	Total credits	: 04

Course Outcomes

After completion of the course students will be able to

1. Calculate stresses due to axial force.
2. Calculate shear force and bending moment in the beam.
3. Calculate deflection and bending stress in the beam.
4. Calculate shear stress due to shear force and torsion.
5. Calculate critical load for column.
6. Calculate principal stresses.

Topics covered

UNIT-I (06 Hours)

Concept of stress and strain:

Normal, lateral, shear and volumetric stresses and strains, Stress-strain curve; Elastic constants and their inter relationship; Generalized Hooke's law;

Stresses due to Axial Load and Temperature

Axial force diagram; Stresses, strains and deformation of determinate and indeterminate bars of prismatic, homogenous and composite cross section.

UNIT-II (06 Hours)

Shear Force and Bending Moment in Beams

Concept of Shear Force and Bending Moment; Relation between Shear Force, Bending Moment and intensity of loading; Shear Force Diagram and Bending Moment Diagram of determinate beams due to concentrated load, uniformly distributed load, uniformly varying load and moments.

UNIT-III (08 Hours)

Deflection of Beams

Concept of relation between deflection, slope, bending moment, shear force and intensity of loading; Macaulay's method, Elastic curve.

Flexural Stresses

Theory and assumptions of pure bending; Moment of resistance; Flexure formula; Flexural rigidity; Modulus of rupture; Flexural stress distribution diagram for various sections; Force resisted by partial cross section.

UNIT-IV (06 Hours)

Shear Stresses

Concept of direct and transverse shear; Shear stress formula; concept of complementary shear stress; Shear stress distribution diagram for symmetrical and unsymmetrical section.

Torsion of Circular Shafts

Theory, assumptions and derivation of torsional formula; Shear stress distribution across cross section; Twisting moment diagram; Shear stresses and strains in determinate and indeterminate shafts of hollow, solid, homogeneous and composite cross sections subjected to twisting moment; Torsional rigidity.

UNIT-V (06 Hours)

Combined Axial and Bending Stress

Concept; Resultant stress due to the axial load and uni-axial or biaxial bending; Core of section.

Axially Loaded Long Columns

Concept of critical load and buckling; Differential equation of elastic curve; Euler's formula for hinged ends; Equivalent length for different end conditions; Limitation of Euler's formula; Rankine's formula.

UNIT-VI (06 Hours)

Principal Stresses and Principal Planes

Normal and shear stresses on any oblique plane. Concept of principal stresses and principal planes. Maximum shear stress; Analytical and graphical method. (Mohr's circle method); Combined effect of axial force, bending moment, shear force and torsion.

Text Books/References

1. R. C. Hibbeler, “Mechanics of Materials”, Pearson Prentice Hall,
2. Rajput R. K., “Strength of Materials”, S. Chand Publication
3. Punmia B. C., Jain, Ashok Kr. Jain Arun Kr., “Mechanics of Materials”, Laxmi Publication.
4. Ramamrutham S. & Narayan R., “Strength of Materials”, DhanpatRai Publishing Co.
5. Beer F..P. and Johnston E.R., “Mechanics of Materials”, McGraw Hill Publication
6. GereJ.M. & Timoshenko S.P., “Mechanics of Materials”, CBS Publishers & Distributors
7. Singer F. L. &Pytel A., “Strength of Materials”, Harper and Row Publication

8 Popov E. P., “Engineering Mechanics of Solids”, Prentice Hall of India (P) Ltd.

9 Singer F. L. &Pytel A., “Strength of Materials”, Harper and Row Publication

Syllabus for Unit Test

Unit Test -I UNIT – I ,II,III

Unit Test -II UNIT – IV,V,VI

PHYSICAL CHEMISTRY

Designation : Basic science

Course Pre-requisites : Basic knowledge for chemistry

TEACHING SCHEME

Lectures : 03 Hours/Week

Practical : 02 Hours /Week

Total : 05 Hours/Week

CREDITS ALLOTTED

Theory : 03

Practical : 01

Total credits : 04

Course Outcomes:

After completion of the course students will be able to

1. Explain the basic concepts of bond forming and reactivity.
2. Describe the principles and applications of spectroscopic techniques such as infra-red UV/Visible absorption spectrometry.
3. Demonstrate the principles and functions of the UV and IR spectroscopy for chemical investigations.
4. Recognize the use of catalysts for industrially important processes.
5. Comprehend Structure-Property Relationship.
6. Interpret concept of Surface and Interfacial Chemistry.

Topics covered

UNIT-I (06 Hours)

Bonding and reactivity

Aromaticity-conditions necessary for delocalization ofelectrons, resonance structures stability rules, resonance in phenol, aniline, benzaldehyde, nitrobenzene molecules, Effect of inductive effect and resonance on pKa and pKb values of acids and bases. Reaction intermediates –carbonations, carbanions, free radicals and theirstability. Types of reagents, types of reactions.

UNIT-II (06 Hours)

Reaction mechanisms

Substitution at saturated carbon (SN1, SN2)- mechanism, factors favoring. Electrophilic aromatic substitution in benzene and mono substituted benzenes, activating and deactivating groups , nitration, Friedal-Craft reactions, sulphonation, diazotization. Nucleophilic substitution on on carbonyl carbon. Addition of HX on C=C 1, 2-Eliminations- E1mechanism, E 2, (Saytzeff, Hoffman products), factors favoring. Rearrangements- Beckman, Claisen, Reformatsky.

UNIT-III (06 Hours)

Instrumental methods of chemical analysis

UV-Visible spectroscopy: Lambert-Beer law, λ max, calculation of λ max for olefinic and cyclic structures, instrumentation, interpretation of spectra, applications. IR Spectroscopy: Introduction, instrumentation (double beam spectrophotometer) characteristic absorption in functional and finger print regions, interpretation of spectra, applications.

UNIT-IV (06 Hours)

Catalysis

Introduction, types of catalyst, criteria or Characteristics of catalyst, adsorption theory of catalysis, catalytic promoters or activators, catalytic poisons, Enzyme catalysis, Applications of catalysts for industrially important processes.

UNIT-V (06 Hours)

Structure –Property Relationship

Molecular interactions and bonds weaker than covalent bonds, e.g. hydrogen bond,dipole interaction,VDW forces etc.and there effects on various properties such as refractive index ,viscosity, surface tension,density,thermal conductivity, specific heat,diffusivity,melting point, boiling point, vapor pressure, heat of formation, latent of diffusion and vaporization,non ideal behavior in solutions, group contribution methods for estimation of these properties(including those of polymers and polymeric solutions).

UNIT-VI (06 Hours)

Surface and Interfacial Chemistry

Concept of surface /interfacial energy and surface /interfacial tension, Thermodynamics of surfaces, Gibbs adsorption equation and isotherm, Curved surfaces-Young, Laplace, Kelvin and Thompson equations contact angel and wetting phenomena,adhesion,cohesion,surface active agents: types and applications, surfactant aggregates, emulsions and micro emulsions preparation, stability and application.

List of Experiments

Term work will consist of the experiments listed below, of which at least eight should be performed in laboratory by the students.

1. Preparation of benzoic acid from benzamide.
2. Preparation of aspirin from salicylic acid.
3. Conductometric titration between strong acid and strong base.
4. Determination of percentage purity of sodium Bicarbonate by gravimetry.
5. Estimation of Cu++ ions by spectrophotometer/colorimeter.
6. Purification of organic compounds by crystallization and sublimation.
7. To determine the number of molecules of water of crystallization in BaCl2.2H2O by heating.
8. Volumetric estimation of aniline from the given solution.
9. Volumetric estimation of acetone from the given solution.
10. Determine viscosity of given liquids by Ostwald's viscometer.
11. To determine ΔH, ΔG, ΔS of the reaction, Zn(s) + Cu2+ (aq) $\rightarrow$ Zn2+ (aq) + Cu(s)

12 Preparation of tetramine copper (II) sulphate.

13 Preparation of potasiumtrioxalato aluminate.

14 Preparation of crystal of potash alum.

15 To determine the equivalent weight of the given metal (Zn or Mg) eudiometrically.

Assignments

1 What is resonance effect? Draw resonating structure of aniline, phenol, phenoxide ion.

2 Nucleophilic substitution.

3 Conductometric titrations.

4 Industrial applications of catalysts.

5 Adsorption theory of catalysis.

6 Gibbs adsorption equation and isotherm

Reference Books

1 Instrumental methods of chemical analysis ----B.K.Sharma, Goel publ.)

2 Instrumental methods of chemical analysis ----Chatwal –Anand

3 Organic chemistry –I L Finar volume I and II

4 Engineering Chemistry ---S.S.Dara

5 Physical chemistry –P L Soni

6 Atkins P.W. and Paula., Physical Chemistry,.8thEdn.,Oxford University Press.

7 Inorganic chemistry ----Cotton, Wilkinson

8 Spectroscopy ---Kalsi

9 Vogels text book of quantitative chemical analysis. (5thEdn.)

Syllabus for Unit Test

Unit Test -I UNIT – I ,II,III

Unit Test -II UNIT – IV,V,VI

CHEMICAL PROCESS CALCULATIONS

Designation : Professional Core

Course Pre-requisites : Students should have

1. Basic knowledge of chemistry

TEACHING SCHEME		CREDITS ALLOTTED	
Lectures	: 3Hours/Week	Theory	: 04
Tutorial	: 1 Hour /Week	Total credits	: 04
Total	: 4 Hours/Week		

Course Outcomes

After completion of the course students will be able to

1. Explain the concept of units and dimensions and solve the problems on basic chemical calculations.
2. Describe the concept of material balance without chemical reactions and solve the problems involved in various unit operations.
3. Explain the concept of material balance involving chemical reactions and solve the problems on unit processes carried out in chemical industry.
4. Explain the concept of recycle, bypass, purge operations and solve problems based on humidification, recycle, bypass and purge operations.
5. Interpret the concepts of energy balance and solve numerical based on them.
6. Apply the knowledge of gross and net calorific values of fuel and solve the problems based on them.

Topics covered

UNIT-I (08 Hours)

Basic Chemical Calculations

Units and dimensions for mass and energy calculation for solid, liquid and gas; Mole concept; Basic composition calculation for homogeneous, two phase and three phase systems,

UNIT-II (08 Hours)

Material balances without Chemical Reactions

Generalized law of conservation of mass; Mass conservation without chemical reaction; Mass balance for unit operations encountered in chemical process industry : Distillation, extraction, evaporation, blending etc.

UNIT-III (08 Hours)

Material balances involving Chemical Reactions

Generalization of law of conservation of mass involving chemical reaction and its simplification; Chemical equations and stoichiometry; Some basic concepts: conversion, yield, selectivity; Material balance for unit processes encountered in chemical process industry: nitration, esterification, acylation, sulfonation etc.

UNIT-IV (08 Hours)

Recycle, bypass and purge operations

Necessity of recycle, bypass and purge streams; Basic calculations of recycle, bypass and purge streams for unit operations and unit processes. Industrial examples of recycling, bypassing and purging with complete mass balance viz. biofuel synthesis, food processing etc.; Humidification operation.

UNIT-V (08 Hours)

Energy Balance

Basic concepts; heat capacity; Sensible heat and latent heat: Clausius-

Clapeyron equation; standard heat of formation, combustion, reaction, Hess's law; General equation of energy balance; Energy balance approach and calculations for exothermic and endothermic reactions with industrial examples; Steam table and its utility; Utility energy balance calculations.

UNIT-VI (08 Hours)

Fuels and Combustion

Types of fuels: solid, liquid and gas; Calculations of energy content of fuel; Analysis of fuel; oxygen requirement and excessity; Adiabatic flame temperature calculations.

Term Work/ Tutorial

Term work includes numerical on the following topics.

1. Basic chemical calculations.
2. Material balances without chemical reactions.
3. Material balances involving chemical reactions.
4. Recycle, bypass, purge and humidification operation.
5. Energy balance.
6. Fuels and combustion.

Assignment

1. Mass and energy balance for any one of following unit operations for given system.
   a) Distillation
   b) Evaporation
   c) Extraction
   d) Crystallization
   e) Drying. etc
2. Mass and energy balance for any one of following unit processes for given system. These assignment may include overall energy and/or mass balance or energy and/or mass balance over a given chemical

process equipment.

a) Nitration

b) Esterification

c) Acylation

d) Fermentation

e) Sulfonation etc.

3. Students have to visit chemical industry and prepare a detailed report on various unit operations and unit processes used in industry.
4. Measurement of calorific values of any two types of fuel.
5. Group discussions on mass and energy balance for unit operations and unit processes carried out in chemical industry
6. Solve last five years GATE question papers with reference to chemical process calculations.
7. Students have to study any five NPTEL videos related to chemical process calculations and prepare/present power point presentation.
8. Numericals based on above six units.
9. Technical interview based on knowledge of chemical process calculations.
10 Prepare models for recycle, bypass and purge operations carried out in chemical industry.
11. With the help of this subject knowledge, write a report on how you would apply your concepts in industry.
12. Prepare a report on unit operations which are newly introduced in the current year.
13. Write a report on your visit to research and development laboratory of national/international repute.In addition to these above stated assignments concern faculty member may design his/her own assignments.

Text Books/References

1. Bhatt, B. I. and Vora, S. M.; Stoichiometry (SI Units), Third Edition, Tata McGraw Hill Publishers, New Delhi.
2. Himmelblau, D. M.; Basic Principles and Calculations in Chemical Engineering, Prentice Hall Publications
3. Hougen, O. A.; Watson, K. M. and Ragatz, R A; Chemical Processes Principles, Part-I, Material and Energy Balances, Asia Publishing House, Bombay
4. Felder, R.M. andRousseau, R.W.; Elementary Principles of Chemical Processes, 3rd edition, WileyJohn& sons Publications
5. Rudd, D.F.; Powers, G.J. and Sirola, J.F.; Process Synthesis, Prentice Hall Publications
6. Shukla, S.D. and Pandey, G. N.; Chemical Engineering Calculations, Lion Press, Kanpur
7. Ranz, W.E.; Describing Chemical Engineering Systems, McGraw Hill Publications.

Syllabus for Unit Test

Unit Test -I	UNIT – I ,II,III
Unit Test -II	UNIT – IV,V,VI

MECHANICAL OPERATION

Designation : Professional Core

Course Pre-requisites : None

TEACHING SCHEME		CREDITS ALLOTTED	
Lectures	: 4 Hours/Week	Theory	: 04
Practical	: 2 Hours /Week	Practical	: 01
Total	: 6 Hours/Week	Total credits	: 05

Course Outcomes

After completion of the course students will be able to

1. Understand the concept of particle size measurement, distribution and analyze the performance of size reduction equipment.
2. Understand the concept of solid storage and solid conveying.
3. Understand the concept of mixing and Calculate the power requirement for agitator.
4. Understand the concept of particle mechanics and sedimentation
5. Understand the concepts of filtration.
6. Understand the concept of separation of solids from fluids.

Topics covered

UNIT-I (08 Hours)

Properties of Solid and Size Reduction

Properties of solid:- Particle size and shape, Mixtures of particles, Cumulative and differential screen analysis, Determination of particle size, Screen effectiveness and capacity, Industrial screening equipments.

Size Reduction:- Crushing efficiency, energy requirements calculations by using different crushing laws, Size reduction equipments: Primary crushers, secondary crushers, Intermediate & fine grinders, Ultra fine grinders, Cutting machines, open circuit & Closed circuit grinding.

UNIT-II (08 Hours)

Handling and Transport of Solids

Storage of Solids:- Bins, silos, hoppers, Janseen's equation, characteristics of Bulk solids.

Transport of Solids :- Conveyors: Working principles, Construction, Advantages, Disadvantages and design calculation of Screw conveyors, Belt Conveyors, Chain & Flight conveyors, Bucket elevators, Pneumatic conveyors.

UNIT-III (08 Hours)

Mixing and Agitation

Necessity of mixing & agitation in chemical industries, Mixers for pastes and plastic masses. Mixers for dry powders. Criteria for mixer effectiveness. Mixing index in blending granular solids. Rate of mixing. Types of equipment, Mixing characteristics, Power consumption, Mixing index calculations, Agitator selection.

UNIT-IV (08 Hours)

Sedimentation

Gravity settling method: Motion of particles in fluid, drag force, drag coefficients, effect of particle shape, Stock's law, hindered settling, Terminal velocity, sink and float method, differential settling. Batch sedimentation, equipments for sedimentation, Kynch theory of sedimentation, calculation of area and depth of batch thickeners and continuous thickeners.

UNIT-V (08 Hours)

Filtration

Filter media and filter aids, classification of filtration, pressure drop through filter cake, filter medium resistance, specific cake resistance, Continuous Filtration, Washing and dewatering of filter cakes, Centrifugal filtration. Selection of filtration equipment.

UNIT-VI (08 Hours)

Separation of solids from fluids

Froth flotation, magnetic separator, scrubbers, fiber and fabric filter, and electrostatic precipitators. Mineral jig, cyclone separator, hydro cyclone types and centrifuges, centrifugal clarifier.

List of Experiments

Term work will consist of the experiments listed below, of which at least eight should be performed in laboratory by the students.

1. To determine effectiveness of given set of standard screen.
2. To determine energy consumption and crushing law constants for jaw crusher.
3. To determine Critical speed of Ball mill & Average particle size of the product obtained in ball mill.
4. To determine mixing Index of a mixture in Ribbon Blender. OR To determine mixing Index of mixture in Sigma Mixer.
5. To determine filter medium resistance and cake resistance by using Vacuum Leaf filter.
6. To determine filter medium resistance and cake resistance by using Plate & frame Filter Press OR by using centrifuge machine.
7. To determine area of batch thickener by conducting batch sedimentation test.
8. To determine separation efficiency by using froth flotation cell.
9. To determine separation efficiency by using magnetic separator.
10. To determine efficiency of Cyclone separator.

Assignments

1 Pilot scale solid-liquid fluidization: Expansion characteristics of solids

2 Estimate power consumption for homogeneous system

3 Industry related unit operation (ANY ONE INDUSTRY) detailing of it.

4 How does filtration fit into the water treatment process?

5 How Does Filtration clean water?
6 What types of filters are used for water treatment? Explain in brief
7 Explain hand pump water filter
8 How does sedimentation fit in to the waste water treatment process?
9 What zones are present in sedimentation basin?
10 How is sedimentation sludge disposed of?
11 What is surface loading rate explain in brief. The flow into clarifier is 3.2 MGD in tank 80 feet long and 40 feet wide. what is surface loading rate?
12 Recent trends in particle size technology.
13 Watch the NPTEL video on this subject of any TWO modules and summarize it
14 Solve numerical problems asked in previous THREE year question papers.
15 Solve questions asked on filtration in previous THREE year question papers.
16 If your particles are not spherical which equivalent particle size would be suitable to calculate for the purpose of filtration ?
17 What media are used in filters? What factors affect filter efficiency?

<u>Text Books/References</u>

1. McCabe, W. L.; Smith, J. C. and Harriott, P.; Unit Operations of Chemical Engineering, 6th edition, McGraw Hill Publications.
2. Coulson, J.M.; Richardson, J. F.;Backhurst, J. R.; Harker, J. H.; Chemical Engineering Volume 2, 6th edition, Pergamon Press.
3. Badger W. L &Banchero J.T. "Introduction to Chemical Engineering", McGraw Hill
4. Foust A. S "Principles of Unit Operation".
5. George G. Brown, "Unit operations", CBS publishers and distributors.

<u>Syllabus for Unit Test</u>

Unit Test -I	UNIT – I ,II,III
Unit Test -II	UNIT – IV,V,VI

SUBJECT: PROFESSIONAL SKILLS DEVELOPMENT

TEACHING SCHEME	:	**Theory : 4 Hours / Week**
EXAMINATION SCHEME	:	**End Semester Examination: 50 Marks**
CREDITS ALLOTED	:	**2**

Course Pre-requisites

The Students should have knowledge of

1. Basic math's and reasoning, the rules of English and comprehensive ability
2. Basic awareness of phrasal verbs used in spoken communication and knowledge of verbs and other words used in professional life.
3. Basic writing techniques taught to them in the first semester.
4. The strengths and achievements analyzed during self awareness session taught in the second semester. They should also be able to identify their long term and short term goals.
5. Basic knowledge and idea about leaders and leadership qualities.
6. Basic awareness of PowerPoint presentation and paper presentation and also should be fluent in English.

Course Objectives

The Professional Skills Development course which is a combination of aptitude and soft skills aims to augment students to face the campus recruitment test and train them on applying short techniques/ tricks to solve questions of Maths, reasoning and English in very less amount of time. The English and soft skills section focuses on the higher aspects of soft skills such as grooming them on leadership, presentation, business communication which would enable them to project themselves as professionals in the corporate sector and/or otherwise.

Course Outcomes

The student should be able to

1. Solve the aptitude test in the recruitment exam and competitive exam by applying short techniques and solve the question in less amount of time. They would be able to handle around 15-20 topics of math's and reasoning and 50 rules of parts of speech.

2. Present themselves with finesse by using around 25-20 idioms and phrases relevant to corporate communication as well as spoken English. They will also learn 50-60 words and other words that are specifically used in meetings, group discussions, presentation and other corporate events.
3. Process their ideas and thoughts (verbal communication) into written communication in an effective, coherent and logical manner within a stipulated time and specific word limit of 500-750 words for essay writing along with limited words for technical writing and report writing.
4. Identify themselves in terms of their strengths. Weaknesses and opportunities available to them for the career growth. They would also learn to overcome their weakness and convert into strengths and also make utilization of the opportunity vis-à-vis their strength. They would also learn to set realistic short/long term goals relevant to them through the SMART goal mnemonic.
5. Differentiate between the different types of leaders and groom themselves to be potential leaders. Based on their qualities and strengths they would learn 5 types of leadership styles and mould themselves according to that. They would also learn 10-15 leadership traits.
6. Prepare PowerPoint presentation and paper presentation effectively by focusing on body language, tone of communication and audiences' needs. They would also learn to handle the questions in an effective and smart way.

<u>Unit I</u> (18 Hours)

Aptitude (Maths, Logical Reasoning, English)

- **Maths**
  - i) Enjoy maths + Number system
  - ii) Number system
  - iii) Percentage, profit and loss

- **Logical Reasoning**
  - i) Coding, Decoding, Number series,
  - ii) Blood relation Directions, cubes & dices
- **English**
  - i) Vocabulary-1
  - ii) Confusing words-1(Homonyms)

Unit II (6 Hours)

Essential Grammar - III

- Idioms and phrases
- Usage of Idioms & phrases in daily conversation
- Activities
- Academic word list- Words to be used in business communication

Unit III (4 Hours)

Written Communication- II

- Essay writing
- Mnemonics to develop ideas and write essays
- Structure of essays
- Technical writing
- Report writing

Unit IV (6 Hours)

SWOT Analysis

- Introduction to SWOT
- Importance to SWOT
- Individual & Organizational SWOT Analysis
- Identifying strengths, weaknesses, threats & opportunities
- Short term goals& Long term goals, Career planning

Unit V (4 Hours)

Interpersonal Skills - III

- Introduction to leadership skills
- Importance of leadership skills
- Types of leadership skills
- Are leaders born or made?

Unit VI (4 Hours)

Presentation Skills

- Introduction to PowerPoint presentation
- Structure & flow of presentation
- Importance of body language
- Presentation by students-evaluation& feedback by trainers

Text Books

1. APAART: Verbal Ability
2. APAART: Logical Reasoning
3. APAART: Quantitative Aptitude
4. APAART: Speak Well 1 (English Language and Communication)
5. APAART: Speak Well 2 (Soft Skills)

$$1)\ \frac{\partial u}{\partial t} = a^2 \frac{\partial^2 u}{\partial x^2},$$

$$2)\ \frac{\partial^2 u}{\partial t^2} = a^2 \frac{\partial^2 u}{\partial x^2};$$

$$3)\ \frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} = 0$$

ENGINEERING MATHEMATICS- III

Designation : Professional Core

Course Pre-requisites : Students should have

Basic knowledge of Mathematics including derivative, integration etc.

TEACHING SCHEME		**CREDITS ALLOTTED**	
Lectures	: 3Hours/Week	Theory	: 04
Tutorial	: 1 Hour /Week	Total credits	: 04
Total	: 4 Hours/Week		

Course Outcomes

After completion of the course students will be able to

1. To develop an ability of mathematical modeling of systems using differential equations and ability to solve linear differential equations with constant coefficient
2. To develop an ability to solve the Laplace, heat and wave equations for a variety of boundary conditions in domains of simple geometry and with simple boundary conditions; the techniques available will include, separation of variables
3. To develop an ability to solve problems on Fourier sine and cosine transform
4. To develop an ability to use theorems to compute the Laplace transform, inverse Laplace transforms
5. To develop an ability to calculate the gradients and directional derivatives of functions of several variables
6. To develop an ability to use Green's theorem to evaluate line integrals along simple closed contours on the plane

Topics covered

UNIT-I (08 Hours)

Linear Differential Equations (LDE)

Solution of nth order LDE with Constant Coefficients, Method of Variation of Parameters, Cauchy's & Legendre's DE, Solution of Simultaneous & Symmetric Simultaneous DE. Applications of LDE to chemical engineering problems and allied engineering.

UNIT-II (08 Hours)

Partial Differential Equations (PDE)

Solution of Partial Differential Equations

1) $\frac{\partial u}{\partial t} = a^2 \frac{\partial^2 u}{\partial x^2}$,

2) $\frac{\partial^2 u}{\partial t^2} = a^2 \frac{\partial^2 u}{\partial x^2}$,

3) $\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} = 0$

By separating variables only. Applications of PDE to problems of Chemical and allied engineering.

UNIT-III (08 Hours)

Fourier Transform (FT)

Fourier Integral theorem. Sine & Cosine Integrals. Fourier Transform, Fourier Cosine Transform, Fourier Sine Transforms and their inverses. Finite FT, Application of FT to problems on one and two dimensional heat flow problems.

UNIT-IV (08 Hours)

Laplace Transform (LT)

Definition of LT, Inverse LT. Properties & theorems. LT of standard functions. LT of some special functions viz. error, 1st order Bessel's, Periodic, Unit Step, Unit Impulse, ramp, jump, parabolic, Si(t) and Ei(t). Problems on finding LT & inverse LT. Applications of LT for solving ordinary differential equations, liquid level systems, consisting of single tank and two tanks in series (interacting and non-interacting systems), second order systems (damped vibrator).

UNIT-V (08 Hours)

Vector Differentiation

Physical Interpretation of Vector Differentiation. Radial, Transverse, Tangential & Normal components of Velocity and Acceleration. Vector differential operator. Gradient, Divergence & Curl. Directional derivative. Vector identities. Irrotational & Solenoidal fields. Application of vector differentiation to chemical engineering.

UNIT-VI (08 Hours)

Vector Integration

Line integral, Surface & Volume integrals. Work done, Green's Lemma, Gauss-Divergence and Stoke's Theorem, Applications of Vectors to problems in Fluid Mechanics, Continuity equations, Stream lines, Equations of motion, Bernoulli's equation.

Assignments

1 Linear differential equation with constants coefficients.

2 Application of LDE and partial differential equations.

3 Fourier transform and inverse fourier a function which is neither even nor odd ,for even and odd function

4 Laplace transform and invese laplace transform and its application to differential equation

5 Vector identities and application of vector differential in mechanics.

6 line integral, surface integral and volume integral.

Text Books/References

1. Advanced Engineering Mathematics by Peter V. O'Neil (Cengage Learning).
2. Advanced Engineering Mathematics by Erwin Kreyszig (Wiley Eastern Ltd.)
3. Engineering Mathematics by B.V. Raman (Tata McGraw-Hill).

4. Advanced Engineering Mathematics, 2e, by M. D. Greenberg (Pearson Education).
5. Advanced Engineering Mathematics, Wylie C.R. & Barrett L.C. (McGraw-Hill, Inc.)
6. Higher Engineering Mathematics by B. S. Grewal (Khanna Publication, Delhi).
7. Applied Mathematics (Volumes I and II) by P. N. Wartikar& J. N. Wartikar (Pune VidyarthiGrihaPrakashan, Pune).
8. Advanced Engineering Mathematics with MATLAB, 2e, by Thomas L. Harman, James Dabney and Norman Richert (Brooks/Cole, Thomson Learning).

Syllabus for Unit Test

Unit Test -I	UNIT – I , II, III
Unit Test -II	UNIT – IV, V, VI

FLUID FLOW OPERATIONS

Designation : Professional Core

Course Pre-requisites : Students should have knowledge of

1. Physics, Engineering Science and Engineering Mechanics.
2. Elements of Civil Engineering

TEACHING SCHEME		**CREDITS ALLOTTED**	
Lectures	: 4 Hours/Week	Theory	: 04
Practical	: 2 Hour /Week	Practical	: 01
Total	: 6 Hours/Week	Total credits	: 05

Course Outcomes

After completion of the course students will be able to

1. Describe the various properties of fluids and basic concept of fluid flow.
2. Apply the basic equations of fluid flow like Continuity and Bernoulli's equation for solving numerical in fluid flow operations.
3. Apply the basics of turbulent flow and flow measuring devices for solving numerical in fluid flow operations
4. Identify and explain the various types of energy losses for fluid flowing through a pipe.
5. Identify and select various types of fluid moving equipments for fluid flow
6. Explain the construction and working of fluidized bed reactor.

Topics covered

UNIT - I (08 Hours)

Basic Concepts of Fluid Flow

Types of fluid: Newtonian and Non-Newtonian fluids; Properties of fluids; Concept of viscosity, calculation and measurement; Models for non-Newtonian fluids; Types of flow: laminar, transition and turbulent and their characteristics; Concept of fluid pressure, pressure measurement and calculation.

UNIT - II (08 Hours)

Equations of Fluid Flow

Basic equations of fluid flow; Equation of continuity and motion (cartesian, cylindrical and spherical coordinates) in laminar flow and its applications for calculation of velocity profiles, shear stress distribution, volumetric flow rate, power etc. in engineering applications; Flow of incompressible fluids.

UNIT - III (08 Hours)

Turbulent Flow

Basics of turbulent flow; Equations of continuity and motion for turbulent flows: Reynolds averaging, Boussinesq hypothesis, Prandtl mixing length theory, Turbulent models; Flow measurement: flow measuring devices; Velocity profile;

UNIT - IV (08 Hours)

Pressure Drop Calculation and Measurement in Pipe Flow

Darcy-Weisbach equation; Bernoulli's equation; Friction factor: laminar, transition and turbulent flow; Models available to predict friction factor; Friction factor: valves, bends, fittings, sudden expansion and contraction, sudden obstruction etc.; Equivalent diameter concept for energy losses.

UNIT - V (08 Hours)

Flow Moving Equipments

Pumps: Types; Selection and specifications; characteristic curves; cavitation phenomena; Net positive suction head (NPSH) calculations; System and operating parameters affecting pump performance; Calculation of power requirement.Blowers and compressor: Selection and specifications; Factors affecting performance; Power calculations for given duty.

UNIT - VI

Flow Through Solids

Expansion characteristics of solids: Drag and drag coefficient (C_D) , terminal settling velocity, settling in presence of other particles; voidage-superficial fluid velocity relationship, $C_D V_S\ N_{Re}$; Boundary layer separation; Pressure drop calculation and measurement: skin and form friction, effect of system, operating and geometrical parameters, Ergun equation, experimental methods of measuring pressure drop. Applications of fluidization: catalytic cracking, chromatographic separation etc.

Term Work

Term work will consist of the experiments listed below, out of which at least eight experiments should be performed in laboratory by the students.

1. To determine kinematic viscosity and to study the effect of temperature on kinematic viscosity of given oil.
2. To study flow characteristics using Reynolds apparatus and determine Reynolds number.
3. To determine the coefficient of discharge for venturimeter.
4. To determine the coefficient of discharge for orificemeter.
5. To determine Darcy Weisbach coefficient of friction of laminar and turbulent flow for given pipe.
6. To determine friction and pressure drop for flow through helical/spiral coils.
7. To find losses due to sudden expansion and contraction in pipe.
8. To calculate minimum fluidization velocity using fluidized bed reactor.
9. To verify Bernoulli's theorem.
10. To study characteristics of centrifugal pump.
11. To Study Darcy's law.
12. To study pressure drop in packed bed for different fluid velocities.
13. To determine the coefficient of discharge for different notches like rectangular notch, 45^0V notch, 60^0V notch and trapezoidal notch.

14. To determine terminal velocity of particles in fluids of different viscosity and plot a graph of drag coefficient (C_D) as a function of N_{Re}.

Assignments

1. Numericals based on above six units.
2. Visit to suppliers and prepare a report on detailed specifications of following fluid moving equipments.
   a) Pumps.
   b) Blowers.
   c) Compressors.
3. Visit to suppliers and prepare a report on detailed specifications of following flow measuring devices.
   a) Venturimeter.
   b) Orificemeter.
   c) Pitot tube.
   d) Roatameters.
4. Students have to study any five NPTEL videos related to fluid flow operations and prepare/present power point presentation.
5. Students have to visit chemical industry and make a detailed report on overall fluid flow operations.
6. Group discussions on any one of the following topics.
   a) Importance of fluid flow operations in chemical industries.
   b) Pumps, blowers and compressors.
   c) Flow measuring devices.
7. Prepare models for various types of valves and write industrial applications.
8. Prepare models for various types of bends and write industrial applications.
9. Prepare models for various types of fittings and write industrial applications.
10. Prepare a report on fluid flow operations which are newly introduced in the current year.

11. Solve last five years GATE question papers with reference to fluid flow operations subject.
12. Write a report on your visit to research and development laboratory of national/international repute.
13. Technical interview based on knowledge of fluid flow operations.
14. With the help of this subject knowledge, write a report on how you would apply your concepts in industry.

In addition to these above stated assignments concern faculty member may design his/her own assignment.

Text Books/ References

1. McCabe, W. L.; Smith, J. C. and Harriott, P.; Unit Operations of Chemical Engineering, 5th edition, McGraw Hill Publications.
2. Coulson, J.M.; Richardson, J. F.; Backhurst, J. R.; Harker, J. H.; Chemical Engineering Volume 1, 6th edition, Pergamon Press.
3. Gupta, S.K.; Momentum transfer operations, Tata McGraw Hill Publishers.
4. Bansal, R. K.; A text book of fluid mechanics and hydraulic machines, Laxmi Publications (P) Ltd, New Delhi.
5. Bird, R.B.; Stewart, W.E.; Lightfoot, E.N.; Transport Phenomena, John Wiley & Sons, New York.
6. Denn, M.M.; Process fluid mechanics, Prentice Hall Publications.

Syllabus for Unit Test

Unit Test - I	UNIT– I, II, III
Unit Test - II	UNIT– IV, V, VI

PROCESS HEAT TRANSFER

Designation : Professional Core

Course Pre-requisites : Students should have

Basic knowledge of units and dimensions, mathematical concepts like differential and integral etc, fluid flow concepts like continuity equation, momentum balance.

TEACHING SCHEME		CREDITS ALLOTTED	
Lectures	: 4 Hours/Week	Theory	: 04
Practical	: 2 Hour /Week	Practical	: 01
Total	: 6 Hours/Week	Total credits	: 05

Course Outcomes

After completion of the course students would be able to

1. Evaluate heat loss through pipe insulation, critical and optimum thickness for insulation.
2. Identify the importance of dimensional analysis and derive the dimensionless numbers.
3. Calculate the heat transfer coefficient and heat transfer rate for vertical, horizontal plate in case of film-wise condensation.
4. Apply appropriate empirical correlations to estimate critical heat flux in boiling.
5. Explain the evaporation phenomena and estimate economy of the evaporator.
6. Compute heat transfer rates in case of conduction, convection and radiation.

Topics covered

UNIT-I (08 Hours)

Heat conduction

Thermal conductivity: solids, liquids, and gases; Generalized equation for heat conduction; Steady state heat conduction through: plane slab, composite slab, hollow cylinder, composite cylinder and hollow sphere; Heat loss through pipe: maximum loss, critical and optimum thickness of insulation; its application for the calculation of temperature profile, maximum temperature rise or drop, heat flow at surface; Heat transfer through extended surfaces of uniform cross section.

UNIT-II (08 Hours)

Convection without phase change

Basic concepts of convection; Natural and forced convection; Dimensional analysis: dimensionless groups and their physical significance; Film coefficients; Factors affecting film coefficient; Fouling resistance; Empirical equations for convection heat transfer in turbulent flow through tubes, through annulus and over a flat plate; Steady state convection heat transfer equation to calculate temperature distribution in laminar and turbulent flows.

UNIT-III (08 Hours)

Convection with phase change

Condensation basic concepts; Dropwise and filmwise condensation; Condensation on surfaces-Nusselt's theory: vertical surface, horizontal surface, and inclined surface.

Boiling types; Effect of physical properties; Pool boiling curve; Correlations used in boiling; Concept of critical heat flux.

UNIT-IV (08 Hours)

Radiation

Basic concepts; Thermal radiation; Black body radiation; Properties and laws of radiation; The radiation shape factor; Laws of shape factor; Various cases of radiation between two surfaces; Radiation shields; Radiant heat exchange in an enclosure having black surfaces.

UNIT-V (08 Hours)

Evaporation

Introduction; Types of evaporators; Material and energy balance; Boiling point elevation; Capacity and economy; Multiple effect evaporators.

UNIT-VI (08 Hours)

Unsteady state processes

Unsteady state heat conduction: infinite slab, infinite cylinder, sphere.

Heat transfer in agitated vessels: calculation of film coefficient in coil, jacket; heating and cooling times; Application to batch reactor and processes.

Assignments

1. Write a report on the recent advances in heat transfer processes with reference to the current year.
2. Solve old (last five years) question papers with reference to particular topic.
3. Prepare a model for any of the heat transfer equipment.
4. Prepare a report on heat transfer equipments which are newly introduced in the current year.
5. Give fifteen minutes presentation (seminar) on particular topic and prepare a report.
6. Evaluate capacity and economy for any industrial evaporator.
7. Estimate how much heat transfer rate is decreased due to the scale formation on surface of industrial heat transfer equipment?
8. By determining optimum thickness of insulation give solution to an industrial problem to minimize the heat loss.
9. Design laboratory manuals better than existing ones with clearly shown specimen calculations.

10. With the help of this subject knowledge, write a guideline report on how you would apply your concepts in industry.
11. Write a technical report on your visit to a process industry.
12. Solve old (last ten years) GATE question papers with reference to heat transfer subject.
13. Group discussion on the recent advances in heat transfer processes.
14. Write a report on your visit to research and development laboratory of national/international repute.
15. Technical interview based on the knowledge of heat transfer.

In addition to these above stated assignments concerned faculty member may design his/her own assignments

Term Work

Term work will consist of the experiments listed below, out of which any eight experiments are to be performed in laboratory by the students.

1. To determine rate of heat flow and thermal conductivity of an insulating material.
2. To determine thermal conductivity of a metal bar.
3. To study Newton's law of cooling to find rate of heat flow.
4 To determine the local heat transfer coefficients using the various correlations in natural convection.
5. To determine heat transfer coefficient in forced convection.
6. To study film wise condensation.
7. To study drop wise condensation.
8. To determine the critical heat flux
9. To study Stefan-Boltzman law and find the value of its constant.
10. To study evaporators.
11. To determine emissivity of an aluminum plate.
12. To study unsteady state processes.

Text Books/References

1. McCabe, W. L., J. Smith, and Harriot: "Unit operations of chemical engineering," Tata McGraw Hill.
2. Kern, D. Q.: "Process Heat Transfer," 11th ed., Tata McGraw Hill Publication, New Delhi.
3. Sukhatme, S. P.: "A Textbook on Heat Transfer,",4th ed., Universities Press, India, 2005.
4. Richardson, J. F., and J. M. Coulson: "Chemical Engineering," Butterworth Heinemann, Volume 1.
5. Holman,J.P.: "Heat Transfer," 9th ed., Tata McGraw Hill Publications, New Delhi,2004.
6. Frank, K., M. Bohn: "Principles of Heat Transfer," 5th edition, PWS Publishing company, Boston, 1997.

Syllabus for Unit Test

Unit Test -I	UNIT – I ,II,III
Unit Test -II	UNIT – IV,V,VI

CHEMICAL ENGINEERING THERMODYNAMICS-II

Designation : Professional Core

Course Pre-requisites : Students should have knowledge of

1. Chemical Engineering Thermodynamics I
2. Mathematics
3 Chemistry
4. Physics

TEACHING SCHEME		**CREDITS ALLOTTED**	
Lectures	: 3 Hours/Week	Theory	: 04
Tutorial	: 1 Hour /Week	Total credits	: 04
Total	: 4 Hours / Week		

Course Outcomes:

After completion of the course students will be able to

1. a) Understand the concept of fugacity and its application to gaseous and liquid systems

   b) Understand residual and excess properties to demarcate non- ideality in gaseous phase and liquid solution

2. a) Understand criteria of phase equilibrium and stability

   b) Make typical phase equilibrium calculations pertaining to VLE, LLE, SLE, SVE, etc.

3. a) Perform bubble P, dew P, bubble T, and dew T calculations for VLE

   b) Carry out thermodynamic consistency test for experimental VLE data

4. a) Understand the criterion for chemical reaction equilibrium

   b) Establish relation of equilibrium constant to composition for gas phase and liquid phase reactions.

5. a) Calculate equilibrium constant for heterogeneous system
   b) Understand phase rule for reacting system and its physical significance
6. Understand thermodynamics of liquid-liquid equilibrium.

Topics covered

UNIT - I (06 Hours)

Solution Thermodynamics

Concept of chemical potential; chemical potential as a criterion of phase equilibria; Concept of non ideality in gaseous mixtures; Fugacity and fugacity coefficient for species in solution; Methods of determination of fugacity coefficient; Concept of non-ideality in liquid mixtures; Activity and activity coefficient for species in solution; Excess properties; Gibbs excess energy; Model for estimation of excess property; Property change of mixing and heat effects in mixing.

UNIT - II (06 Hours)

Phase Equilibria

Criteria of phase equilibrium; Criterion of stability; Phase equilibria in single and multi component system; Phase rule: Duhems theorm; LLE, VLLE, SLE, and SVE; Phase diagrams; Dilute solution laws: Nernst's law, osmotic equilibrium.

UNIT - III (06 Hours)

Vapor-liquid equilibrium (VLE)

Qualitative behavior of VLE; Basic equation for vapor- liquid equilibrium; Liquid phase properties from VLE data; VLE at low to moderate pressures: excess Gibbs free energy models; Azeotropic data; VLE at high pressures; Multicomponent vapor- liquid equilibria; Bubble point and dew point calculations; Thermodynamic consistency test for VLE data.

UNIT - IV (06 Hours)

Chemical reaction equilibria

The reaction coordinate; Application of equilibrium criteria to chemical reactions; The standard Gibbs energy change and the equilibrium constant; Effect of temperature on the equilibrium constant; Evaluation of equilibrium constant; Relation of equilibrium constants to composition; Phase rule for reacting systems; Multi-reaction equilibria.

UNIT - V (06 Hours)

Heterogeneous reaction equilibrium

Notable industrial heterogeneous systems and thermodynamic role; The Gibbs energy change and equilibrium constant; Estimation of equilibrium constant for heterogeneous system by defining standard state of the phases involved; Pressure of decomposition; Simultaneous reactions; Combined physical and chemical equilibria.

UNIT - VI (06 Hours)

Liquid-liquid Equilibria (LLE)

Quantitative behavior of LLE; Basic equation governing LLE; Distribution coefficient (Partition Coefficient); Activity coefficient and its determination; Selection of extractant; Solubility parameters and estimation.

Tutorials/Assignments

1 Questions involving fugacity and activity for the species in solution.

2 Solving numerical in connection with phase equilibria.

3 Solving numerical based on application of Raoult's law for the calculation of dew point and bubble point

4 Conducting surprise MCQ test for students.

5 Draw P-xy and T-xy diagrams.

6 Solving numerical based on chemical reaction equilibrium.

7 Enhancement in collaborative learning is done through, group assignments that will be given to encourage students to work with classmates to discuss and complete homework assignments.

8 Students have to study any five NPTEL videos related to Chemical Engineering Thermodynamics I and prepare/present power point presentation.

9 Group discussions on any of the following topics:

   a) Importance of Phase equilibria in chemical industries.

   b) Thermodynamic properties for pure species and species in solution

10 Preparation of a brief report on applicability of liquid-liquid equilibrium (LLE) in chemical engineering systems.

11 Solve question papers of CET II of previous THREE years.

12 Unsolved numerical from the reference books on various topics studied.

Term Work

Term work includes minimum 08 assignments/problems on each unit covered

Text Books/ References

1. J. M. Smith and H. C. Van Ness, "Introduction to Chemical Engineering Thermodynamics", McGraw- Hill Publication
2. T. E. Daubert, " Chemical Engineering Thermodynamics", McGraw- Hill Publication
3. K.V. Narayanan," Chemical Engineering Thermodynamics", PHI Learning Pvt. Ltd.
4. B. F. Dodge, "Chemical Engineering Thermodynamics", McGraw- Hill Publication
5. M. D. Koretsky, "Engineering and Chemical Thermodynamics", 2nd Edition, John Wiley & Sons

6. S. I. Sandler, “Chemical Engineering Thermodynamics”, McGraw- Hill Publication
7. S. Glasstone, “Thermodynamics for Chemists”, Affileated East West Press Pvt.Ltd.

Syllabus for Unit Test

Unit Test - I	UNIT– I, II, and III
Unit Test - II	UNIT– IV, V, and VI

CHEMICAL PROCESS INDUSTRIES

Designation : Professional Core

Course Pre-requisites: None

TEACHING SCHEME		**CREDITS ALLOTTED**	
Lectures	: 02 Hours/Week	Theory	: 03
Tutorial	: 01 Hours /Week	Total credits	: 03
Total	: 03 Hours/Week		

Course Outcomes

After completion of the course students will be able to

1. Understand the concept of Unit operation and Unit processes as well the significance of process flow diagram.
2. Understand the manufacturing processes for soda ash, caustic and chlorine and Indian scenario of chlor-alkali industries.
3. Understand manufacturing processes of sulfur and nitrogen industry
4. Understand nitration of hydrocarbons and typical industrial process for nitration
5. Understand sulfonation and sulfation process used in organic industry
6. Understand processes for various petrochemicals

Topics covered

UNIT-I (08 Hours)

Concept of Unit Operation and Unit process

Unit operations and unit processes, Concept of block diagram, process flow diagram (ASME guidelines).

Water for the chemical process industry and its treatment: Boiler feed-water, Cooling tower water, Process Plant water.

UNIT-II (08 Hours)

Chlor -alkali industries

current status (Indian and global), Production and consumption pattern, Different processes for the manufacture of Soda ash, Caustic and chlorine

UNIT-III (08 Hours)

Sulfur Industry

Current status (Indian and global), Production and consumption pattern Sulfur and Manufacture of sulfuric acid, Different processes and comparison.

Nitrogen Industry

Current status (Indian and global), Production and consumption pattern Ammonia, Nitric acid, Urea and other nitrogen fertilizers, Mixed fertilizers.

UNIT-IV (08 Hours)

Nitration

Nitrating Agents, Kinetics and Mechanism of Aromatic Nitration, Nitration of Paraffinic hydrocarbons, Liquid phase nitration, Nitro compounds, and Commercial nitration process.

UNIT-V (08 Hours)

Sulfonation and Sulfation

Sulfonating and sulfating agents and their principal applications, Sulfonation and Sulfation of aliphatic compounds, Sulfonation of aromatic compounds, Commercial sulfonation process.

UNIT-VI (08 Hours)

Petrochemicals

Production of petrochemical precursors - olefins and aromatics, Production of ethylene, propylene, formaldehyde, methanol, ethylene oxide, ethanolamine, cumene, ethylene glycol, ethyl benzene

List of Practicals

The practical shall include at least (6) assignments from the various units mentioned in the syllabus.

One industrial visit should be arranged to the process industry and students should prepare the report on the same as a part of the term work.

Expert Interaction

Lecture(s) by eminent scholar(s) on the topic(s) mentioned in the syllabus.

Assignments

1. One industrial visit should be arranged to the process industry and the students will prepare the report which includes the consumption pattern of the products produced, process flow diagram and process description, major engineering problems in the industry.
2. Students should prepare the plant-layout for the industry visited.
3. Students should visit one CETP (Central effluent Treatment Plant) nearby and prepare the report which includes different unit operations in CETP, Significance of each unit.
4. Students should visit one STP (Sewage treatment plant) and prepare the report which includes different unit operations in STP, block diagram.
5. Students should compile the list of vendors (manufacturers of pumps, contact, and address) along with the details like type, specifications, and costs and should prepare the comparative for the same.
6. Students should prepare the report on “Material of construction” for pumps for special applications using the data from assignment 4.
7. Students should make a report on “Indian scenario of inorganic industries” which will include the name of industries (from different chemical zones), products manufactured, and production capacity.
8. Students should make a report on “Fertilizer industries in Maharashtra and Gujarat” which will include the name of industries (from different chemical zones), products manufactured, and production capacity.
9. Model making of any one Unit operation used in chemical process industry.

10 Describe the different equipment used to run the process plant with different utilities.

11 Students should compile the list of Boiler manufacturers, contacts, and address along with their product range specifications.

12 Students should compile the list of vendors providing "water treatment plants" in chemical process industries along with their product specifications.

13 Give a presentation on "commercial aspects of petrochemical products".

14 AutoCAD drawing of process flow diagram for any one process from the syllabus

Text Books

1. Dryden, C. E. "Outlines of Chemical Technology" (Edited and Revised by M.Gopal Rao and Sittig .M) East West Press. ,New Delhi,3 rd Edition(1997).
2. Austin G. T » Shreve's Chemical Process Industries", 5th ed., McGraw Hill.(1984)
3. Groggins, Unit process in organic synthesis, Tata McGraw-Hill Education

Reference Books

1 Faith, W. L., Keyes, D. B. and Clark, R. L., "Industrial Chemicals" John Wiley.(1975).

2 Kirk and Othmer, "Encyclopaedia of Chemical Technology" Wiley (2004).

3 Pandey G.N &Shukla.S.D, "Chemical Technology Vol - I" Vikas publication.

Syllabus for Unit Test

Unit Test -I UNIT – I ,II,III

Unit Test -II UNIT – IV,V,VI

SUBJECT: PROFESSIONAL SKILLS DEVELOPMENT

TEACHING SCHEME	:	**Theory : 4 Hours / Week**
EXAMINATION SCHEME	:	**End Semester Examination: 100 Marks**
CREDITS ALLOTED	:	**4**

Course Pre-requisites

The Students should have knowledge of

1. Basic concepts of Maths, Logical reasoning and English Grammar taught in the last semester.
2. An overall idea about the difference in personal and professional communication in terms of vocabulary used.
3. Knowledge of writing skills, importance of professionalism in emails and letters.
4. They should be aware of concepts of self esteem, self-assessment and its importance in setting long term and short term goals.
5. Awareness of the interpersonal skills like team work and introduction to Leadership taught during the last semester.
6. Body language and importance of non verbal communication to maintain professionalism.

Course Objectives

The Professional Skills Development 4 is an extension of PSD- 3 with focus on the remaining topics of Maths and Logical reasoning. The further complex concepts of Aptitude and Grammat aims to acquaint them with the level of complexity presented in recruitment tests and also provide them techniques to solve such question with tricks/methods in a very short period. The English communication and soft skills section of PSD-4 focuses on the higher aspects of soft skills such as grooming them on corporate etiquettes and various formats of email/ letter writing so that can present themselves as professionals further both in oral and written communication.

Course Outcomes

The student should be able to

1. Learn further concepts of Maths, Logical reasoning and English grammar and apply short cuts/ tricks to solve questions in less time. Learn remaining 25-30 rules of grammar relevant from the recruitment point of view.
2. Use appropriate words in the right context both academically and professionally. Students would have approximately around 80-100 words from the academic word list prescribed in the syllabus.
3. Understand the importance of email etiquettes and distinguish between the format of formal and informal emails/letters. They would be able to draft professional mails and letters like job application letters, cover letters, and apology emails with proper structure and words which are necessary in the corporate life.
4. Apply various strategies of conflict resolution through amicable way to settle team conflicts/disputes. They would learn to handle criticism and feedback in a positive way as an individual as well as a team.
5. Understand the major concepts of leadership like coaching, mentoring. They would learn effective time management strategies- Pareto principle (the 80-20 rule of time management) and apply them in the corporate life.
6. Understand the importance of grooming, body language and etiquettes in the corporate sector. They would be able to conduct themselves in a professional and impressive way by conducting themselves according to situations in the professional sector. They would also learn various strategies and conversational techniques to handle telephonic interviews confidently.

Unit I (18 Hours)

Aptitude (Maths, Logical Reasoning, English)

- **Maths**
  - i) Simple Interest and Compound Interest
  - ii) Ratio, Proportion and Average
  - iii) Mixture and Allegation

- **Logical Reasoning**
  i) Data Interpretation
  ii) Data Sufficiency
- **English**
  i) Grammar I
  ii) Vocabulary - Analogies

Unit II (4 Hours)

Essential Grammar - IV

- Vocabulary – Academic word List

Unit III (6 Hours)

Written Communication- III

- Email writing and etiquettes – formal and informal email writing, format of various types of email, do's and don'ts of email writing
- Letter writing – formal letters, job application letter, cover letter.
- Essay writing – mnemonics top develop ideas and write essays, structure of essays

Unit IV (4 Hours)

Self Awareness and Conflict Resolution

- Self-assessment & Perception & attitudes.
- Analyzing skills & weaknesses and habits.
- Developing positive attitude & handling criticism positively
- Handling conflicts in the personal and corporate sector
- Causes of conflicts in work scenario.
- Ways and methods for conflict resolution

Unit V (6 Hours)

Interpersonal Skills - III

- Mentoring, Difference between Leadership and Management
- Leading with examples
- Time management -The Time Management Matrix, Pareto Principle

Unit VI (4 Hours)

Corporate Etiquettes and Grooming

- Introduction to grooming & etiquettes
- Ways of handling telephonic interviews

Text Books

1. APAART: Verbal Ability
2. APAART: Logical Reasoning
3. APAART: Quantitative Aptitude
4. APAART: Speak Well 1 (English Language and Communication)
5. APAART: Speak Well 2 (Soft Skills)

RULES REGARDING ATKT, CONTINUOUS ASSESSMENT AND AWARD OF CLASS

Standars of Passing and ATKT Rules

1. For all courses, both UE (Universtiy Evaluation) and IA (Internal Assessment) constitue separate heads - of - passing (HoP). In ordar 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 course is atleast 6.0 (50 % Aggregate). The GPA for a course will be calculated only if the learner passes at the UE.
2. A student who fail 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 backlog candidate and clear the HoP.

Rules of ATKT

1. A student is allowed to carry backlog of courses prescribed for B.Tech Sem - I, III, V, VII to B.Tech Sem - II, IV, VI, VIII respectively.
2. A student is allowed to keep term of Sem - III, if he/she is failing in any number of subjects of Sem I & II.
3. A student is allowed to keep term of Sem - V, if he/she is failing in any number of subjects of Sem - III & IV but passed in all subjects of Sem - I & II.
4. A student is allowed to keep term of Sem - VII, if he/she is failing in any number of subjects of Sem - V & VI but passed in all subjects of Sem - III & IV.

Award of Class for the Degree Considering CGPA

Award of Honours

A student who has completed the minimum credits specified for the programme shall be decleared 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 at the End of the Programme are as given below.

Range of CGPA	Final Grade	Performance Descriptor	Equivalent Range of Marks (%)
$9.50 \le CGPA \le 10.00$	0	Outstanding	$80 \le Marks \le 100$
$9.00 \le CGPA \le 9.49$	A+	Excellent	$70 \le Marks \le 80$
$8.00 \le CGPA \le 8.99$	A	Very Good	$60 \le Marks \le 70$
$7.00 \le CGPA \le 7.99$	B+	Good	$55 \le Marks \le 60$
$6.00 \le CGPA \le 6.99$	B	Average	$50 \le Marks \le 55$
$5.00 \le CGPA \le 5.99$	C	Satisfactory	$40 \le Marks \le 50$
CGPA Below 5.00	F	Fail	Marks Below 40

Vision

To provide quality chemical engineers for the growth and development of the nation.

Mission

Nurture students into dynamic chemical engineers for societal progress

Programme Educational Objectives (PEOs)

A. Practice chemical engineering in conventional, multidisciplinary and emerging fields.

B. Pursue advanced studies or other forms of continuing education.

C. Demonstrate professionalism, ethical and social responsibility and desire for lifelong learning.

Programme outcomes (POs)

A chemical engineering graduate will be able to

1. Apply knowledge of mathematics, science and engineering principles to solve wide range of open ended chemical engineering problems.
2. Analyze the problem and give feasible solutions using fundamentals of mathematics, basic sciences and engineering sciences.
3. Design chemical process equipments and processes to meet desired needs with realistic constraints.
4. Conduct engineering experiments to analyze and interpret the information obtained from the experiment to synthesis and design valid conclusions.
5. Utilize the techniques, analytical skills and modern computational tools necessary for successful chemical engineering practice.
6. Develop the culture of health and safety in chemical engineering practice by adhering to statutory regulations.
7. Understand the impact of chemical engineering solution in a techno-economic, environmental and societal context for sustainable development.

8. Understand the need for ethical decision making in engineering practice.
9. Function effectively as an individual and as a member or leader within multi disciplinary teams.
10. Express ideas and position clearly and concisely in both oral and in written communication.
11. Understand the fundamental precept of effective project management and finance.
12. Appreciate the need for and engage in lifelong learning to maintain and enhance the practice of chemical engineering.
13. Acquire entrepreneurship skills and business insight.

B.TECH (CHEMICAL) SEM :- V

Sr. No.	Subject	Teaching Scheme (Hours/week)			Examination Scheme (Marks)							Credit		
		L	P/D	T	End Semester Examination	Continuous Assessment			TW/O	TW/P	Total	Theory	P/D	Total
						Unit Test	Attendance	Assignments						
1	Elective-I	3	-	-	60	20	10	10	-	-	**100**	3	-	**3**
2	Mass Transfer Operation	4	2	-	60	20	10	10	-	50	**150**	4	1	**5**
3	Chemical Reaction Engineering- I	4	2	-	60	20	10	10	-	50	**150**	4	1	**5**
4	Chemical Engineering Mathematics	3	-	1	60	20	10	10	50	-	**150**	4	-	**4**
5	Computer Programming for Chemical Engineers –I	3	2	-	60	20	10	10	-	50	**150**	3	1	**4**
6	Professional Skill Development-V	4	-	-	100	-	-	-	-	-	**100**	4	-	**4**
Total		**21**	**6**	**1**	**400**	**100**	**50**	**50**	**50**	**150**	**800**	22	3	**25**

Elective-I:

i) Multiphase Flow:

ii) Advanced Material Sciences:

iii) Rheology:

iv) Combustion Engineering:

Sr. No.	Subject	Teaching Scheme (Hours/week)			Examination Scheme (Marks)							Credit		
		L	P/D	T	End Semester Examination	Continuous Assessment			TW/ O	TW/ P	Total	Theory	P/D	Total
						Unit Test	Atten dance	Assign ments						
7	Elective-II	3	-	-	60	20	10	10	-	-	**100**	3	-	**3**
8	Separation Techniques	4	2	-	60	20	10	10	-	50	**150**	4	1	**5**
9	Chemical Process Equipment Design– I	3	2	-	60	20	10	10	-	25	**125**	3	1	**4**
10	Chemical Reaction Engineering - II	3	2	-	60	20	10	10	-	50	**150**	3	1	**4**
11	Process Instrumentation and Instrumental Methods of Analysis	3	2	-	60	20	10	10	-	25	**125**	3	1	**4**
12	Professional Skill Development-VI	4	-	-	100	-	-	-	-	-	**100**	4	-	**4**
13	Computer Programming For Chemical Engineering-II	-	2	-	-	-	-	-	-	50	**50**	-	1	**1**
Total		**20**	**10**	-	**400**	**100**	**50**	**50**	-	**200**	**800**	20	5	**25**

Total Credits

Semester V : 25

Semester VI : 25

Grand Total : 50

Elective-II

i) Biofuel Technology:

ii) Food Technology:

iii) Polymer Technology:

iv) Nanomaterials:

ELECTIVE-I : MULTIPHASE FLOW

Designation : Elective

Course Pre-requisites : Students should have basic knowledge of

1 Fluid Flow Operations

2 Process Heat Transfer

TEACHING SCHEME	**CREDITS ALLOTTED**
Lectures : 3 Hours/Week	Theory : 03
	Total credits : 03

Course Outcomes

After completion of the course students will be able to

1. Explain the concept of two phase flow and describe the flow types, flow regimes in horizontal and vertical flow
2. Describe the two phase flow classifications.
3. Explain the mixing power correlations.
4. Identify and explain packed bed, fluidized bed, bubble column and its design aspects.
5. Explain the concept of multiphase flow and identify the flow regimes.
6. Explain cavitation and RTD in multiphase flow system.

Topics covered

UNIT-I (06 Hours)

Gas/liquid and liquid/liquid Two phase flow

Scope and significance of multiphase flows, Dimensionless numbers in multiphase flows; Flow types and regimes in horizontal and vertical flow, Regime maps, Behaviour of non-Newtonian fluids in two phase flow.

UNIT-II (06 Hours)

Flow Classification

Two-phase Co-current flow of Gas-Liquid, Gas-Solid and Liquid-Liquid, Upward and Downward Flow in Vertical pipes. Suspensions of Solid and their transport in Horizontal Pipes. Drag Reduction Phenomena, Laminar, Turbulent and Creeping Flow Regimes.

UNIT-III (06 Hours)

Mixing Power Correlations

Theories of Intensity and Scale of Turbulence. Calculation of Circulation Velocities and Power Consumption in Agitated Vessels for Newtonian and Non-Newtonian Fluids. Blending and Mixing of Phases, flow patterns. Power requires for aeration to suspend to an Immiscible Liquid or Solids in Slurry Reactors, Prediction of optimum speed of Impeller Rotor. Mixing equipments.

UNIT-IV (06 Hours)

Quantification of Flow System

Prediction of Holdup, Pressure Drop and bubble size in pipe flow, Lockhart – Martinelli Parameters, Bubble Column and its Design aspects; Flow through Packed Bed and Fluidized Bed, Minimum Carryover Velocity. Holdup Ratios, Pressure Drop and Transport Velocities and their prediction. Solid-Fluid Conveying and Settling.

UNIT-V (06 Hours)

Flow in Three - Phase Systems

Introduction to three phase flow; Flow regime identification, pressure drop, void fraction and flow rate measurement, Prediction of Holdup, Pressure Drop and throughput velocities in three –phase system. phase separation and settling behaviour, analysis of stratified and bubble flow, formation of bubbles and drops and their size distribution and hold up in different flow system, momentum and energy relations.

UNIT-VI (06 Hours)

RTD in multiphase flow system

Non-Ideal Flow: Residence time distribution of fluid in vessel, non-ideal flow patterns, E, F, C curve, Mean and variance, residence time, Models for non-ideal flow.

Cavitation

Introduction, types of cavitation, mechanism of cavitation. Key features of bubble cavitation: cavitation inception, cavitation bubble collapse, shape distortion during bubble collapse, cavitation damage. Cavitation bubbles: observations of cavitating bubbles, cavitation noise and cavitation luminescence.

Assignments

1. Give fifteen minutes presentation (seminar) on particular topic and prepare a report.
2. Students have to study any five NPTEL videos related to multiphase flow and prepare/present power point presentation.
3. Students have to visit chemical industry and make a detailed report on multiphase flow.
4. Write a report on the recent advances in multiphase flow with reference to the current year.
5. Prepare models for bubble column, packed bed and fluidized bed reactors.
6. With the help of this subject knowledge, write a guideline report on how you would apply your concepts in industry.
7. Write a report on your visit to research and development laboratory of national/international repute.
8. Solve old (last five years) GATE question papers with reference to multiphase flow.
9. Group discussions on any one topic from above six units.
10. Technical interview based on the knowledge of multiphase flow.

In addition to these above stated assignments concerned faculty member may design his/her own assignments

Text Books / References:

1. Wallis, G.B.; One Dimensional Two Phase Flow, McGraw Hill Book Co., New York, 1969.
2. Hewitt, G.F.; Measurement of Two Phase Flow Parameters.
3. Govier, G. W. and Aziz, K.; The Flow of Complex Mixture in Pipes, Richardson, Tex.: Society of Petroleum Engineers 2008.
4. Butterworth and Hewitt, Two Phase Flow
5. John, G. Collier and John, R. Thome,; Convective Boiling and Condensation, Oxford University Press, 3rd Edition, 2002.
6. Levenspiel, O.; Chemical Reaction Engineering, 3rd Ed , John Wiley & Sons, Singapore (1999).
7. Doraiswamy, L.K., and Sharma, M.M.; Heterogeneous Reactions: Volume 2 Fluid-Fluid-Solid Reaction, John Wiley & Sons, 1984, Singapore
8. Coulson, J.M. and Richardson, J.F.; Chemical Engineering, Vol I, 6th edition, Oxford, 1999.
9. D.G. Knudsan and D. L. Katz. Fluid Dynamics and Heat transfer. Mc-Graw Hill, 1958
10. A.H. P. Skelland "Non Newtonian flow and Heat transfer" John Wiley 1867
11. Brodkey, R. S.; The Phenomena of Fluid Motions", Addision –Weseley, New York, 1967.
12. Hestroni, G., (Ed.) ; Hand book of Multiphase systems, Hemisphere Publishing, Washington, 1982.
13. Christopher, E. Brenner; Fundamentals of multiphase flows, Cambridge University Press 2005.

Syllabus for Unit Test

Unit Test -I	UNIT – I ,II,III
Unit Test -II	UNIT – IV,V,VI

ELECTIVE I: ADVANCED MATERIAL SCIENCE

Designation : Elective

Course Pre-requisites :

1. Basic chemistry, Basic physics, Chemical Engineering Materials, Physical chemistry, Chemical Reaction Engineering, Chemical Engineering Thermodynamics

TEACHING SCHEME	**CREDITS ALLOTTED**
Lectures: 3 Hours/Week	Theory : 03

Course Outcomes:

1. Explain basics of polymers and their classifications
2. Explain various polymer properties and the their effect on engineering properties
3. Determine suitable process for polymer synthesis and describe its mechanism
4. Understand the basics of polymer characterizations and discuss its effect on properties
5. Explain the formation of composites and blends in polymers
6. Explain the methods of polymer compounding and processing

Advance Material

1. Determine the composition of composite material and its preparation for desired properties.
2. Prepare the metal composite to obtain desired properties.
3. Characterize composite and other Materials.
4. Determine energy obtained from concerned nuclear change.
5. Determine applicability of biomaterials depending upon their properties.
6. Select nano-material for desired application.

Topics covered

UNIT-I (06 Hours)

Material composites

Introduction to composite materials, factors influencing the properties of composite materials like fiber parameter, matrix, interface & molding methods. Phase selection criteria. Reinforcing mechanisms. Interfaces, advantages and disadvantages. Polymer composites. Reinforcing and matrix materials, prepregs, fiber winding techniques, fabrication techniques, laminates, mechanical behavior, etc.

UNIT-II (06 Hours)

Composite and reinforcement

Metal composites, types of reinforcement, chemical compatibility, fabrication processes, mechanical behavior and properties, ceramic composites. Matrices and reinforcement. Why to reinforce ceramics, fabrication methods, crack propagation and mechanical behavior.

UNIT-III (06 Hours)

Carbon composites

Carbon composites, their properties, fabrication methods and their applications, ablative polymers, their applications, air craft materials, characterization technique for compositas and materials XRD, FTIR, SRM, TEM and their applications.

UNIT-IV (06 Hours)

Nuclear materials

Atomic structure, atomic number, mass number, isotopes, nuclear energy and nuclear forces, binding energy, nuclear stability, radioactivity, nuclear reactions, nuclear fissions, nuclear fusion, Types of waste –disposal – radiation hazards and prevention

UNIT-V (06 Hours)

Biomaterials

Properties of biomaterials: Physical, thermal, electrical and optical properties of bio-materials and their application to processing. Novel Biomaterials and their importance in chemicals. Engineering and Tissue Engineering: Hydrogels, self-assembling peptides, Implants other materials: Metallic implant materials, hydroxyapatite glass ceramics carbons, Polymeric implant, medical applications.

UNIT-VI (06 Hours)

Nanomaterials

Basics - distinction between molecules, nanoparticles and bulk materials; size-dependent properties. Nanoparticles: nano cluster, nano rod, nanotube (CNT) and nanowire. Synthesis: precipitation, thermolysis, hydrothermal, solvothermal, electrode position, chemical vapour deposition, laser ablation; Properties and applications

Assignments

1. Prepare the report on any advanced material comprising its significance, preparation, characterization, processing, properties and application

References/Text Books

1. L.C. Merrite, "Basic principles of Nuclear science and Reactors" Wiley Eastern 1977.
2. Polymers of high technology, electronics and photonics, Bowden M.J & Turner S.R., ACS Symp. Ser. 346, 1987.
3. Composite Materials , Chawala K.K., Springer Science & Business Media.
4. Buddy D. Ratner Allan S. Hoffman Frederick J. SchoenJack E. Lemons Biomaterials Science, Second Edition: Wiley Science 2004.
5. "An Introduction to Materials Engineering and Science for Chemical and Materials Engineers," by Brian S. Mitchell; Wiley-Interscience, 2003; ISBN 0471436232.

6. Carl C. Koch (ed.), "Nanostructured Materials", Processing, Properties and Potential Applications, Noyes Publications, Norwich, New York, U.S.A.
7. Bhusan, Bharat (Ed), “Springer Handbook of Nanotechnology”, 2nd Edition, 2007.

Syllabus for Unit Test

Unit Test –I	UNIT – I ,II,III
Unit Test –II	UNIT – IV,V,VI

ELECTIVE-I: RHEOLOGY

Designation : Elective

TEACHING SCHEME		**CREDITS ALLOTTED**	
Lectures	: 3 Hours/Week	Theory	: 03
Practical	: ---	Practical	: ---
Total	: 3Hours/Week	Total credits	: 03
		Total credits	: 03

Course Outcomes

After completion of the course students would be able to

1. Apply the rheological models to study the rheology of non-Newtonian fluids
2. Describe the operation of instruments used for measurements of rheological properties
3. Obtain the rheological behavior of non-Newtonian fluids
4. Explain the rheological models for rubber compounds
5. Describe the models to represent behavior of polymer liquids
6. Obtain the variable influencing the rheology of fluids

Topics covered

UNIT-I (08 Hours)

Introduction

Types of fluid flow, time dependant fluids, shear rate dependant fluids, Newtonian and Non Newtonian fluids, Definition of Rheology, Rheological Perspective, The importance of nonlinearity, Solids and liquids, Components of rheological research: Rheometry, Constitutive equations.

UNIT-II (08 Hours)

Rheological Models

Power law fluid Model, Eyring Model, Bingham Plastic fluid model, Ellis fluid model, Eyring-Powel model , Reiner-Phillipoff model , Meter model. Instruments used for measurements of Rheological properties capillary rheometer, melt flow index, cone and plate viscometer, Torque rheometer, Mooney viscometer

UNIT-III (08 Hours)

Experimental Studies of Rheological Behavior

Steady Shear Flow: Elongation Flow, Oscillating Flow: Stress Relaxation, Temperature Dependence: Processability, Test & Dependence upon Polymer Structure, Shear Flow Boundary Conditions and Slippage, Flow induced Degradation & Mechanochemistry.

UNIT-IV (08 Hours)

Rheology of Rubber

Rheological Models and Approaches to Flow Analysis: One Dimensional Rheological Models for Rubber Compounds: Plastic Viscous Model, Plastic Viscoelastic Model, Thixotropic Model, Equation of Motion and Dimensional Analysis of Non-Newtonian Fluids: General, Viscoelastic Fluids, Plastic Fluids, Energy Equation & Non Isothermal Flow :Energy Equation, Dimensional Analysis, Classification of Flows :Internal & External Flow, Hydrodynamic Lubrication Theory.

UNIT-V (08 Hours)

Rheology of polymers

Introduction

Elastic materials ,Viscous materials, Viscoelasticity, Effect of rate of strain, temperature and time on mechanical behavior of polymeric materials, creep, stress relaxation Models to represent behavior of Polymer Liquids

Mechanical models, stress strain response of spring and dashpot Viscoelastic models, Maxwell element, Voigt Oelvin element, response to creep and stress relaxation, Four parameter model, dynamic mechanical properties, behavior of Maxwell element and relaxation spectra

UNIT-VI (08 Hours)

Variable influencing the Rheology of fluids

Effect of Temperature, Effect of Pressure, Effect of Molecular weight & Molecular structure, effect of entanglement of molecules & molecular motions.

Assignments

1. Group discussion on the recent advances in rheology.
2. Presentation on a instruments used for measurements of rheological properties.
3. Group discussion on importance of studying this elective.
4. Technical interview based on the knowledge of rheology.
5. Presentation on rheological models for rubber compounds.
6. Write a report on your visit to research and development laboratory of national/international repute.
7. Technical interview based on the knowledge of rheology.
8. Preparation of report on recent trends in rheology of polymers.
9. Group discussion on variable influencing the rheology of fluids

In addition to these above stated assignments concerned faculty member may design his/her own assignments

Text Books/References

1. R. B. Bird, W. E. Stewart, E. N. Lightfoot, “ Transport Phenomena” Wiley-India, New Delhi
2. Dr. B. R.Gupta, “Rheology of Elastomers”
3. H.A. Barnes, J. F. Hutton and K. Walters, “An Introduction to Rheology”

4. R. P. Chhabra & J. F. Richardson , “Non-Newtonian Flow and Applied Rheology”
5. Chang Dae Han, “Rheology in Polymer Processing”, Academic Press, New York
6. R.S. Lenk, “Polymer Rheology”, Applied Science, London

<u>Syllabus for Unit Test</u>

Unit Test -I	UNIT – I ,II,III
Unit Test -II	UNIT – IV,V,VI

ELECTIVE-I: COMBUSTION ENGINEERING

Designation : Elective

Course Pre-requisites : Students should have

1. Basic knowledge of chemistry

TEACHING SCHEME	**CREDITS ALLOTTED**
Lectures: 3Hours/Week	Theory : 03
	Total credits : 03

Course Outcomes

After completion of the course students will be able to

1. Identify the fundamental definitions, properties and various measurement techniques for fuels.
2. Describe the combustion techniques of solid fuel i.e. coal.
3. Explain the concept of exploration of crude petroleum and refinery equipments.
4. Explain about different important gaseous fuels
5. Emphasis is given to combustion of various fuels in the light of thermodynamics and applies the knowledge of gross and net calorific values of fuel and solves the problems based on them.
6. Describe the incineration technology.

Topics covered

UNIT-I (06 Hours)

Introduction

History of Fuels : History of solid fuel, History of liquid fuels and gaseous fuels, Production, present scenario and consumption pattern of fuels, Fundamental definitions, properties and various measurements: Definitions and properties of solid fuels, Definitions and properties of liquid and gaseous fuels, Various measurement techniques.

UNIT-II (06 Hours)

Solid Fossil Fuel (Coal)

Coal classification, composition and basis, Coal mining, Coal preparation and washing, Combustion of coal and coke making (Action of heat on different coal samples, Different types of coal combustion techniques, Coal tar distillation), Coal liquefaction (Direct liquefaction, Indirect liquefaction), Coal gasification

UNIT-III

Liquid Fossil Fuel (Petroleum)

Exploration of crude petroleum, Evaluation of crude, Distillation (Atmospheric distillation, Vacuum distillation), Secondary processing (Cracking, Thermal cracking, Visbreaking, Coking, Catalytic cracking, Reforming of naphtha, Hydrotreatment, dewaxing, deasphalting), Refinery equipments.

UNIT-IV

Gaseous Fuels

Natural gas and LPG, Producer gas, Water gas, Hydrogen, Acetylene, Other fuel gases

UNIT-V

Combustion Technology

Fundamentals of thermochemistry, Combustion air calculation, Calculation of calorific value of fuels, Adiabatic flame temperature calculation, Mechanism and kinetics of combustion, Flame properties, Combustion burners, Combustion furnaces, Internal combustion engines

UNIT-VI

Incineration Technology

Classification, Key Issues, Pretreatment of Waste, Sorting, Homogenization, Moving Grate Incineration, Rotary Kiln Incineration, Fluidized Bed

Incineration, advantages, disadvantages and applications of incineration. Furnaces and Boilers.

Assignment

1. Presentations on any topic of combustion engineering.
2. Recent trends in combustion technology.
3. Alternative fuel for engines.
4. Measurement of calorific values of any two types of fuel.
5. Detail study on solid fossil fuel.
6. Solve last five years GATE question papers with reference to combustion engineering.
7. Students have to study any five NPTEL videos related to combustion engineering and prepare/present power point presentation.
8. Numerical based on above fifth unit.
9. Detail study on liquid fossil fuel.
10 Detail study on gaseous fuels.
11. With the help of this subject knowledge, write a report on how you would apply your concepts in industry.
12. Prepare a report on combustion technology which is newly introduced in the current year.
13. Write a report on incineration technology.

In addition to these above stated assignments concern faculty member may design his/her won.

Text Books/References

1. Richard A. Dave, “Modern Petroleum Technology”, Vol 1 , Upstream, 6th ed., John Wiley & Sons. Ltd.2002.
2. Alan G. Lucas, “Modern Petroleum Technology”, Vol 2, Downstream, 6th ed., John Wiley & Sons. Ltd.2002.
3. Irvin Glassman, “Combustion”, 2nd ed., Academic Press.2009.

4. B.K. Bhaskar Rao, “Modern Petroleum Refining Processes”, 5th ed., Oxford & IBH Publishing Co. Pvt. Ltd.2007.
5. John Griswold ,”Fuels Combustion and Furnaces” , Mc-Graw Hill Book Company Inc.1988.
6. Samir Sarkar, “Fuels and Combustion”, 3rd. ed Universities Press.2009.
7. W.L. Nelson, “Petroleum Refinery Engineering”, 4th ed. Mc-Graw Hill Book Company.1958.

Syllabus for Unit Test

Unit Test -I	UNIT – I ,II,III
Unit Test -II	UNIT – IV,V,VI

MASS TRANSFER OPERATION

Designation : Professional Core

Course Pre-requisites : Students should have basic knowledge of

1 Heat Transfer operation

2 Unit Operations and stiochiometry

TEACHING SCHEME		CREDITS ALLOTTED	
Lectures	: 4 Hours/Week	Theory	: 04
Practical	: 2 Hour /Week	Practical	: 01
Total	: 6Hours/Week	Total credits	: 05

Course Outcomes

After completion of the course students would be able to

1. Evaluate diffusivity and rate of diffusion.
2. Evaluate mass transfer coefficients and understand interphase mass transfer.
3. Calculate the height of transfer unit, number of transfer unit, in absorption column.
4. Calculate rate of mass transfer in humidification.
5. Estimate rate and time of drying.
6. Analyze type of crystallization and estimate yield of crystallization.

Topics covered

UNIT-I (08 Hours)

Diffusion

Molecular diffusion in fluids: Steady state diffusion in fluids at rest and in laminar flow, Steady state diffusion of A through nondiffusing B , equimolal counter diffusion, steady state diffusion in multicomponent mixture , molecular diffusion in fluids, diffusivity of liquids and gases, effect of temperature and pressure on diffusivity, diffusion in solids. Laws of diffusion and empirical equations – Maxwell's law, Stefan's law, Winkle man's method.

UNIT-II (08 Hours)

Mass transfer Coefficient and Interphase Mass Transfer

a) Mass transfer coefficients: Mass transfer coefficient in laminar flow and in turbulent flow. Relation of individual and overall mass transfer coefficient. Theories of mass transfer. Mass, heat and momentum transfer analogies.

b) Interphase mass transfer. Equilibrium in mass transfer, two resistance concept. diffusion between phases. Steady state co-current and counter current processes. continuous crosscurrent, counter-current, crosscurrent cascade operations and mass balances.

UNIT-III (08 Hours)

Absorption

Introduction to absorption, types of tower packing's, contact between liquid and gas, pressure drop and limiting flow rates, material balances for each flow , limiting gas-liquid ratio, rate of absorption, calculation of HTU, NTU and HETP. Alternate forms of transfer coefficients and their relations. Tray Efficiencies, absorption in plate columns, absorption with chemical reaction. Equipments for absorption column.

UNIT-IV (08 Hours)

Humidification

Vapor-liquid equilibrium, enthalpy for pure substances, definitions of humidity terms, adiabatic saturation temperature, wet bulb and dry bulb temperatures, study of humidity charts, lewis relation. method of adiabatic humidification and dehumidification. Equipments for humidification, cooling tower design.

UNIT-V

Drying

Basic principles of drying. equilibrium in drying. definitions of terms in drying, types of moisture binding, rate of drying curve, mechanism of batch drying and continuous drying, time requirement for drying, mechanism of moisture movement in solids.

Equipments used for drying

Classification of dryers, solids handling in dryers, equipments for batch and continuous drying processes: working principle of tray driers, tower driers, rotary driers, spray driers. Concept of freeze drying (08 Hours)

UNIT-VI

Crystallisation

Introduction to the process, principal rate of crystallization, Mier's supersaturation theory, growth and properties of crystals, crystallisation rate, calculations of yield, mass and enthalpy balances. Equipments used in crystallization.

Assignments

1. Write a report on the recent advances in mass transfer processes with reference to the current year.
2. Solve old (last five years) question papers with reference to particular topic.
3. Prepare a model for any of the Mass transfer equipment.
4. Prepare a report on Mass transfer equipments which are newly introduced in the current year.
5. Give fifteen minutes presentation (seminar) on particular topic and prepare a report.
6. Evaluate efficiencies of different Gas-liquid contact equipment. .

7. With the help of this subject knowledge, write a guideline report on how you would apply your concepts in industry.
8. Design laboratory manuals better than existing ones with clearly shown specimen calculations.
9. Compare working and principles for different mass transfer operations.
10. Solve numerical for any industrial data.
11. Write a technical report on your visit to a process industry.
12. Solve old (last ten years) GATE question papers with reference to Mass transfer-I subject.
13. Group discussion on the recent advances in mass Transfer equipments.
14. Write a report on your visit to research and development laboratory of national/international repute.
15. Technical interview based on the knowledge of Mass transfer.

In addition to these above stated assignments concerned faculty member may design his/her own assignments

<u>Term Work</u>

Term work will consist of the experiments listed below, out of which any eight experiments are to be performed in laboratory by the students.

1. To calculate diffusion coefficient in Liquid-Liquid diffusion.
2. To calculate diffusion coefficient in still air..
3. To study characteristics of Wetted Wall Column.
4 To calculate individual and overall interface mass transfer coefficient.
5. To estimate efficiency of cooling Tower.
6. To estimate rate of drying in tray drier/rotary drier
7. To study the crystallization process by air, water cooling and seeding.
8. Humidification and Dehumidification experiment.
9. To study agitated batch crystallizer

10. Study of Spray drier

Text Books/References

1. McCabe, W. L., J. Smith, and Harriot: "Unit operations of chemical engineering," Tata McGraw Hill.
2. Treybal R.E., Mass Transfer Operations, 3rd Ed., McGrawHill, 1981.
3. King C. J. "Separation Techniques," McGraw Hill Publications
4. Richardson, J. F., and J. M. Coulson: "Chemical Engineering," Butterworth Heinemann, Volume 1.
5. E. L. Cussler, "Diffusion Mass Transfer in fluid systems " 3rd Ed. Cambridge Series in Chemical Engineering.

Syllabus for Unit Test

Unit Test -I	UNIT – I ,II,III
Unit Test -II	UNIT – IV,V,VI

CHEMICAL REACTION ENGINEERING-I

Designation : Professional Core

Course Pre-requisites : Students should have basic knowledge of

1 Analytical and physical Chemistry

2 Process Calculation

3 Mathematics including integration and derivation

TEACHING SCHEME	**CREDITS ALLOTTED**
Lectures : 4 Hours/Week	Theory : 04
Practical : 2 Hour /Week	Practical : 01
Total : 6Hours/Week	Total credits : 05

Course Outcomes

After completion of the course students would be able to

1. Define rates of homogeneous chemical reactions and express the temperature dependent term of a rate equation with Arrhenius' Law and other theories
2. Design experiments, analyze and interpret data, and apply the results to chemical systems and processes.
3. Design ideal batch reactors, ideal CSTR reactors and ideal plug flow reactors.
4. Analyze multiple reactor system, autocatalytic and recycle reactors.
5. Specify operating conditions to produce desired products from parallel and series chemical reactions.
6. Evaluate effect of temperature on reaction.

Topics covered

UNIT-I (08 Hours)

Chemical Kinetics

Classification of reactions, rate laws and stoichiometry, relative rates of reaction, reaction order, rate limiting step, half life, concentration-dependent term of a rate equation, temperature-dependent term of a rate equation, Temperature dependency from Arrhenius law, Transition state theory, collision theory, rate equation using partial pressure and concentration, their interrelation, searching for a reaction mechanism.

UNIT-II (08 Hours)

Interpretation of Batch reactor data

Interpretation of batch experimental kinetics data using integral and differential analysis, constant volume batch reactor system, design equation for zero, first, second and third order irreversible and reversible reactions, graphical interpretation of these equations and their limitations, variable volume batch reactors, design equation for zero, first and second order irreversible and reversible reactions, graphical interpretation of their limitations.

UNIT-III

Introduction to Reactor Design

Single ideal reactors under steady state conditions, design equations for batch, mixed flow & plug flow reactor, development of rate expression for mean holding time for a plug flow reactor, space time and space velocity, Introduction to Semi-batch reactor.

UNIT-IV

Isothermal flow reactors

Size comparison of reactor performance, sequences of reactors, reactors with recycle. optimum size determination, reactors in series and parallel, performance of infinite number of back mix reactors in series, back mix and plug flow reactors of different sizes in series and their optimum way of staging, optimum recycle ratio for auto –catalytic (recycle) reactors.

UNIT-V (08 Hours)

Design of reactors for Single and Multiple reactions

Parallel and consecutive reactions in batch, CSTR and PFR, qualitative discussion about product distribution, quantitative treatment of product distribution and reactor size, factors affecting such as choice, optimum yield, conversion, selectivity, reactivity on consecutive and parallel reactions in reactors.

UNIT-VI (08 Hours)

Non-Isothermal reactor for homogeneous reactor systems

Energy balances in reactors, adiabatic operations, non-adiabatic operations, stability of reactors, non-isothermal homogeneous reactor systems, rates of heat exchanges for different reactors, adiabatic operations for batch and continuous reactors, optimum temperature progression, rate, temperature and conversion profiles for exothermic and endothermic reactions.

Assignments

1. Write a report on the recent advances in chemical reaction engineering with reference to the current year.
2. Give fifteen minutes presentation (seminar) on particular topic and prepare a report.
3. With the help of this subject knowledge, write a guideline report on how you would apply your concepts in industry.
4. Derive the rate equations for various combinations of reactors.
5. Suggest best suitable reactor arrangement for zero, first and second order reaction.
6. Explain in detail use of kinetics in equipment/reactor design.
7. Design laboratory manuals better than existing ones with clearly shown specimen calculations.
8. Solve old (last five years) question papers with reference to particular topic.

9. Prepare a model for any of the reactor.
10. Solve old (last ten years) GATE question papers with reference to chemical reaction engineering subject.
11. Group discussion on the recent advances in reaction engineering.
12. Write a report on your visit to research and development laboratory of national/international repute.
13. Technical interview based on the knowledge of chemical reaction engineering.

In addition to these above stated assignments concerned faculty member may design his/her own assignments

Term Work

Term work will consist of the experiments listed below, out of which any eight experiments are to be performed in laboratory by the students.

1. Study of first order reaction.
2. Study of PFR & CSTR combination in second order reaction.
3. Rate constant of hydrolysis of methyl acetate by dilute HCl.
4 Energy of activation of a reaction between K2S2O8 and KI
5. Study of homogeneous catalytic reaction, decomposition of hydrogen peroxide, acid catalysed ester hydrolysis.
6. Hydrolysis of ester (e.g. ethyl acetate) by alkali (NaOH).
7. Study of CSTR combination in first order reactions.
8. Determination of Arrhenius parameters.
9. Rate constant for saponification of ethyl acetate with NaOH using CSTR.
10. Rate constant for saponification of ethyl acetate with NaOH at ambient conditions using PFR.
11. Rate constant for saponification of ethyl acetate with NaOH at ambient conditions using

    (i) Isothermal batch reactor (ii) Isothermal CSTR.
12. Study and operation of an adiabatic batch reactor.

13. Study of a reversible reaction in a batch reactor.
14. To determine energy of activation of reaction of ethyl acetate with sodium hydroxide.
15. Find out specific rate constant and activation energy of a reaction in a plug flow reactor.
16. Use MATLAB software to simulate Batch / CSTR / Plug flow reactor data.

Text Books/References

1. Octave Levenspiel, "Chemical Reaction Engineering", 3rd Edition, John Wiley and sons, New Delhi, 2007. (ISBN 9788126510009).
2. Scott Fogler H, "Elements of Chemical Reaction Engineering", 4th Edition, Prentice Hall of India, New Delhi, 2006. (ISBN : 9788120334168).
3. Keith J. Laidler, "Chemical Kinetics", 3rd Edition, Pearson Education Inc. (ISBN: 9788131709726).
4. Smith J.M., "Chemical Engineering kinetics", 3rd Edition, McGraw Hill, 1981. (ISBN: 0070665745).

Syllabus for Unit Test

Unit Test -I UNIT – I ,II,III

Unit Test -II UNIT – IV,V,VI

CHEMICAL ENGINEERING MATHEMATICS

Designation : Professional Core

Course Pre-requisites : Students should have

Basic knowledge of Mathematics including derivative, integration etc.

TEACHING SCHEME

Lectures : 3Hours/Week

Tutorial : 1Hour/Week

CREDITS ALLOTTED

Theory : 03

Tutorial : 01

Total credits : 04

Course Outcomes

After completion of the course students will be able to

1. Compute the roots of the equation using methods like Secant method, Bisection method, False position method etc.
2. Apply Numerical differentiation methods such Euler's method, Modified Euler's method, Runge-Kutta methods etc.
3. Apply Numerical integration methods such as Trapezoidal rule, Simpson method, Romberg method etc.
4. Evaluate the problems on special matrices using Matrix inversion method, LU decomposition etc.
5. Evaluate curve fitting problems.
6. Optimize Linear programming problems.

Topics covered

UNIT-I (06 Hours)

Root of equation

Solve Fluid flow, heat transfer problems using Picard method, Secant method, Bisection method, False position method, Newton-Rapson method, modified Newton-Rapson method, Muller method.

UNIT-II

Numerical Differentiation

Solve mass transfer, chemical reaction engineering, heat transfer problems using Euler's method, Modified Euler's method, Runge-Kutta methods, Milne's predictor-corrector method, Richardson Extrapolation.

UNIT-III

Numerical Integration

Trapezoidal rule, Simpson 1/3 and 3/8 rule, Multiple integrals, Romberg integration, Stirlings formula, LaGarange method, Cauchys integral formula.

UNIT-IV

Multiple algebraic equations using Matrix

Matrix inversion method, Gauss elimination, Gauss Jordan method, LU decomposition method, Gauss Seidal method, Jacobian method.

UNIT-V

Curve fitting and Statistics

Linear regression, multiple linear regressions, polynomial regression, general linear least squares, Non-linear regression. Introduction to Statistics, application of Statistics, histogram method, measuring centre values by median, mode methods.

UNIT-VI

Optimization

Graphical method, Simplex method, Golden section search method, Linear programming case studies such as least cost design of tank, least cost treatment of wastewater, chemical Process e.g. reactors, heat exchangers, evaporators etc.

Assignments

There will be six (6) assignments from various units mentioned in the syllabus. Each assignment will carry 10 marks.

List of assignments

1. Finding the roots of polymeric equations mentioned in the fluid mechanics. Equations such as buoyancy of ball, liquid level in manometer etc.
2. Solving the equations from mass transfer, Momentum transfer using Numerical differentiation methods.
3. Evaluating the integrals from heat transfer using Numerical integral methods.
4. Solving linear problems from process calculation using matrix methods.
5. Finding rate equation, equilibrium curve using experimental data.
6. Applying optimization method for equation of cost for various equipments, insulation thickness etc.
7. With the help of this subject knowledge, write a guideline report on how you would apply your concepts in industry
8. Solve old (last five years) question papers with reference to particular topic.
9. Solve old (last ten years) GATE question papers with reference to chemical engineering mathematics subject.

Tutorials / Term work

1. Solving problems on roots of equation.
2. Use numerical differential methods for problems on chemical reaction engineering, mass transfer, heat transfer etc.
3. Use numerical integration methods for problems on chemical reaction engineering, mass transfer, heat transfer etc.
4. Solve problems on multiple algebraic equations using Matrix.

5. Analyze and solve the problems on curve fitting.
6. Applying optimization method for industrial problems.

Text Books/References

1. Chapra S. C., R.P. Canale, "Numerical Methods for Engineers", Tata-McGraw Hill Publications.
2. T. F. Edgar, D. M. Himmblblau. , "Optimization of Chemical Processes", Tata-McGraw Hill Publications.
3. M. K. Jain, S. R .K. Iyengar, R. K. Jain. , "Numerical methods for Scientific and Engineering Computational", new age international Publishers.
4. S. S. Sastri. , "Introductory methods of Numerical analysis", Prentice-Hall India.
5. S. Pushpavanam, "Mathematical Methods for Chemical Engineering", Printice-Hall of India.
6. E. Balagurusamy. , "Numerical Methods", McGraw Hill Education (India) Private Limited.

Syllabus for Unit Test

Unit Test -I	UNIT – I , II, III
Unit Test -II	UNIT – IV, V, VI

COMPUTER PROGRAMMING FOR CHEMICAL ENGINEERS - I

Designation : Computing

Course Pre-requisites : Students should have basic knowledge of Computer fundamentals

TEACHING SCHEME		**CREDITS ALLOTTED**	
Lectures	: 3 Hours/Week	Theory	: 03
Practical	: 2 Hour /Week	Practical	: 01
Total	: 5Hours/Week	Total credits	: 04

Course Outcomes

After completion of the course students will be able to

1. Apply the knowledge of constant, variables and data types used in visual basic and write programs.
2. Write coding in VB and prepare interface using various controls like option button, check box, list box, text box, command button etc.
3. Apply the knowledge of Visual Basic to various chemical engineering calculations.
4. Explain and apply the HTML tags for web page.
5. Design a web page and apply dynamic effects to the page using the knowledge of HTML.
6. Explain and apply the various DHTML tags and object models for web page.

Topics covered

UNIT-I (06 Hours)

Visual Basic

Introduction to visual basic, object oriented programming and Graphics User Interface (GUI). Editions of visual basic. Variable: Types of variable declaration, scope of variable. Data Types, conversion of data types, array of controls. Control constructs and loop statements used in visual basic.

UNIT-II (06 Hours)

Important Visual Basic controls like Text box, command button, option button, check box, list box, combo box, frame, label and Timer control. Events: mouse, key and focus events. Working with menus, toolbars, status bars. Scope of variables and procedures. Data controls. Creating MDI applications.

UNIT-III (06 Hours)

Application of Visual Basic for Chemical Engineering: Various calculations and solutions in chemical engineering like calculation of LMTD for co-current and counter current heat exchangers, Design of distillation column, evaporator, dryer, mixed flow reactor etc.

UNIT-IV (06 Hours)

HTML

Introduction to HTML, components of HTML, structure tags, block level tags, text level tags, horizontal rules, colours in web page. Design parameters. List: ordered, unordered and definition list, generating lists.

UNIT-V (06 Hours)

Web page designing parameters. Adding graphics/images. Hyperlinks. Tables. Frames. Style sheets. Applying dynamic effects to the page. Working with forms in a web page.

UNIT-VI

DHTML

Introduction to DHTML, DHTML Object Model. Events. Handing text attributes. Dynamically changing style. Dynamically changing content. Dynamically altering the placement of elements

Assignments

1. Discuss the client-server applications with appropriate example
2. Discuss web applications with appropriate example
3. Explain e-commerce applications
4. Design your own home page using various HTML tags
5. Design your own blog for technical discussion.
6. Give fifteen minutes presentation (seminar) on particular topic and prepare a report.
7. To create various animations using Timer control.
8. Design various unit operations used in chemical industry using knowledge of visual basic.
9. Students have to study any five NPTEL videos related to HTML, DHTML and visual basic and prepare/present power point presentation.
10. Programs based on above six units.
11. With the help of this subject knowledge, write a guideline report on how you would apply your concepts in industry.
12. Group discussion on the recent advances in HTML, DHTML and visual basic.
13. Technical interview based on the knowledge of HTML, DHTML and visual basic.

In addition to these above stated assignments concerned faculty member may design his/her own assignments

Term Work

Term work will consist of the programs/practicals listed below, out of which any eight programs/practicals are to be performed in laboratory by the students.

1. Development of visual basic interface and programs using click events.
2. Development of visual basic interface and programs using option button.
3. Development of visual basic interface and programs using list box control.

4 Development of visual basic interface and programs using various control statements

5. Development of visual basic interface and programs using various loop statements

6. Development of visual basic interface and programs using Timer control.

7. Application of visual basic to various chemical engineering calculations.

8. To create table and use of table tags in HTML to design a web page.

9. Web page design as per given output

10. Design a web page using the image and hyperlink.

11. Design a web page using ordered list, unordered list and definition list.

12. HTML code to display given form.

<u>Text Books/References</u>

1. Holzschlag, M. E.; Using HTML – 4, Eastern Economy Publication
2. Holzner, S. ; HTML Black Book, Dreamtech Press
3. Thomas Powell; HTML& CSS: The Complete reference, 5th edition," BPB Publications
4. Gurewich; Learn VB In 21 Days, San's Publications
5. Cornell; Visual Basic 6 from the ground, Tata McGraw Hill Publishers
6. Hollis; Visual Basic 6 : Design, specification & Objects, Longman Publications
7. Ivan Bayross; Web Enabled Commercial Application Development Using HTML, DHTML, JavaScript, Perl CGI, PBP Publications.

<u>Syllabus for Unit Test</u>

Unit Test -I	UNIT – I ,II,IV
Unit Test -II	UNIT – III,V,VI

PROFESSIONAL SKILLS DEVELOPMENT

TEACHING SCHEME	**CREDITS ALLOTED**
Theory : 4 Hours / Week	4

Course Pre-requisites

The Students should have knowledge of

1. Basic concepts of Maths, Logical reasoning and English Grammar taught in the last semester.
2. An overall idea about vocabulary, Public speaking skills taught in the last semester
3. Knowledge of writing skills, importance of professionalism in emails and letters.
4. Knowledge on handling criticism and the concept of conflicts.
5. Awareness of the interpersonal skills like team work and its importance in the corporate sector.

Course Objectives

The Professional Skills Development 5 is an extension of PSD- 4 with focus on the remaining topics of Aptitude, Reasoning and Grammar. The further complex concepts of Aptitude and Grammar aims to acquaint them with the topics and also provide them techniques to solve the question with tricks/methods in a very short period. The English communication and soft skills section of PSD-5 focuses on the higher aspects of soft skills training students on how to handle Group Discussions during placement process and other topics such as grooming them on how to handle conflicts effectively in the corporate scenario and also the correct attitude/approach to solve problems collectively from a team's perspective and also individually.

Course Outcomes

The student should be able to

1. Learn further concepts of Maths, Logical reasoning and English

grammar and apply short cuts/ tricks to solve questions in less time. Learn remaining 25-30 rules of grammar topics of tenses and Sub- verb agreement relevant from the recruitment point of view.

2. Use Mnemonics, and learn appropriate strategies to handle complex topics in GDs and ways to handle them. Students would learn the appropriate ways of stating opinions, disagreeing or communicating during the Group Discussion Process.
3. Apply various strategies of conflict resolution through amicable way to settle team conflicts/disputes. They would learn to handle criticism and feedback in a positive way as an individual as well as a team.
5. Students would learn effective time management strategies- Pareto principle (the 80-20 rule of time management) and apply them in the corporate life. It would be a continuation of the topic covered during the previous semester PSD-4
6. Learn to handle Case studies effectively and incorporate the right approach towards Case Studies asked during the recruitment process.

Unit I (24Hours)

Aptitude (Maths, Logical Reasoning, English)

- Maths
    - Time, Speed & Distance
    - Time & Work
    - Simple Interest & Compound Interest in continuation
    - Maths Revision
- Logical Reasoning
    - Data Interpretation
    - Data Sufficiency
    - Set Theory & Syllogisms
    - Reasoning Revision
- English
    - Grammar – II – (Adjective, Verb, Sub- Verb Agreement)

- Grammar- (Tenses)
- Vocabulary
- Verbal Ability- Revision

<u>Unit II</u> (24Hours)

Soft Skills & English Communication

- Situational Conversation
- Situational Writing
- GD Orientation
- Mock GD-1
- Mock GD-2
- Mock GD-3
- Conflict Resolution
- Problem Solving Skills
- Time- Management Skills
- Handling Case Studies
- Management Games
- Business Meeting Etiquettes

<u>Text Books</u>

1. APAART: Verbal Ability
2. APAART: Logical Reasoning
3. APAART: Quantitative Aptitude
4. APAART: Speak Well 1 (English Language and Communication)
5. APAART: Speak Well 2 (Soft Skills)

ELECTIVE-II: BIOFUEL TECHNOLOGY

Designation : Elective

Course Pre-requisites : Students should have basic knowledge of

1 Biology

2 Basics of Chemical Engineering

TEACHING SCHEME	**CREDITS ALLOTTED**
Lectures : 3 Hours/Week	Theory : 03
Total : 3 Hours/Week	Total credits : 03

Course Outcomes

After completion of the course students would be able to describe

1. How petroleum and bio-based fuels affect the global carbon cycle
2. The attributes of biofuels that make them suitable as a fuel for a specific application
3. Limitations of petroleum fuel and biofuel and importance of biodiesel
4. Global impacts of bioethanol and biobutanol on energy sector
5. Technological advances and challenges to be overcome for biohydrogen production
6. Importance and aspects of manufacturing processes of microbial fuel cells

Topics covered

UNIT-I (06 Hours)

Introduction to Biofuels

Biofuels, energy use and efficiency, generations of biofuels, alternative energies, types of biofuels, advantages and disadvantages of different biofuels, economics, and policies.

UNIT-II (06 Hours)

Renewable Feedstocks

Feedstocks: Biomass, starch, sugar, lignocellulosic, agro and industrial by-products, pretreatment of feedstock, biomass production for fuel – algal cultures, yeasts (lipid and carbohydrate), sources of oils – edible and non edible

UNIT-III (06 Hours)

Production of biodiesel

Chemical, thermodynamic, and reaction kinetic aspects of biodiesel production: esterification and transesterification, free fatty acids; saponification; single step and two step biodiesel production, catalysts for biodiesel production – homogeneous (alkali/acidic) and heterogeneous, general procedure of biodiesel production and purification. algal biodiesel production, quality control aspects, methods to improve the biodiesel yield, process flow diagrams

UNIT-IV (06 Hours)

Production of bioethanol and biobutanol

Process technology for ABE using different feedstocks; by-products of biofuel industry as feedstock; selection of micro-organisms and feedstock – ethanol/butanol tolerance; determination of ABE yield; recovery of biofuels, process integration, advances in bioethanol and biobutanol production.

UNIT-V (06 Hours)

Production of Biohydrogen

Enzymes involved in H2 production; photobiological H2 production: biophotolysis and photo-fermentation; H2 production by fermentation: biochemical pathway, batch fermentation, factors affecting H2 production, carbon sources, process and culture parameters; detection and quantification of H2, reactors for biohydrogen production. Biogas:

Use of different feedstock to produce biogas, methods of biogas generation, equipment design to improve the yield, application of biogas as fuel

UNIT-VI (06 Hours)

Microbial Fuel Cells (MFC)

Biochemical basis; components of MFC fuel cell design, microbial cultures, MFC performance methods: substrate and biomass measurements, basic power calculations, MFC performance, single vs two-chamber designs, Applications of MFC

Text Books/References

1. C.M. Drapcho, N.P. Nhuan, T.H. Walker. Biofuels Engineering Process Technology, Mc Graw Hill Publishers, New York, 2008.
2. R.M. Jonathan. Biofuels – Methods and Protocols (Methods in Molecular Biology Series), Humana Press, New York, 2009.
3. L. Olsson (Ed.), Biofuels (Advances in Biochemical Engineering/ Biotechnology Series, Springer-Verlag Publishers, Berlin, 2007.
4. A.N. Glazer, H. Nikaido, Microbial Biotechnology – Fundamentals of Applied Microbiology, 2 Ed., Cambridge University Press, 2007.
5. R. C. Brown, Biorenewable Resources: Engineering New Products from Agriculture, Wiley-Blackwell Publishing (2003)

Syllabus for Unit Test

Unit Test -I UNIT – I , II, III

Unit Test -II UNIT – IV,V,VI

ELECTIVE-II: FOOD TECHNOLOGY

Designation : Elective

Course Pre-requisites : Basic knowledge of microbiology and biochemistry

TEACHING SCHEME		**CREDITS ALLOTTED**	
Lectures	: 3 Hours/Week	Theory	: 03
Total	: 3 Hours/Week	Total credits	: 03

Course Outcomes

After completion of the course students would be able to

1. Evaluate analysis of suitable chemical constitute and their significance in food products.
2. Identify the significance of fluid flow and rheological properties of food; develop the Process and equipment design aspect for food processing.
3. Draw basic flow sheet development for food processing, construction and plant layout.
4. Implement suitable equipment design and their design parameters for canning and retort processing.
5. Chose and apply suitable food preservation technique, give details of preservation, significance and estimate economy of the food preservation.
6. Select and do the packaging of fresh food and processed food, implement newer trends in packaging.

Topics covered

UNIT-I (06 Hours)

Introduction to food technology

Introduction to food technology, different types of food products, Application of Engineering in Food industries. Analysis of chemical constituents in food products, their characterization and significance.

UNIT-II (06 Hours)

Food Engineering

Principles of mass and energy balance in food processing operations. Transport phenomena with respect to foods. Fluid dynamics, Rheological properties of foods. Process design aspects. Concentration with thermal and membranes processes. Process and equipment design for food processing.

UNIT-III (06 Hours)

Food Process Engineering

Important aspects of product and process development. Basic flow sheet development for food processing. Other food processing such as Bakery machines and equipment; Food processing plant layout, material of construction, corrosion, waste utilization.

UNIT-IV

Thermal processing

Canning and retort processing – process design and equipment. Equipment design aspects, dryers and their design parameters. Construction of cold storages, Types of freezers and their design parameters

UNIT-V (06 Hours)

Principles of food preservation

Aims and objectives of preservation and processing of foods. Preservation by high temperature, Preservation by low temperature, Preservation by water removal. Different preservation technique: chemical preservatives. Controlled and modified atmospheric storage.

UNIT-VI (06 Hours)

Food Packaging Technology

Concept of packaging, Functions of a Food Package, Aseptic Packaging. Packaging as a method for conservation and protection of foods. Different packaging materials and their properties, Environmental friendly food packing material, Food product characteristics and package requirement, Evaluation of quality and safety of packaging materials.

Text Books/References

1. The Fundamentals of Food Engineering, Charm SE, 1963, The Avi Publishing Co.
2. S. Saclarow and R.C. Griffin. Principles of Food Packaging
3. RS Kirk and R. Sawyer.1991. Pearson's Chemical Analysis of Foods. 9th Ed. Harlow, UK, Longman Scientific and Technical.
4. M. Mathlouthi. Food Packaging and Preservation : theory and practice, Springer Science
5. R.T. Toledo. Fundamentals of Food Process Engineering, 2000, Chapman and Hall.
6. N.W. Desrosier. The Technology of Food Preservation, 1977, The AVI Publishing Co. Inc.
7. P.J. Fellows. Food Processing Technology: Principles and Practice, 2005, CBS Publishers.
8. D.R. Heldman and R.P. Singh. Food Process Engineering, 1984, Chapman and Hall.
9. J.M. Apple. Plant Layout and Material Handling, 1977, John Wiley & Sons.

Syllabus for Unit Test

Unit Test -I	UNIT – I , II, III
Unit Test -II	UNIT – IV, V, VI

ELECTIVE-II: POLYMER TECHNOLOGY

Designation : Elective

Course Pre-requisites :

1. Basic chemistry, Physical chemistry, Chemical Reaction Engineering, Chemical Engineering Thermodynamics

TEACHING SCHEME	**CREDITS ALLOTTED**
Lectures : 3 Hours/Week	Theory : 03

Course Outcomes

1. Define Mechanism of polymerization reaction for given monomer-polymer system
2. Characterize polymer properties and analyze tgeur effect ib oikymer stability.
3. Select suitable method of polymerization for monomer-polymer system.
4. Analyze polymer structure and its effect on properties.
5. Form composites / blends in polymers to obtain desired properties.
6. Select the methods of polymer compounding and processing for desired outcome.

Topics covered

UNIT-I (06 Hours)

Introduction to polymers

Introduction, polymer microstructure, homopolymers-heteropolymers, monomers as building block of polymers, historical development, classifications of polymers and polymerization reactions, chain growth and step growth polymerization, mechanism of polymerization, polymer liquids and polymer solids

UNIT-II (06 Hours)

Polymer properties

Molecular weight of polymers (Mw, Mn, Mv), Molecular weight distribution, determination of molecular weights, polymer morphology, polymer structure – linear, branched and crosslinked, presence of functionality, chemical bonding in polymers, sterioisomerism, effect these factors on chemical, thermal and mechanical properties of polymers

UNIT-III (06 Hours)

Synthesis of polymers

Polymerization techniques: bulk, solution, suspension, emulsion polymerization with their merits and demerits, kinetics of polymerization; free radical chain polymerization, cationic polymerization, anionic polymerization, polycondensation, co-polymerization and its kinetics, Smith Ewarts kinetics for emulsion polymerization, continuous emulsion polymerization, Ziegler-Natta catalyst. Safety precautions during synthesis of polymers.

UNIT-IV (06 Hours)

Polymer structure and effect on properties

Chemical and geometrical structure of polymer molecules, microstructure based on chemical structure, microstructure based on geometrical structure, Glass transition temperature, factors influencing glass transition – molecular weight, plasticisers, copolymer concentration, and their effect on polymer properties; crystallinity, effect of presence of crystallinity on polymer properties

UNIT-V (06 Hours)

Polymer composite and blends

Difference between blends and composites, their significance, choice of polymers for blending, blend miscibility-miscible and immiscible blends, thermodynamics, phase morphology, polymer alloys, polymer eutectics, plastic-plastic, rubber-plastic and rubber-rubber blends, FRP, particulate, long and short fibre reinforced composites.

UNIT-VI (06 Hours)

Polymer processing and compounding

Polymer compounding-need and significance, different compounding ingredients for rubber and plastics, crosslinking and vulcanization.

Methods of processing

Compression molding, transfer molding, injection molding, blow molding, reaction injection molding, extrusion, pultrusion, calendaring, rotational molding, thermoforming, rubber processing in two-roll mill, internal mixer.

Assignments

1. Prepare the report on any one polymer comprising its significance, preparation, characterization, processing and properties

References/Text Books

1. Text book for polymer science; F. W. Billmeyer, Wiley Interscience Publications (John Wiley and Sons)
2. Polymer Science, V. R. Gowarikar, N. V. Viswanathan, J. Shreedhar; Wiley Estern Limited
3. Principles of Polymerizations; Odion G. G.; Mc-Graw Hill
4. Fundamentals of polymer Engineering, Arie Ram, Plenum Press
5. Polymer Physics, Michael Rubinstein, Ralph H. Colby, Wiley Interscience Publications (John Wiley and Sons)
6. Polymer data handbook, James E. Mark (Ed.), Oxford University Press

Syllabus for Unit Test

Unit Test –I UNIT – I ,II,III

Unit Test –II UNIT – IV,V,VI

ELECTIVE-II: NANOMATERIALS

Designation : Elective

Course Pre-requisites : Students should have knowledge of

1. Chemistry, Physics

TEACHING SCHEME
Lectures : 3 Hours/Week

CREDITS ALLOTTED
Theory : 03
Total credits : 03

Course Outcomes

After completion of the course students will be able to

1. Define the concept of nanomaterials and Nanotechnology
2. Express various types of nanomaterials and characterization techniques
3. Distinguish between the synthesis techniques for nanomaterials and apply the appropriate synthesis technique.
4. Recognize the properties of nanomaterials and effect on them due to nanoscale.
5. Express the Chemical and Catalytic Aspects of Nanomaterials
6. Recognize the various modes and methods for synthesis of polymer nanocomposite

Topics covered

UNIT - I (06 Hours)

Introduction to Nanomaterials

Basic definitions: Nanoscience, Nanotechnology, Nanomaterial, Nanostructure, Nanomachine; Historical perspective on nanomaterials, Advantages of nanomaterials, Importance of nanomaterials, Top down and bottom up approaches to manufacture nanomaterials. Applications of Nanomaterials

Types of nanomaterial/Nanostructures

Classification of nanomaterial based on the number of dimensions: 0-D, 1-D, 2-D, and 3-D nanostructures; Quantum dots, Quantum wire, Core/Shell structures, Nanotubes, nanorodes, nanowires, nanofibers.

UNIT - II

Characterization Techniques

X-ray Diffraction, Scanning Electron Microscopy (SEM), Transmission Electron microscopy (TEM), Optical spectroscopy, Atomic Force Micrograph (AFM), Partical Size Analyzer.

Synthesis of Nanomaterials

Classification of Nanoparticle Synthesis Techniques, Solid-State Synthesis of Nanoparticles, Vapor-Phase Synthesis of Nanoparticles, Inert Gas Condensation of Nanoparticles, Chemical Vapor Condensation (CVC),

UNIT - III

Technology of Nanoparticles Synthesis

Plasma-Based Synthesis of Nanoparticles, Flame-Based Synthesis of Nanoparticles, Spray Pyrolysis of Nanoparticles; Solution Processing of Nanoparticles, Sol-Gel Processing, Solution Precipitation, Water–Oil Microemulsion (Reverse Micelle) Method.

UNIT - IV

Nanomaterial properties

Physical properties of nanostructured materials, Chemical properties, Mechanical properties, Magnetic and structural properties, Optical properties, Thermal properties; Influence of nano structuring on mechanical, optical, electronic, magnetic and chemical properties; Gramsize effects on strength of metals optical properties of quantum dots and quantum wires, carbon nano tubes: magnetic behavior.

UNIT - V

Chemical and Catalytic Aspects of Nanomaterials

Nanomaterials in catalysis, Importance of surface to volume ratios, nanocrystal shapes and defects as they relate to heterogeneous catalysis, Controlled pore size materials, nanoparticles as chemical reagents; Examples of metal, metal oxide and metal sulfide nanoparticles in catalytic processes

UNIT - VI

Polymer Nanocomposites

Generalities on polymer composites, From “Micro” to “Nano” composites: Effect of particle dimensions, Nanocomposites preparation pathways: Importance of the interfacial compatibilization, Current scientific and technical advances in polymer nanocomposites

Tutorials/Assignments

The internal assessment shall consist of minimum SIX assignments from the following list

1. Questions involving classification of nanomaterial
2. Prepare one assignment considering any one nanomaterial on: Influence of Nano structuring on Mechanical - Optical, electronic, magnetic and chemical properties
3. Conducting surprise MCQ test for students
4. Questions involving various techniques employed for nanomaterial characterization
5. Enhancement in collaborative learning is done through, group assignments that will be given to encourage students to work with classmates to discuss and complete homework assignments
6. Students have to study any five research papers related to specific topic in nanomaterials and prepare/present power point presentation
7. Brief report on ‘Environmental, health and ethical concerns that are associated with nanomaterials

8. Group discussions on any of the following topics:
   a) Importance of Nanomaterials in chemical industries.
   b) Current scientific and technical advances in Nanomaterials
   c) Methods of synthesis for nanomaterials
9. Preparation of a brief report on applicability of nanomaterials in chemical engineering operations
10. Conducting open-book class test

Text Books/ References

1. Charles P. Poole, Frank J. Owens, "Introduction to Nanotechnology", Wiley Interscience
2. B S Murty, P Shankar, Baldev Raj, B B Rath, James Murday, "Textbook of Nanoscience and Nanotechnology" Universities Press (India) Private Limited
3. Mark A. Ratner, Daniel Ratner, "Nanotechnology: A gentle introduction to the next Big Idea", Prentice Hall, 1st Edition
4. Yury Gogotsi, "Nanomaterials Handbook", CRC Press, Taylor & Francis Group
5. Gu¨nter Schmid, "Nanoparticles From Theory to Application", Wiley-VCH Verlag GmbH & Co
6. C. Br´echignac P. Houdy M. Lahmani, "Nanomaterials and Nanochemistry", Springer Berlin Heidelberg New York
7. Kenneth J. Klabunde, "Nanoscale Materials in Chemistry", John Wiley & Sons, Inc
8. Alain Nouailhat, "An Introduction to Nanoscience and Nanotechnology", Wiley-ISTE; 1st Edition

Syllabus for Unit Test

Unit Test - I	UNIT– I, II, and III
Unit Test - II	UNIT– IV, V, and VI

SEPARATION TECHNIQUES

Designation : Professional Core

Course Pre-requisites : Students should have basic knowledge of

1 Fundamentals of mass transfer

2 Fundamentals of heat transfer

TEACHING SCHEME	**CREDITS ALLOTTED**
Lectures : 4 Hours/Week	Theory : 04
Practical : 2 Hour /Week	Practical : 01
Total : 6Hours/Week	Total credits : 05

Course Outcomes

After completion of the course students would be able to

1. Apply the basics of distillation for the binary separation of ideal and nonideal mixture and determine the extent of separation obtained.
2. Describe the operation of continuous rectification and determine the number of stages required for distillation.
3. Determine the number of stages required for separation using liquid-liquid extraction and describe the extractors used industrially.
4. Obtain the requirement of solvent in leaching operation and obtain the extent of separation.
5. Plot the adsorption isotherms and estimate the amount of adsorption using single and multistage operations.
6. Explain the operation and applications of novel separation techniques

Topics covered

UNIT-I (08 Hours)

Introduction

Review of various separation techniques, Selection of the technique of separation, pros and cons of various methods.

Basics of Distillation

Equilibrium of vapor and liquid, relative volatility, Raoult's law, Ideal and Non-ideal behavior study, Azeotropes, positive and negative deviation from ideality, Methods of distillation - simple, flash distillation, Rayleigh's equation, Graphical and analytical method for determination of the compositions, Introduction to reactive distillation, Azeotropic distillation, Molecular or low pressure distillation, Extractive distillation.

UNIT-II (08 Hours)

Rectification

Continuous rectification for binary systems, Tray towers, McCabe Thiele's method of calculation of number of trays, Method of Ponchon Savarit, Enthalpy concentration diagrams, Tray efficiencies, Concept of reflux, cold reflux, partial and total cold reflux, Effect of feed temperature and q-line equation derivation, Total reflux, Optimum reflux, Fenske Underwood equation, Condenser and reboilers used in distillation, Use of open steam for distillation, Rectification of Azeotropic mixtures.

Distillation in packed towers

HETP concept, HTU and NTU calculations, Distillation column internals: Type of trays, Type of packing used.

UNIT-III (08 Hours)

Adsorption

Types of adsorption, Nature of adsorbents, Equilibria in adsorption- Single gases and vapors, adsorption hysteresis, Effect of temperature, Heat of adsorption, adsorption of liquids, Langmuir isotherms, Freundlich isotherms, Introduction to pressure swing and temperature swing adsorption,

Equipment

Continuous contact, Steady state moving bed absorbers.

Ion exchange process

Basic principles and chemical reactions, Techniques and applications, Equilibria and rate of ion exchange, Equipment studies.

UNIT-IV (08 Hours)

Liquid- Liquid Extraction

Introduction, Choice of solvent, Ternary equilibrium, Binodal solubility curve, Single stage extraction, Multistage crosscurrent and countercurrent extraction, extraction calculations using triangular and rectangular coordinates, Solvent free basis calculations, Nxy diagrams, Material balances, Continuous countercurrent extraction with reflux, stage efficiency.

Continuous countercurrent extraction in packed columns

HTU and NTU calculations. Types of extractors: Stage type and differential extractors.

UNIT-V

Leaching (Solid Liquid Extraction)

Introduction: Classification of leaching processes, Factors affecting the leaching process, Solid –liquid equilibria.

Methods of calculation: Single stage leaching, multistage cross-current leaching, Continuous countercurrent leaching.

Leaching Equipments: Unsteady state and steady state equipment.

UNIT-VI (08 Hours)

Novel separation techniques

Membrane separation techniques- Ultrafiltration, Nano-filtration, Reverse osmosis process, Electro dialysis, Rate based processes such as diffusion coefficient based inert gas generating from air by carbon molecular sieves.

Assignments

1. Group discussion on the recent advances in mass transfer operations.
2. Solve previous university question papers with reference to particular topic of this subject.
3. Seminar presentation on a particular topic specified in the syllabus and submission of report based on it.
4. Estimation of composition of vapor and liquid in flash distillation
5. Compute the composition of residue and distillate in simple distillation.
6. Evaluation of number of stages using McCabe Thiele and Ponchon Savarit method.
7. HTU and NTU calculation for distillation in packed columns.
8. Group discussion on equipments used for extraction.
9. Estimate the number of stages required for single and multistage extraction operation.
10. Estimate the number of stages required for single and multistage leaching operation.
11. Group discussion on ion exchange technique and its application.
12. With the help of this subject knowledge, write a guideline report on how you would apply your concepts in industry.
13. Presentation on novel separation techniques.
14. Solve old GATE question papers with reference to this subject.
15. Group discussion on the recent advances in separation techniques.
16. Write a report on your visit to research and development laboratory of national/international repute.
17. Technical interview based on the knowledge of separation techniques.

In addition to these above stated assignments concerned faculty member may design his/her own assignments

Term Work

Term work will consist of the experiments listed below, out of which any eight experiments are to be performed in laboratory by the students.

1. Simple distillation
2. Distillation with total reflux
3. Steam distillation
4 Equilibrium diagrams for liquid -liquid extraction
5. Cross current multistage extraction
6. York Schiebel column for extraction
7. Bubble cap distillation column
8. Sieve tray distillation column
9. Vapour liquid equilibria
10. Solid liquid extraction of oil
11. Langmuir and Freundlich adsorption isotherm

Text Books/References

1. Treybal R. E., "Mass Transfer Operation",McGraw Hill publication.
2. Coulson J. M. Richardson, "Chemical engineering", Vol, I and II, Pergamon Press.
3. King C. J., "Separation Techniques", McGraw Hill publication.
4. Smith B. D., "Design of Equilibrium stage process", McGraw Hill publication.

Syllabus for Unit Test

Unit Test -I	UNIT – I ,II,III
Unit Test -II	UNIT – IV,V,VI

CHEMICAL PROCESS EQUIPMENT DESIGN-I

Designation : Professional Core

Course Pre-requisites : Students should have basic knowledge of

1. Unit Operations involved in chemical engineering
2. Heat transfer and Mass transfer and Mechanical operation equipments.

TEACHING SCHEME	**CREDITS ALLOTTED**
Lectures: 3 Hours/Week	Theory : 03
Drawing : 2 Hour /Week	Drawing : 01
Total : 5Hours/Week	Total credits : 04

Course Outcomes

After completion of the course students would be able to

1. Apply and understand different codes for equipment design.
2. Deign different heads used for equipments
3. Identify and design different supports used for process equipments.
4. Study and design process and mechanical aspect of heat exchangers
5. Calculate various stresses acting on vessels
6. Design different equipments like cyclone separator, gravity thickener, decanter, fluid –fluid separator, electrostatic precipitator, cooling towers, evaporators, dryers, crystallizers.

Topics covered

UNIT-I (06 Hours)

Introduction to Process Equipment Design

Introduction to various mechanical properties of materials to be used as material of construction, resistance of metals to corrosion under varying conditions of temperature and pressure etc. Theories of failures, application and use of various codes and standards in design. Representation of different utilities and symbols, General design procedure, equipment classification, study of design parameters such as maximum working pressure, design pressure, design temperature, design stress & factor of safety, design of wall thickness & minimum actual thickness, corrosion allowance, design loading, possions ratio.

UNIT-II (06 Hours)

Design of pressure vessels and storage tank

Design of pressure vessels and storage tank: Vessels subjected to internal pressure and combined loading, cylindrical and spherical shell, resultant stresses induced in pressure vessel, stresses in high pressure vessels, optimum vessel size, design of various heads & closures such as flat head, torrispherial head, elliptical head, hemispherical head, and conical head.

Design of storage tank, types of storage tank, types of roof for storage tank, types of losses in floating roof tank, estimation of nozzle diameter for drain in storage tank.

UNIT-III (06 Hours)

Introduction to various Supports

Introduction to various Supports, design of various supports such as skirt support, skirt bearing plate, leg support, bracket support, saddle support, design of tall vertical column, anchor bolts, base ring, ring stiffeners, wind girders, flanges & nozzles, detail design of number of bolts & nozzles. Stresses induced in supports like dead weight, wind load, seismic load.

UNIT-IV (06 Hours)

Design of Heat exchangers

Classification of heat exchangers, flow arrangements, types of heat exchanger, LMTD and effectiveness NTU method,

Process design of shell and tube heat exchanger - heat transfer coefficient calculations, number of tube calculation, pressure drop calculation on tube side and shell side. Process design of double pipe heat exchanger, types of fouling, fouling resistance in heat exchangers. Mechanical design aspects of heat exchanger. Differential expansion and thermal stresses in heat exchanger. Introduction to fin type, plate type heat exchanger. (06 Hours)

UNIT-V (06 Hours)

Design of Agitators

Design of Agitators: types of agitators, selection criteria, design of blades, power calculation, flow patterns, calculation of bending moment, twisting moment, and combined effect.

UNIT-VI (06 Hours)

Design of some separation equipments

Design of some separation equipment like cyclone separator, gravity thickener, decanter, fluid –fluid separator, electrostatic precipitator, evaporators.

Assignments

1. Write a report on different codes and symbols used in design.
2. Solve old (last five years) question papers with reference to particular topic.
3. Prepare a model for any of the equipment
4. Prepare a report on advance equipments which are newly introduced in the current year.
5. Give fifteen minutes presentation (seminar) on particular topic and prepare a report.
6. Prepare model for different roofs used in storage vessels.
7. Prepare a chart for different construction of materials in equipment design.
8. Prepare a presentations on newly introduced equipments in current year
9. Design laboratory manuals better than existing ones with clearly shown specimen calculations.

10. With the help of this subject knowledge, write a guideline report on how you would apply your concepts in designing a economic plant layout for any industry.
11. Write a technical report on your visit to a process industry.
12. Solve old (last ten years) GATE question papers with reference to design subject.
13. Group discussion on the recent advances in equipment design
14. Write a report on your visit to research and development laboratory of national/international repute.
15. Technical interview based on the knowledge of design

In addition to these above stated assignments concerned faculty member may design his/her own assignments

Term Work

Term work will consist of the Practicals and drawings listed below, out of which any eight are to be done by students. Any one drawing in Autocad.

1. Detailed design and drawing of enclosures and supports
2. Design of pressure vessels.
3. Calculation of heat transfer coefficient, No of tubes and rate of heat flow in shell and tube heat exchanger
4 Calculate pressure drop for tube and shell side heat exchanger.
5. Detailed design and drawing of agitated vessel.
6. Detailed design and drawing of cyclone separator.
7. Detailed design and drawing of cooling towers
8. Detailed design and drawing of crystallizer
9. Detailed design and drawing of gravity thickener.
10. Design of storage tanks.
11. Design of Supports.
12 Calculation of heat transfer coefficient,rate of heat flow and effectiveness in Double pipe heat exchanger.
13 Calculation of heat transfer coefficient,rate of heat flow and effectiveness in fin type heat exchanger.

Text Books/References

1. Joshi. M.V, and Mahajani. V.V, "Process Equipment Design," 3rd Edn. Macmillan India Limited, New Delhi, 1996
2. Bownell, L.E., and Young, E.M., "Process Equipment Design", Wiley Eastern, 1968.
3. Sinnott. R.K, Coulson & Richardson's, "Chemical Engineering", Volume 6, 3rd Edn., Butterworth Heinemann, New Delhi, 1999.
4. Bhattacharya B C, Chemical Equipment Design , CBS publishers.
5. Dawande S D, " Process Equipment Design" DENETT publishers

Syllabus for Unit Test

Unit Test -I	UNIT – I ,II,III
Unit Test -II	UNIT – IV,V,VI

CHEMICAL REACTION ENGINEERING-II

Designation : Professional Core

Course Pre-requisites : Students should have basic knowledge of

1 Chemical reaction engineering-I
2 Stiochiometry
3. Mass transfer

TEACHING SCHEME	CREDITS ALLOTTED
Lectures : 3 Hours/Week	Theory : 03
Practical : 2 Hour /Week	Practical : 01
Total : 5Hours/Week	Total credits : 04

Course Outcomes

After completion of the course students would be able to

1. a) Write the overall rate equation for heterogeneous reactions.
   b) Study kinetics and design of fluid solid non catalytic reactions.
2. Define the mechanism of catalytic reactions.
3. Calculate the height of fluid fluid non catalytic reactions.
4. Learn the kinetics and design of solid catalyzed reactions.
5. Learn the diffusion and reaction kinetics for porous catalyst.
6. Develop the kinetics of nonideal flow.

Topics covered

UNIT-I (06 Hours)

Introduction to heterogeneous reaction systems

Fluid-solid non catalytic reactions: Types of heterogeneous reactions. Steps involved in developing overall rate equation. Linearizing a nonlinear rate equation contacting patterns for heterogeneous reaction systems. Propose models i.e. progressive conversion model and unreacted core model.

Steps/resistance involved in these models. Individual and overall/global rate equation. Determination of rate controlling step. Application to design of fluid solid reactor by identifying the type of flow of phases.

UNIT-II (06 Hours)

Fluid-fluid non catalytic reactions

Kinetic regimes for mass transfer and reaction. Rate equation for different cases/regimes. Clues to kinetic regimes using different methods. Application to design of packed bed reactor.

UNIT-III (06 Hours)

Catalysis (fluid-solid catalytic reactions)

The nature of catalytic reactions. The mechanism of catalytic reactions. Steps involved in catalytic reactions. Types of adsorption, Langmuir adsorption isotherm. Synthesizing a rate law rate limiting step, preparation of catalyst and its deactivation, poisoning and regeneration. Nature and mechanism of catalyst reactions.

UNIT-IV (06 Hours)

Solid catalyzed reactions

Introduction, Rate equation, Film resistance controlling, surface flow controlling , Pore diffusion controlling, Experimental methods for finding rates, construction, operation and design of Catalytic reactors : Fixed bed reactor, Fluidized bed reactor.

UNIT-V (06 Hours)

Diffusion and reaction in porous catalysts

Diffusion and reaction in spherical catalyst pellets. Internal effectiveness factor. Overall effectiveness factor. Estimation of diffusion- and reaction-limited regimes. Mass transfer and reaction in a packed-bed. Chemical vapor decomposition (CVD) reactors.

UNIT-VI

Basics of Non-ideal Flow

The Residence Time Distribution Functions and their Relationships Role of RTD in determining reactor behavior Experimental methods for finding E, the pulse experiment, the step experiment, relationship between E, F & C curve.Introduction to Dispersion Model, Tank in series model.

Assignments

1. List different types of heterogeneous reactions in chemical industry.
2. Write a report on " Importance of heterogeneous reactions in Chemical Industry"
3. Select any five industrial heterogeneous reactions and write rate equations for the reactions.
4. Give power point presentation on models for heterogeneous reactions.
5. Design a reactor for fluid solid non catalytic reactions.
6. Do the experiments on Reactor lab software.
7. Give power point presentation on different types of adsorption isotherms.
8. Solve any five old question papers.
9. Solve ten problems on kinetics and design of fluid fluid non catalytic reactions.
10. List out different types if industrial catalyst with characteristics.
11. Draw different types of contacting patterns for heterogeneous reactions used in industry.
12. Give a presentation on any reactor used for heterogeneous reactions in industry
13. Write a report on research (review) paper on reactors used for heterogeneous reactions.
14. Industrial visit to a chemical industry.
15. Write a report on industrial visit. Give emphasis on details of reactor.

In addition to these above stated assignments concerned faculty member may design his/her own assignments

Term Work:

Term work will consist of the experiments listed below, out of which any eight experiments are to be performed in laboratory by the students.

1. To study residence time distribution in packed bed reactor.
2. To study residence time distribution in plug flow reactor.
3. To study residence time distribution in continuous stirred tank reactor.
4. To study CSTR, PFR in series.
5. To study CSTR in series.
6. Determination Surface area of catalysts.
7. Determination of bulk density, apparent density, and true density of catalyst.
8. Determination Pore volume of catalysts.

Text Books/References

1. Levenspiel Octave. “Chemical Reaction Engineering,” Wiley Eastern Publications
2. Smith J.M. “Chemical Engineering Kinetics,” McGraw-Hill Publications
3. Fogler H.S. “Elements of Chemical Reaction Engineering,” Eastern Economy Publications
4. Carberry & Verma “Chemical and Catalytic Reaction Engineering”
5. H. Scott Fogler “Elements of Chemical Reaction Engineering”
6. Doraiswamy L.K. and Sharma M.M. “Heterogeneous Reactions: Analysis Examples and reactor design.” Vol.1 & 2.
7. C.G. Hill. “An Introduction to Chemical Reaction Kinetics & Reactor Design.”
8. Dawande, “Principles of Reaction Engineering.” Denett publications

Syllabus for Unit Test

Unit Test -I UNIT – I ,II,III

Unit Test -II UNIT – IV,V,VI

PROCESS INSTRUMENTATION AND INTRUMENTAL METHODS OF ANALYSIS

Designation : Professional Core

Course Pre-requisites : Students should have Basic knowledge of Mathematics.

TEACHING SCHEME

Lectures : 3 Hour/Week

Tutorial : 2 Hour /Week

Total : 5 Hour /Week

CREDITS ALLOTTED

Theory : 03

Practical : 01

Total credits : 04

Course Outcomes:

After completion of the course students will be able to

1. To explain the need of process instrumentation and process control in chemical industries.
2. To describe various chemical analysis instruments.
3. To explain conductometry, turbidimetry and refractometry.
4. To describe chromatoghraphy methods.
5. To develop an ability to use theorems to compute the Laplace transform, inverse Laplace transforms. To calculate the transfer functions for first order and second order systems.
6. To explain various control action for first order and second order system.

Topics covered

UNIT-I (06 Hours)

Introduction: Basic Concepts and characteristics of measurement system, various elements of instrument, performance characteristics.

Temperature measurement

Introduction, methods of temperature measurement by expansion thermometers, filled system thermometers, electrical temperature instruments, pyrometers. Calibration of Thermometers

Level measurement

Displacers, ultrasonic, microwaves, laser light.

UNIT-II (06 Hours)

Introduction to instrumental methods of analysis

General Introduction, classification of instrumental methods, spectroscopy, properties of electromagnetic radiation, pH metry, Karl Fischer Titration.

Visible Spectrophotometry & Colorimetry

Deviation from Beer's law, instrumentation applications. Molar compositions of complexes, examples.

UNIT-III (06 Hours)

Conductometry

Introduction, laws, conductance, measurements, types of conductometric titrations, applications, advantages and disadvantages.

Nephelometry and Turbidimetry

Introduction, theory, comparison with spectrophotometry, instrumentation, applications.

Refractometry

Introduction, Abbe refractometer, instrumentation, applications.

UNIT-IV (06 Hours)

Chromatography

Introduction, types, theoretical principles, theories of chromatography, development of chromatography, qualitative and quantitative analysis, applications and numerical.

Gas Chromatography

Introduction, principles of gas chromatography, gas liquid chromatography, instrumentation, evaluation, retention volume, resolution. Branches of gas chromatography, applications and numerical.

High Performance (Pressure) Liquid Chromatography

Introduction, principles, instrumentation, apparatus & materials, column efficiency and selectivity, applications. GC-MS, LC-MS.

UNIT-V (06 Hours)

Process dynamics

Introduction, tools of dynamics analysis, ideal forcing function, input output model, transfer function models, proportion of transfer function, poles & zeros of transfer function with qualitative response, dynamic behavior of pure integrator, pure gain, first order & second order systems (with or without dead time), physical example of these systems.

UNIT-VI (06 Hours)

Introduction to feedback control

Final Control Elements - Valve characteristics. Instrumentation symbols. Introduction to Process Flow Diagram (PFD) and Piping & Instrumentation Diagram (P&ID).

Control theory basics

The control loops, process control terms, components of control loops, basic control action i.e. on-off, P, I, D, PI, PD, PID for 1st order process control loops and 2nd order response.

List of Experiments

Term work will consist of the experiments listed below, of which at least eight should be performed in laboratory by the students.

1. To Study the characteristics of On-Off Controller.
2. Calibration of Bimetallic thermometer.

3. Gas Chromatography.
4. High Performance Liquid Chromatography.
5. UV Spectrophotometer.
6. Dynamic behavior of non interacting system.
7. Dynamic behavior of interacting system.
8. Mercury Thermometer With well and Without Well.
9. Conductivity meter.
10. PH meter analysis.
11. Manometer Tuning.
12. To Study the Thermocouple.
13. Calibration of RTD.

Assignments

1. Students have to visit chemical industry and prepare a detailed report on various instruments used for process variable measurement.
2. Students have to visit chemical industry and prepare a detailed report on various instruments used for chemical analysis.
3. Watch NPTEL video and make report on various instruments used for process variable measurement.
4. Presentation on instruments used for process variable measurement.
5. Group discussions on instruments used for process variable measurement.
6. To find Transfer Function for 1st order and 2nd order Instrument or process.
7. Draw the Control Loop for HE for different process variable control.
8. Draw the Control Loop for Batch Reactor for different process variable control.
9. Draw the Control Loop for CSTR for different process variable control.

Text Books/References

1 S.K.Singh, “Industrial Instrumentation & Control”, Tata McGraw Hill publishing company ltd, New Delhi, 2000

2 D. Pastranabis, “Principals of industrial instrumentation”, 2nd edition, Tata McGraw 4 Hill publishing company ltd, New Delhi, 2003

3 Eckman D.P. “Industrial Instrumentation”, Willey Eastern Ltd, New Delhi, 1984.

4 A.C. Shrivastav “Techniques in Instrumentation”, New Delhi, 1984.

5 W.Boltan, “Instrumentation and Process Measurement”, Orient Longman Ltd, Hyderabad, 1st Edition, 1993.

6 Willard H.H, “Instrumental methods of analysis”, 6th Edition, CBS Publication New Delhi 1986

7 Galen W. Ewing, “Instrumental Methods of Chemical Analysis”, 5th Edition, McGraw Hill Book Company, Singapore, 1990

8 D. A. Skoog, “Principal of Instrumental Analysis”, Southern Collage Publication, Japan 1984

9 G. R. Chatwal, S.K. Anand, “Instrumental method of chemical analysis”, 5th Edition, Himalaya Publishing House, Mumbai 2002.

10 Ray Choudhuri and Ray Choudhuri “Process Instrumentation, Dynamics and control for Engineers”, 1st Edition, Asian Books Pvt Ltd, New Delhi, 2003.

11 B.G. Liptak, “Instrument Engineers Handbook” , 4th Edition , CRC Press, 2005.

Syllabus for Unit Test

Unit Test -I UNIT – I , II, III

Unit Test -II UNIT – IV, V, VI

COMPUTER PROGRAMMING FOR CHEMICAL ENGINEERING - II

Designation : Computing

Course Pre-requisites : Students should have basic knowledge of

1 Computer fundamentals

2 Computer Programming for Chemical Engineering-I

TEACHING SCHEME		**CREDITS ALLOTTED**	
Practical	: 2 Hour /Week	Practical	: 01
		Total credits	: 01

Course Outcomes

After completion of the course students will be able to

1. Apply the knowledge of constant, variables, data types and various standard input output functions to write C-programs.
2. Prepare a flow chart and write C-programs using control constructs and looping statements.
3. Explain the concept of single dimensional and multidimensional arrays and write C-programs for single dimensional arrays, multidimensional arrays.
4. Write C-programs using string.
5. Explain the concept of pointer and write C-programs using pointers.
6. Apply the knowledge of C-programming language, CHEMCAD, MATLAB for chemical engineering calculations.

Term Work:

Term work will consist of the programs/practicals listed below, out of which any eight programs/practicals are to be performed in laboratory by the students.

- C-Programming Language: Introduction, Character sets, constant, variables and Data Types: integer, float, double, char, string. Operators: arithmetic, relational, logical, increment and decrement, assignment, conditional. Standard input-output functions: printf ( ), scanf ( ), getch ( ) or getchar( ).

1. Programs based on standard input-output functions used in C-Programming.

- Control statements: programs using if statement, if-else statement, goto statement and switch-case statement.

2. Programs based on if-else statements.
3. Programs based on goto statements.
4. Programs based on switch-case statements.

- Loop statements: programs using while loop, do-while loop and for loop.

5. Programs based on while loop.
6. Programs based on do-while loop.
7. Programs based on for loop.
8. Programs to solve chemical engineering problems.

- Arrays: single dimensional and multi-dimensional arrays.

9. Programs based on single dimensional arrays.
10. Programs based on multi-dimensional arrays.

- String: programs using string. String functions: strlen( )/ strcpy( )/ strrev( )/ strcat ( )/strlwr ( )/ strupr ( )/ strcmp ( ).

11. Programs based on strings and string functions.

- Pointers: programs using pointers. Use of * and & operators. Pointer arithmetic's. Use of pointers

  Pointer and function: parameter passing to function by reference and by value. File handling, Linked list

12. Programs based on pointers and function

- Application of C-programming language, CHEMCAD and MATLAB for Chemical Engineering: various calculations and solutions in Chemical Engineering.

- Term work includes programs based on following unit operations

  13. Design of co-current and counter current heat exchanger
  14. Design of Distillation column
  15. Design of Mixed Flow Reactor
  16. Design of Evaporator etc.

  In addition to these above stated programs / practicals concern faculty member may design his/her own programs / practicals.

Text Books/References

1. Kanetkar, Y.C.; Let Us C, 4th revised edition, BPB Publications
2. Cooper, M.; The Spirit of 'C' – An introduction to modern programming, Jaico Publisher
3. Rajaraman, V.; Fundamentals of Computers, Prentice Hall of India
4. Balagurusamy, E.; Programming in ANSY C, 2nd Edition, McGraw Hill Publication
5. Sanders, D. H.; Computers Today, McGraw Hill Publications

PROFESSIONAL SKILLS DEVELOPMENT (6)

TEACHING SCHEME	**CREDITS ALLOTED**
Theory : 4 Hours / Week	4

Course Pre-requisites

The Students should have knowledge of

1. Concepts of Maths, Logical reasoning and English Grammar taught in the last semester.
2. A basic knowledge of Group Discussion, DO's and Don'ts done in the previous sem.
3. Basic knowledge of writing skills, importance of professionalism in emails and letters.
4. Knowledge on the concepts of criticism, feedback and conflicts.
5. Awareness of the interpersonal skills like team work and introduction to Leadership taught during the last semester.
6. Brief idea about professional and business meeting etiquettes.

Course Objectives

The Professional Skills Development 6 is an extension of PSD- 5 with focus on the remaining topics of Aptitude and Grammar. The further complex concepts of Permutation and Combination, Probability and grammatical topics such as prepositions etc would be dealt with. The objective here is to acquaint them with the level of complexity presented in recruitment tests and also provide them techniques to solve such question with tricks/methods in a very short period. The English communication and soft skills section of PSD-6 focuses on the other important aspects of soft skills training students such as techniques of effectively handling Personal Interviews during placement process and understand the dynamics of structured Resume and PIs

Course Outcomes

The student should be able to

1. Learn further concepts of Maths, Logical reasoning and English grammar and apply short cuts/ tricks to solve questions in less time. Learn remaining 25-30 rules of grammar topics such as prepositions,

conjunctions etc relevant from the recruitment point of view.

2. Learn to handle vocabulary questions such as synonyms and analogies in recruitment test and other competitive exams
3. Understand and Learn techniques/Strategies of how to handle Personal interviews during recruitment process. Through Mock PIs students would be taught the appropriate ways of answering tricky questions in Interview and would learn the correct body language etc to be demonstrated in an interview process.
4. They would be acquainted with the differences between CV, Bio- Data and Resume and they would learn the correct format of a Résumé along with methods and styles to make their Resumes interesting.
5. Students would learn to incorporate various rules of written communication in business writing scenario with the appropriate tone and words.
6. Understand the importance of grooming, body language and etiquettes in the corporate sector. They would be able to conduct themselves in a professional and impressive way by conducting themselves according to situations in the professional sector.

<u>Unit I</u> (24Hours)

Aptitude (Maths, Logical Reasoning, English)

- Maths
    - Permutation & Combinatiom
    - Probability
    - Maths Revision -1
    - Maths Revision - 2
- Logical Reasoning
    - Matching, Selection & Arrangement
    - Clocks & Calendars, Visual Reasoning
    - Input , Output & Flow Chart.
    - Reasoning Revision- 1

    - Reasoning Revision-2
- English
    - Grammar – III– (Prepositions& Conjunctions)
    - Grammar- (Articles & Parallelism)
    - Verbal Ability Revision- I

Unit II (24Hours)

Soft Skills & English Communication

- Resume-I
- Resume- II
- Mock GD
- Mock GD
- Personal Interviews-I
- Personal Interviews-II
- Mock PI
- Mock PI
- Extempore Speeches, Group Interviews
- Written Skills- Revision
- Stress Management
- Business Writing Tones.

Text Books

1. APAART: Verbal Ability
2. APAART: Logical Reasoning
3. APAART: Quantitative Aptitude
4. APAART: Speak Well 1 (English Language and Communication)
5. APAART: Speak Well 2 (Soft Skills)

RULES REGARDING ATKT, CONTINUOUS ASSESSMENT AND AWARD OF CLASS

Standars of Passing and ATKT Rules

1. For all courses, both UE (Universtiy Evaluation) and IA (Internal Assessment) constitue separate heads - of - passing (HoP). In ordar 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 course is atleast 6.0 (50 % Aggregate). The GPA for a course will be calculated only if the learner passes at the UE.
2. A student who fail 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 backlog candidate and clear the HoP.

Rules of ATKT

1. A student is allowed to carry backlog of courses prescribed for B.Tech Sem - I, III, V, VII to B.Tech Sem - II, IV, VI, VIII respectively.
2. A student is allowed to keep term of Sem - III, if he/she is failing in any number of subjects of Sem I & II.
3. A student is allowed to keep term of Sem - V, if he/she is failing in any number of subjects of Sem - III & IV but passed in all subjects of Sem - I & II.
4. A student is allowed to keep term of Sem - VII, if he/she is failing in any number of subjects of Sem - V & VI but passed in all subjects of Sem - III & IV.

Award of Class for the Degree Considering CGPA

Award of Honours

A student who has completed the minimum credits specified for the programme shall be decleared 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 at the End of the Programme are as given below.

Range of CGPA	Final Grade	Performance Descriptor	Equivalent Range of Marks (%)
9.50 ≤ CGPA ≤ 10.00	0	Outstanding	80 ≤ Marks ≤ 100
9.00 ≤ CGPA ≤ 9.49	A+	Excellent	70 ≤ Marks ≤ 80
8.00 ≤ CGPA ≤ 8.99	A	Very Good	60 ≤ Marks ≤ 70
7.00 ≤ CGPA ≤ 7.99	B+	Good	55 ≤ Marks ≤ 60
6.00 ≤ CGPA ≤ 6.99	B	Average	50 ≤ Marks ≤ 55
5.00 ≤ CGPA ≤ 5.99	C	Satisfactory	40 ≤ Marks ≤ 50
CGPA Below 5.00	F	Fail	Marks Below 40

BHARATI VIDYAPEETH DEEMED UNIVERSITY
Pune.

Faculty of Engineering & Technology
Programme : B. Tech. (Chemical)

COURSE STRUCTURE AND SYLLABUS

(Choice Based Credit System - 2014 Course)

Chemical Engineering (Sem VII and Sem VIII)

Bharati Vidyapeeth Deemed University, Pune

Bharati Vidyapeeth, the parent organization of this University is one of the largest educational organizations in the country. It has 171 educational units under its umbrella including 67 Colleges and Institutes of conventional and professional education.

The Department of Human Resource Development, Government of India on the recommendations of the University Grants Commission accorded the status of "Deemed to be University" initially to a cluster of 12 units of Bharati Vidyapeeth. Subsequently, 17 additional colleges / institutes were brought within the ambit of Bharati Vidyapeeth Deemed University wide various notifications of the Government of India. Bharati Vidyapeeth Deemed University commenced its functioning on 26th April, 1996.

Constituent Units of Bharati Vidyapeeth Deemed University

1. BVDU Medical College, Pune.
2. BVDU Dental College & Hospital, Pune
3. BVDU College of Ayurved, Pune
4. BVDU Homoeopathic Medical College, Pune
5. BVDU College of Nursing, Pune
6. BVDU Yashwantrao Mohite College of Arts, Science & Commerce, Pune.
7. BVDU New Law College, Pune
8. BVDU Social Sciences Centre (M.S.W.), Pune
9. BVDU Yashwantrao Chavan Institute of Social Science Studies & Research, Pune.
10. BVDU Centre for Research & Development in Pharmaceutical Sciences & Applied Chemistry, Pune
11. BVDU College of Physical Education, Pune.
12. BVDU Institute of Environment Education & Research, Pune
13. BVDU Institute of Management & Entrepreneurship Development, Pune
14. BVDU Poona College of Pharmacy, Pune
15. BVDU College of Engineering, Pune
16. BVDU Interactive Research School in Health Affairs (IRSHA), Pune
17. BVDU Rajiv Gandhi Institute of Information Technology & Biotechnology, Pune
18. BVDU College of Architecture, Pune
19. BVDU Abhijit Kadam Institute of Management & Social Sciences, Solapur
20. BVDU Institute of Management, Kolhapur
21. BVDU Institute of Management & Rural Development administration, Sangli
22. BVDU Institute of Management & Research, New Delhi

23. BVDU Institute of Hotel Management & Catering Technology, Pune
24. BVDU Yashwantrao Mohite Institute of Management, Malakapur-Karad
25. BVDU Medical College & Hospital, Sangli
26. BVDU Dental College & Hospital, Mumbai
27. BVDU Dental College & Hospital, Sangli
28. BVDU College of Nursing, Sangli
29. BVDU College of Nursing, Navi Mumbai

The status of University was given to a cluster of these colleges and institutes in appreciation of the high level of their academic excellence and for their potential for further growth.

During the last 20 years or so, the University has achieved higher pinnacles of academic excellence and has established its reputation to such an extent that it attracts students not only from various parts of India but also from abroad. According to a survey conducted by Association of Indian Universities, this University is one among the top ten Universities in the country preferred by the overseas students for admissions. At present, there are more than 850 overseas students from 47 countries on the rolls of constituent units of this University.

During the last 20 years, there has been tremendous academic expansion of the University. It now conducts in all 305 courses in its constituent units, of them 108 are Post Graduate, 45 are Under Graduate and 55 Diploma level courses. 12 Fellowship and 5 certificate courses. All the professional courses which the University conducts such as those of Medicine, Dentistry, Engineering etc., have approval of the respective statutory councils, viz., Medical Council of India, Dental Council of India, All India Council for Technical Education etc.

The University is a throbbing center of research activities and has launched Ph.D. programmes in 77 subjects and M.Phil in 3 subjects. It has also introduced quite few innovative academic programmes such as Masters in Clinical Optometry, M.Tech. in Nano Technology etc.

The University's performance and achievements were assessed by the "National Assessment and Accreditation Council" and it was reaccredited with a prestigious "A" grade in 2011. Some programmes of the constituent units such as College of Engineering at Pune, Management Institute in Delhi and others have also been accredited by "National Board of Accreditation". Three constituent units of Bharati Vidyapeeth Deemed University are also the recipients of ISO 9001-2001 certifications.

College Information :

Bharati Vidyapeeth University College of Engineering, Pune (BVUCOE) established in 1983, a constituent unit of BVU (University with 'A' Grade status by MHRD, accredited to Grade 'A' by NAAC in 2004 and 2011) and holds a place of pride and is amongst the most reputed institute. It has been ranked to 61st by National Institutional Ranking Framework (NIRF) with criteriawise ranking as 5th in Graduate Outcome (GO), 13th in Outreach and Inclusivity (OI), 44th in Teaching Learning Resources (TLR) and 62nd in Perception (PR). This also made institute to stand 4th in the State of Maharashtra. Further, DATAQUEST-CMR national survey also ranked this institute to 4th among private technical institutions of India, 29th by Times of India and 41st by OUTLOOK. This is the only institute selected by MHRD for its Technical Education Quality Improvement Programme (TEQIP-II – 1.1 Programme) for the grant of Rs. 4 Crores.

BVUCOE, Pune offers 09 graduate, 08 post graduates programmes and Doctoral programmes in 08 disciplines. All Programmes are accredited by National Board of Accreditation (NBA) twice and we have applied for third cycle of accreditation.

Institute has its own spacious well designed building measuring 26,286 sq. m. and it houses 101 labs, 43 class rooms, and 21 tutorial rooms. The library of the institute is a five storied building and houses periodical section, computer center, reading hall, reference section. It contents more than 60,000 books, 15,000 volumes, 80 national and 81 international journals subscription and digital library facility. Digital library of institute with 66,944 number of journals in e-form is one of the richest source of knowledge in e-form for students and faculty members. The Library, Laboratories, Equipments, Learning resources and Software constantly get upgraded and updated in tune with the changing time. An Investment of Rs.119.95 million is made in the last five years.

The structured faculty development programme has strengthened quality of Teaching - Learning Process in the institute. 35 faculty members with Ph. D. qualifications have been proved as resources for research, innovations and sound Teaching – Learning Process. As a part of quality improvement programme 04 number faculty members were deputed to International Universities, Institutions of national importance such as IIT, NIT etc. for qualification improvement. Team of 206 faculty members with average experience 11.7 years and average age 38.3 years indicates teachers with fine blend of experience and youth. Faculty members are well conversant and trained for use of latest softwares and latest equipments being purchased every year as policy of upgrading laboratories. In last five years college has invested Rs. 119.95 million in laboratory upgradation. Institute organized 138 number of continuing education programmes in last five years to keep sharpen skills of faculty members. Further, 1389 faculty members were deputed to attend various workshops and training programmes for sharing and enhancing their knowledge. Faculty members also play active role in curriculum development as Member of Board of Studies of various subjects and other statutory bodies of the University.

The research quality is indicative of the university penchant for quality. The research publications in reputed international and national refereed journals and conferences have shown a steady and significant rise over the years which is aptly reflected by 1091 Research papers publications in reputed national and international journals in last five years. Grant of Rs. 152.73 Lakhs from funding agencies such as UGC, DST, DRDO, AICTE etc. fetched by faculty members is strong indicator of research aptitude of faculty members. Seed money up to Rs. 3 lakhs under Institutionally Funded Research Programme (IFRP) nurtures research aptitude of faculty members. 575 number of publications in standard research databases such as SCOPUS, Web of Science, Google Scholar etc. in last five years throws light on quality of publications by faculty members of this institute. These publications by faculty members have received 137 number of citations in the same period. Institute has 02 patents to its credit and filed 05 patents.

The institute has collaboration with international universities such as North Carolina A & T State University, Greensboro, USA, Joint School of Nanoscience and Nanoengineering (JSNN), USA, The University of Tokushima, Japan, ARM University, USA and with industries such as TCS, SKF India Ltd. Every year one faculty member is deputed for Ph. D. programme in NCAT with scholarship. Students of M. Tech. (Nanotechnology) joins JSNN, USA to pursue their dissertation research work for six months with scholarship to the tune of $1000 per month. Further, NCAT, USA, The University of Tokushima, Japan contributes intellectually as well as financially to organize biannual international conference NANOCON. Three editions of NANOCON are conducted since 2010 with their association. In association with Eduvance & GAATsis, a " Center of Excellence in Embedded Systems" is established in the Institute with donation of Educational kits like ARM development boards from ARM University Program and PSoC kits by Cypress Semiconductors are used for developing projects in the sponsored laboratory. TCS supports students and faculty members for faculty enablement programmes and student development programme. Establishment of Lubricant Conditioning Monitoring Laboratory is outcome of collaboration with SKF India Ltd.

Being Deemed University college takes advantage of academic autonomy in making the curriculum industry oriented and enable students to make employable. In-plant training (45 days), courses such as Professional Skill Development introduced as integrated part of course structure. In-plant training enable students to interact within their associated industries for gaining practical field experience and professional exposure. Curriculum is Choice Based Credit System which makes students path of joining international universities for their higher studies smoother.

Today, qualitative soft skill development in students is more pertinent to a student's professional career. The institute regularly arranges training programme in the area of personality development, aptitude test, group discussion and personal interview. Through its Employment Enhancement Programme (EEP) designed for third year students which comprises of communication skill quantities analysis, corporate culture, IT Training and soft skills. This programme is conducted in association with professional institutes of national repute for effective execution and implementation. To enhance their professional experience and get them head start in the industry, an innovative programme is initiated on student mentoring "Saturday @ BV", wherein speakers are entrepreneurs and high ranked corporate who share their experiences, hardship and their corporate journey.

In it's long, multi-pronged, persistent and pain staking efforts for producing quality engineering professionals, institute has produced more than 1068 entrepreneurs.

PROGRAMME : CHEMICAL ENGINEERING

A). INSTITUTE VISION

To be world class institute for social transformation through dynamic education

MISSION

To provide quality technical education with advanced equipment, qualified faculty members, infrastructure to meet needs of profession and society.

To provide an environment conductive to innovation, creativity, research and entrepreneurial leadership.

To practice and promote professional ethics, transparency and accountability for social community, economics and environmental conditions.

B). DEPARTMENT

VISION:

To be globally recognized chemical engineering department for academic excellence and research.

MISSION:

- To impart quality Chemical Engineering education to provide professionally competent engineers.
- To develop conducive research environment to meet ever-changing aspirations of chemical and allied fields.
- To promote entrepreneurship and leadership qualities with a strong foundation of social and professional ethics.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

- Practice Chemical Engineering in conventional, multidisciplinary and emerging fields
- Pursue advanced studies or other forms of continuing education
- Demonstrate professionalism, ethical and social responsibility and desire for lifelong learning

PROGRAMME OUTCOMES (POs):

- Apply knowledge of mathematics, science and engineering principles to solve wide range of open ended Chemical Engineering problems.
- Analyze the problem and give feasible solutions using fundamentals of mathematics, basic sciences and engineering sciences.

- Design chemical process equipments and processes to meet desired needs with realistic constraints.
- Conduct engineering experiments to analyze and interpret the information obtained from the experiment to synthesis and design valid conclusions.
- Utilize the techniques, analytical skills and modern computational tools necessary for successful Chemical Engineering practice.
- Develop the culture of health and safety in Chemical Engineering practice by adhering to statutory regulations.
- Understand the impact of Chemical Engineering solution in a techno-economic, environmental and societal context for sustainable development.
- Understand the need for ethical decision making in engineering practice.
- Function effectively as an individual and as a member or leader within multi disciplinary teams.
- Express ideas and position clearly and concisely in both oral and in written communication.
- Understand the fundamental precept of effective project management and finance.
- Appreciate the need for and engage in lifelong learning to maintain and enhance the practice of Chemical Engineering.
- Acquire entrepreneurship skills and business insight.

Bharati Vidyapeeth University
Faculty of Engineering and Technology
Programme: B. Tech. (Chemical) Semester VII- 2014 Course

Sr. No.	Subject	Teaching Scheme (Hours/week)			Examination Scheme (Marks)							Credit		
		L	P/D	T	End Semester Examination	Continuous Assessment: Unit Test	Continuous Assessment: Attendance	Continuous Assessment: Assignments	TW/O	TW/P	Total	Theory	P/D	Total
1	Elective-III	3	2	-	60	20	10	10	50	-	**150**	3	1	**4**
2	Chemical Process Equipment Design- II	3	2	-	60	20	10	10	50	-	**150**	3	1	**4**
3	Plant Utilities and Process Safety	3	-	-	60	20	10	10	-	-	**100**	3	-	**3**
4	Process Dynamics and Control	3	2	-	60	20	10	10	-	50	**150**	3	1	**4**
5	Multiphase Reaction Engineering	3	-	-	60	20	10	10	-	-	**100**	3	-	**3**
6	Industrial Training	-	-	-	-	-	-	-	50	-	**50**	-	3	**3**
7	Project [Stage I]	-	4	-	-	-	-	-	100	-	**100**	-	4	**4**
	Total	**15**	**10**	**-**	**300**	**100**	**50**	**50**	**250**	**50**	**800**	15	10	**25**

Elective-I

1. Combustion Engineering
2. Advanced Material Science
3. Multiphase Flow
4. Rheology

Elective-II

1. Biofuel Technology
2. Polymer Technology
3. Food Technology
4. Nanomaterials

Bharati Vidyapeeth University

Faculty of Engineering and Technology

Programme: B. Tech. (Chemical) - Semester VIII - 2014 Course

Sr. No.	Subject	Teaching Scheme (Hours/week)			Examination Scheme (Marks)							Credit		
		L	P/D	T	End Semester Examination	Continuous Assessment			TW/O	TW/P	Total	Theory	P/D	Total
						Unit Test	Attendance	Assignments						
8	Elective-IV	3	2	-	60	20	10	10	50	-	150	3	1	4
9	Plant Design, Project Engineerir and Costing	3	2	-	60	20	10	10	50	-	150	3	1	4
10	Industrial Management	3	-	-	60	20	10	10	-	-	100	3	-	3
11	Chemical Process Modeling an Simulation	3	2	-	60	20	10	10	-	50	150	3	1	4
12	Seminar	-	-	2	-	-	-	-	50	-	50	2	-	2
13	Project [Stage II]	-	6	-	-	-	-	-	200	-	200	-	8	8
Total		**15**	**6**	**8**	**240**	**80**	**40**	**40**	**350**	**50**	**800**	14	11	**25**

Total Credits
Semester VII : 25
Semester VIII : 25
Grand Total : 50

Elective-III

1. Petroleum Refinery Engineering
2. Membrane Separation
3. Fuel Cell Technology
4. Advanced Oxidation Processes

Elective-VI

1. Hazardous Waste Management
2. Bio-separations
3. Energy Engineering
4. Green Technology

CHEMICAL PROCESS EQUIPMENT DESIGN-II

TEACHING SCHEME	CREDITS ALLOTTED
Lectures : 03 Hrs/Week	Theory : 03 Credits
Drawing : 02 Hours / Week	Practical :01 Credit
Total : 05Hours/Week	Total credits : 04

Course Pre-requisites

Students should have basic knowledge of

1 Unit Operations involved in chemical engineering

2 Heat transfer and Mass transfer and Mechanical operation equipments.

Course Objectives

After completion of the course, students would be able to

1. Design evaporator and crystallizers.
2. Design Dryers and Filters.
3. Design different columns used in distillation/Absorption.
4. Identify and design different packings used in packed columns.
5. Calculate height of packing, column diameter in packed columns.
6. Understand importance of process safety and Hazard Analysis.

Course Outcomes

After completion of the course, students would be able to

1. Design evaporator and crystallizers.
2. Design Dryers and Filters.
3. Design different columns used in distillation/Absorption.
4. Identify and design different packings used in packed columns.
5. Calculate height of packing, column diameter in packed columns.
6. Understand importance of process safety and Hazard Analysis.

UNIT-I (06)

Evaporators & Crystallizers

Classification of vaporizing equipment, evaporators such as kettle, thermosiphon, vertical, horizontal etc., Chemical evaporators, natural circulation & forced circulation evaporators, the calculation of chemical evaporators, crystallizers, types of crystallizers, design considerations. Case studies on evaporators.

UNIT-II (06)

Filters & Dryers:

Various types of filters like vacuum filters, pressure filters, centrifuges and rotary drum filters, design of rotary drum filters, including design of drum, shaft, bearing and drive system. Types of dryers, batch type dryers, continuous dryers.

UNIT-III (06)

Tray Column Design

Design of plate column- distillation columns, design variables in distillation, design methods for binary systems, plate efficiency, approximate column sizing, plate Contactors, plate hydraulic design.

UNIT-IV (06)

Packed Column Design

Choices of packing, types of packing, packed bed height (distillation and absorption), HETP, HTU, NTU, Cornell's method, Onda's method, column diameter, column internals, column auxiliaries.

UNIT-V (06)

Piping Design I

Definition and Application of Piping, Classification of pipe, Piping Material Specifications, Manufacturing Method, Weight and Size Standards STD , Extra Strong XS , Double Extra Strong XXS etc. Pressure Temperature Rating System, Pipe Fittings, Types of Flanges, Types of Valves,

UNIT-VI (06)

Piping Design II

Codes and Standards, Piping elements, Pipe Hydraulics and Sizing, Mechanical Design, Fundamentals Piping Drawing, Basics Development of Plot Plan, Equipment and Piping Layout, Stress Analysis Static and Dynamic, Selection and Design of Supports and Expansion Joints,Transient Fluid flow Analysis. Friction Factor, Moody Diagram, Minor Losses in Piping ,Equivalent Length Method & Loss Coefficient Method,

Term work

Term work will consist of the Practicals and drawings listed below, out of which any eight are to be done by students. Any one drawing in Autocad.

1. Design and drawing of evaporator.
2. Design and drawing of crystallizer.
3. Design and drawing of rotary filter.
4 Detailed design and drawing of piping layout.
5. Detailed design and drawing of spray dryer..
6. Detailed design and drawing of distillation column.
7. Detailed design and drawing of absorption column..
8. Study various packings.
9. Design and calculations of packed column.
10. Study the contains of stress analysis of pipes.
11. Detailed design and drawing of piping supports.

Assignments

1. Write a report on different evaporators and crystallizer
2. Types of Dryers and filters.
3. Designing of Distillation column.
4. Designing of Absorption column.
5. Importance of piping design.
6. Pipe sizing and supports
7. Report on Equivalent Length Method & Loss Coefficient Method,
8. Solve old (last five years) question papers with reference to particular topic.
9. Prepare a model for any of the equipment
10. Prepare a report on advance equipments which are newly introduced in the current year.
11. Give fifteen minutes presentation (seminar) on particular topic and prepare a report.
12. Solve old (last ten years) GATE question papers with reference to design subject.
13. Group discussion on the recent advances in equipment design
14. Write a report on your visit to research and development laboratory of national/international repute.
15. Technical interview based on the knowledge of design

In addition to these above stated assignments concerned faculty member may design his/her own assignments

Text Books / References

1. Joshi. M.V, and Mahajani. V.V, "Process Equipment Design," 3rd Edn. Macmillan India Limited, New Delhi, 1996
2. Bownell, L.E., and Young, E.M., "Process Equipment Design", Wiley Eastern, 1968.
3. Sinnott. R.K, Coulson & Richardson's, "Chemical Engineering", Volume 6, 3rd Edn., Butterworth Heinemann, New Delhi, 1999.
4. Bhattacharya B C, Chemical Equipment Design , CBS publishers.
5. Dawande S D, " Process Equipment Design" DENETT publishers

Syllabus for Unit Test

Unit Test -I	UNIT – I ,II,III
Unit Test -II	UNIT – IV,V,VI

MULTIPHASE REACTION ENGINEERING

TEACHING SCHEME
Lectures : 03 Hrs/Week

CREDITS ALLOTTED
Theory : 03 Credits
Practical :01 Credit
Total credits : 04

Course Pre-requisites

Students should have basic knowledge of

1. Thermodynamics
2. Transport Processes

Course Objectives

Students will get basic knowledge of electronic components, devices, microcontroller, digital electronics and communication.

Course Outcomes

After completion of the course students would be able to

1 Recognize the importance of multiphase reactors.

2 Determine chemical reaction equilibrium constant and rate controlling step for heterogeneous system.

3 Recognize the effect of system and operating parameters on the hydrodynamics of multiphase reactors.

4 Recognize the significance of mixing and determine extent of mixing in multiphase system

5 Determine the effect of system, geometric, and operating parameters on heat and mass transfer coefficients.

6 Enumerate the effect of hold up in the design of multiphase reactors

UNIT - I (06)

Introduction to Multiphase Reactor Engineering

Resistors, Inductors and Capacitors and their types, Construction and characteristics of PN junction diode, Zener Diode, Tunnel diode, Bipolar junction transistors CB,CC,CE circuits, Field Effect transistors.

UNIT - II (06)

Thermodynamics and kinetics

Notable industrial heterogeneous systems and thermodynamic role. Application of equilibrium criteria to chemical reactions. The Gibbs energy change and equilibrium constant. Estimation of equilibrium constant for heterogeneous system by defining standard state of the phases involved. Determination of rate controlling step: intrinsic kinetics for heterogeneous systems

UNIT - III (06)

Hydrodynamic Characteristics

Hydrodynamic characteristics of different multiphase reactors: Mechanically Agitated Contactors (MAC), Bubble Columns, Slurry Reactors, Fluidized Beds, Loop Reactors and Modified Versions

UNIT - IV (06)

Mixing Studies

Effect of geometrical, system, and operating parameters on phase mixing in multiphase reactors. Quantification of phase mixing. Development of a mathematical model.

UNIT - V (06)

Heat Transfer and Mass Transfer Studies

Effect of geometrical, system, and operating parameters on heat transfer coefficient in multiphase reactors. Quantification of heat transfer coefficient. Application of correlations available to different multiphase reactors. Experimental techniques used for estimation of mass transfer coefficient and selection of suitable technique for a multiphase reactor. Effect of geometrical, system, and operating parameters on mass transfer coefficient in multiphase reactors. Quantification of mass transfer coefficient. Application of correlations available to different multiphase reactors.

UNIT - VI (06)

Design Aspects of Multiphase Reactors

Pressure drop, Fractional phase hold- up, mass and heat transfer coefficient, extent of mixing, etc.

Assignment

1. Enumerate any one industrial relevant multiphase system
2. Refer any one recently published article related to multiphase system and make presentation
3. Estimate the power requirement for a given impeller
4. Visit to any chemical process industry to study atleast one multiphase system
5. List the pressure measurement tools available in the market
6. List and enumerate physical significance of the empirical correlations available in the literature to estimate liquid dispersion coefficient.
7. List and enumerate physical significance the empirical correlations available in the literature to estimate mass transfer coefficient.
8. Refer any review article perati
9. Technical interview based on the knowledge of analytical techniques.
10. List out all the principles of the analytical techniques.
11. Perform any one chromatographic technique.
12. Find out different types of proteins with structure.
13. Prepare a report on downstream processing.

In addition to these above stated assignments concerned faculty member may design his/her own assignments.

Text Books/Reference Books

1 L. K. Doraiswamy and M. M. Sharma, “Heterogeneous Reactions”, 2nd Edition, Volume I and II.

2 G. B. Tatterson, ”Fluid Mixing and Gas Dispersion in Stirred Reactors”, 10th Edition, Academic Press, London, 1994

3 W. D. Deckwer, “Bubble Column Reactors”, Cambridge University Press, New York, 2000

4 DiazoKunji and O. Levenspiel, “Fluidization Engineering”, 2nd Edition, Butterworth Heinemann, 1991.

5 J. F. Devidson and Harrison, ” Fluidization”, 10th Edition, Academic Press, London, 1994

Syllabus for Unit Test

Unit Test -1 UNIT – I, II, III

Unit Test -2 UNIT – IV, V, VI

PLANT UTILITIES AND PROCESS SAFETY

TEACHING SCHEME
Lectures : 3 Hours/Week

CREDITS ALLOTTED
Theory : 03
Total Credits : 03

Course Pre-requisites

Students should have knowledge of

1. Chemical Technology, Chemical Process Industries

Course Outcomes

After completion of the course students will be able to

1. Identify the common utilities required for Chemical Plant.
2. Express various types of boilers and their selection.
3. Analyze the importance of insulation and air pressure in process.
4. Identify and analyze the hazards.
5. Integrate the theoretical and practice knowledge to understand hazards activities.
6. Implement the safety designs and procedures.

UNIT - I (06)

Identification of common plant utilities

Role and importance of pant utilities in chemical plants, Water, compressed air, steam, vacuum, refrigeration, venting, flaring and pollution abating. Water and its quality, storage and distribution for cooling and fire fighting, Water resource management.

UNIT - II (06)

Steam Generation and Utilization

Steam generation and its application in chemical process plants, distribution and utilization; Types of boilers and their operation; steam economy, Steam condensers and condensate utilization, Steam generation by utilizing process waste heat using thermic fluids, Selection and sizing of boilers; waste heat boilers.

UNIT - III (06)

Compressors, blowers and Vacuum Pumps

Compressors, blowers and vacuum pumps and their performance characteristics; Methods of developing vacuum and their limitations, material handling under vacuum, Creation of low pressure/vacuum by pumps and ejectors.

Refrigeration and HVAC

fundamentals of refrigeration, refrigerant management and safety, Selection of refrigerants; Processes of HVAC, Psychometric Chart and Air-Conditioning System, Ventilation and Indoor Air Quality.

UNIT - IV (06)

Elements of Safety

Elements of safety, safety and site selection; Plant layout and unit plot planning; Definition of risk and hazard, Identification and assessment of the hazards, distinction between hazards and risk, Industrial hygiene, toxicological studies, Hazard operability (HAZOP) hazard analysis (HAZAN); Safety Integrity Level (SIL) Studies; Technology selection and transfer, choosing the right process.

UNIT - V (06)

Safety in Chemical Processes

Introduction, Chemical Process classification, Process design and safety parameters. Safety parameters in the process design of phenol from cumene, safety in polyvinyl chloride plant.

Chemicals and their Hazards

Acetonitrile, acetyl chloride, butyl amine, acrylamide, acrylonitrile, allyl alcohol, benzene, bromine, isopropyl alcohol, acetaldehyde, ethylene oxide, butane, n-hexane, anhydrous ammonia, acetone, toluene, p-xylene, acetic acid, monochloro benzene, oleum, carbon monoxide.

UNIT - VI (06)

Safety Procedures and Designs

Process Safety Hierarchy, Process Safety Strategies, Managing Safety, Safety Reviews and Accident Investigations, Designs for Process Safety, Inherently Safer Designs, Controls: Double Block and Bleed, Safeguards or Redundancy, Block Valves, Explosion Suppression, Designs for Runaway Reactions.

Tutorials/Assignments:

The internal assessment shall consist of minimum SIX assignments from the following list

1. Prepare a report on safety issues of any one particular industry.
2. Prepare Utility Line Diagram (ULD) for typical process.
3. Write a report on HAZOP study of one particular hazard.
4. Prepare a report on the color codes for utility pipelines in chemical plants.
5. Enhancement in collaborative learning is done through, group assignments that will be given to encourage students to work with classmates to discuss and complete homework assignments
6. Write a report on " Importance of Industrial Hygiene in Chemical Industry"
7. Group discussions on any of the following topics:
    a) Importance of various utilities in chemical industries.
    b) Process safety in petroleum industry
    c) HAZOP Vs HAZAN
8. Design a manual for application of utilities for various plants.
9. With the help of this subject knowledge, write a guideline report on how you would apply your concepts in industry.
10. Write a technical report on HAZAN study of any one particular threat.
11. Elaborate the role of safety engineer in Chemical industry.
12. Organizing a industrial visit to nearby industry to understand the plant utilities and safety measures.
13. Write a report on your visit to research and development laboratory of national/international repute.

Text Books/

1. Chemical Process Plants-Managing Plant Utilities, Volume One
2. Chemical Process Plants-Managing Plant Utilities, Volume Two

3. Robert McDowall, “Fundamentals of HVAC Systems”, Butterworth-Heinemann Elsevier, First edition 2006
4. John J. McKetta, “Encyclopedia of Chemical Processing and Design“, Volume 44 CRC Press, 1993
5. Daniel A. Crowl, Joseph F. Louvar, “Chemical Process Safety Fundamentals with Applications”, Prentice Hall, Third Edition, 2011
6. Trevor A. Kletz, “Hazop & Hazan: Identifying and Assessing Process Industry Hazards”, Fouth Edition, CRC Press, 1999.

Syllabus for Unit Test

Unit Test -1	UNIT – I, II, III
Unit Test -2	UNIT – IV, V, VI

B. TECH. (CHEMICAL) SEM. VII

Designation: Professional Core

PROCESS DYNAMICS AND CONTROL

TEACHING SCHEME	CREDITS ALLOTTED
Lectures: 3Hours/Week	Theory : 03
Tutorial : 2 Hour /Week	Practical : 01
Total: 5 Hour /Week	Total credits: 04

Course Pre-requisites

Students should have

1. Basic knowledge of Mathematics.
2. Process Instrumentation and Instrumental Methods of Analysis

Course Outcomes

After completion of the course students will be able to

1. To give details of basic control action and develop mathematical models for control purpose.
2. To illustrate behavior of chemical processes.
3. To elucidate transient response of system.
4. To describe stability of the system.
5. To analyze frequency response of process.
6. To apply knowledge for controller selection and tuning.

UNIT - I (06)

Introduction :

Block diagrams, closed loop and open loop control systems, Basic control actions.

Open Loop Response of Simple Systems:

Dynamics of first order systems using transfer functions; Various first order responses such as, a thermometer bulb. General response to step, ramp, impulse, and sinusoidal inputs; Concentration and temperature responses of a stirred tank

UNIT - II (06)

Dynamic Behavior of Chemical Processes :

Linearization of liquid level systems: Response of a pressure system, second order systems, the manometer; Response of interacting and non interacting systems. Transfer functions and the input-output models. Dynamics and analysis of first, second and higher order systems.

UNIT - III (06)

Transient Response of Control Systems:

Servo and regulated operation, General equations for the transient response, proportional control of a signal capacity process; Integral control, Proportional-integral control and derivative action.

UNIT - IV (06)

Stability:

Concept of stability, Stability criterion, Routh test for stability.

Root Locus Analysis:

Concept of root locus, Locus diagram.

UNIT - V (06)

Frequency Response Analysis:

First order systems, Bode diagram, and Complex numbers to get frequency response. Nyquist plot.

UNIT - VI (06)

Advanced Control Schemes:

Controller selection and tuning, Control valve characteristics and sizing, cascade control, Feed forward and ratio control. Introduction of digital control system.

List of Experiments:

Term work will consist of the experiments listed below, of which at least eight should be performed in laboratory by the students.

1. To study the closed loop pressure control for P control action and calculate offset.
2. To study the closed loop pressure control for PI action PID action.
3. To study optimizing performance for pressure control trainer by using tuning technique with help of PID action.
4. To study closed loop system for servo problem having PI action consideration.
5. To study the closed loop flow controller
6. To study the closed loop level controller
7. To study the ratio controller
8. To study the cascade controller
9. Root locus analysis on software (Ex. MATLAB)
10. Bode plot on software (Ex. MATLAB)
11. Nyquist plot on software (Ex. MATLAB)
12. PID control loop simulation for a first order process (Ex. SIMULINK)

Assignments

1. Students have to visit chemical industry and prepare a detailed report on various controllers used in industry.
2. Watch NPTEL video and make report on various topics in process dynamics and control
3. Group discussions on controllers used for chemical processes.
4. To find Transfer Function for 1st order and 2nd order process.
5. Draw the Control Loop and Block Diagram for different chemical processes.
6. Solve numerical questions in last three year question papers.
7. Write note on Advance Controllers.
8. Explain Digital Controllers.
9. Explain IMC Controller in Detail.

10. Explain MPC Controller in Detail.
11. Explain process Identification of any Chemical Process in detail
12. Explain Optimal control of any one Chemical Process.

Text Books/

1 G. Stephanopoulos, Chemical Process Control: An introduction to theory and practice, Prentice Hall, New Jersey, 1984.

2 P. Harriott, Process Control, Reprint of text,ed. Tata McGraw Hill, 1983.

3 D. R. Coughanowr, Process system analysis and control, 2nded, McGraw Hill, 1991.

4 Seborg, D.E., Edgar, T.F. and Mellichamp, "Process dynamics and control," Wiley, New York, D.A. 2003.

Syllabus for Unit Test

Unit Test -1 UNIT – I, II, III

Unit Test -2 UNIT – IV, V, VI

CHEMICAL PROCESS MODELING AND SIMULATION

TEACHING SCHEME	CREDITS ALLOTTED
Lectures: 3 Hours/Week	Theory : 03
Practical : 2 Hour /Week	Practical: 01
Total : 5Hours/Week	Total credits: 04

Course Pre-requisites

Students should have basic knowledge of

1 Heat transfer, Mass transfer, Chemical reaction engineering, Process Dynamics and Control
2 Process Calculation
3 Mathematics including integration and derivation

Course Outcomes

After completion of the course students would be able to

1 Express mass balance, energy balance and momentum balance equation for various chemical process systems.
2 Express models for heat transfer equipment such as double pipe heat exchangers, shell and tube heat exchanger, etc.
3 Develop models for distillation columns, etc.
4 Develop models for reaction equipment such as batch reactor, CSTR, etc.
5 Recognize simulation approaches.
6 Simulate model equations using numerical methods.

UNIT - I (06)

Introduction to modeling:

Introduction, definition of modeling, different types of models, applications of mathematical modeling, principles of formation, lumped model, distributed parameter model, Fundamental laws: continuity equation, energy equation, equations of motions, transport equations, equations of state, chemical kinetics

UNIT - II (06)

Modeling of Heat transfer equipment:

Double pipe heat exchanger, shell and tube heat exchanger, two heated tanks, single component vaporizer, steady-state heat Conduction through a hollow cylindrical pipe, heat transfer with coil

UNIT - III (06)

Modeling of distillation columns:

Ideal binary distillation column, multi component non-ideal distillation column, batch distillation with holdup, flash distillation, packed column design

UNIT - IV (06)

Modeling of reactors:

Two phase CSTR with heat removal, series of isothermal constant holdup CSTRs, CSTRs with variable holdups, Gas phase-pressurized CSTR, Non–Isothermal CSTR, Batch reactor, gas liquid bubble reactor, semi-batch reactor.

UNIT - V (06)

Introduction to simulation:

Introduction to simulation, definition of simulation, approaches of simulation: modular approaches, equation-solving approach, decomposition of networks: tearing algorithms, algorithms based on the signal flow graph, algorithms based on reduced digraph.

UNIT - VI (06)

Simulations using numerical methods:

Use of numerical methods to solve mathematical model equations of Gravity flow tank, Three CSTRs in series, Non-isothermal CSTR, Binary distillation column, Multi-component distillation column, Batch reactor.

Assignment

1. Write a report on the importance of modeling with reference to the process industries.
2. Solve old (last five years) question papers with reference to particular topic.
3. Discuss the importance of modeling and simulation w. r. t. science and engineering
4. Prepare a report on application of modeling and simulation.
5. Give fifteen minute presentation (seminar) on particular topic and prepare a report.
6. Obtain any industrial data for modeling and simulation.
7. With the help of this subject knowledge, write a guideline report on how you would apply your concepts in industry.
8. Discuss different software available for modeling and simulation.
9. Write a technical report on your visit to a process industry with respect to modeling.
10. Group discussion on the recent advances in simulation software.
11. Prepare a report on modeling and simulation of all different chemicals reactors.
12. Technical interview based on the knowledge of Modeling simulation.
13. Students may take any industrial case e.g. manufacturing of Maleic anhydride and solve this case using standard simulation software like Aspen Plus, HYSIS

    In addition to these above stated assignments concerned faculty member may design his/her own assignments.

Term Work

Term work will consist of the practicals listed below, out of which any eight practicals are to be performed in laboratory by the students.

1. Study of gravity flow tank.

2. Study of Batch reactor
3. Simulation of CSTR
4. Simulation of bubble point temperature
5. Simulation of distillation column.
6. Simulation of heat exchanger
7. Simulation of first order reaction system in batch reactor.
8. Simulation of first order reaction system in CSTR
9. Study of a reversible reaction in a batch reactor.
10. Simulation of any model equation.
11. Study of CSTR combination in first order reactions.

For simulation, faculty member may use any suitable simulation software like MATLAB, ASPEN, CHEMCAD, etc. In addition to these above stated practicals concerned faculty member may design his/her own practicals.

Text Books/ Reference Books

1. W. L. Luyben, Process Modeling Simulation and Control for Chemical Engineers, McGraw Hill, 1990.
2. S.C. Chapra, R.P. Canale, Numerical Methods for Engineers, 6th Edition, Tata-McGraw Hill Publications, 2012.
3. R.E.G. Franks, Modeling and Simulation in Chemical Engineering, WielyIntrscience, NY, 1972.
4. B.V. Babu, Process Plant Simulation, Oxford University Press, NY 2004.
5. D. Himmelblau, K.B. Bischoff, Process Analysis and Simulation, John Wiley & Sons, 1968

Syllabus for Unit Test

Unit Test -1	UNIT – I, II, III
Unit Test -2	UNIT – IV, V, VI

INDUSTRIAL MANAGEMENT

TEACHING SCHEME	CREDITS ALLOTTED
Lectures: 3 Hours/Week	Theory : 03
	Drawing: 00
Total:3 Hours/Week	Total credits: 03

Course Pre-requisites

Students should have basic knowledge of

1. Concept of Management.

Course Outcomes

After completion of the course, students would be able to

1. Know the types of business.
2. Understand the types of organization
3. Understand the forms of ownership.
4. Know the concepts of material management.
5. Know the concepts quality management.
6. Know the various acts.

Unit I (6 Hours)

Outline of Business

Types of Business, Industrial sectors Globalization Management Process, Principles of Management, Functions of Management

Unit II (6 Hours)

Organizational Management

Organization, Types of organization, Departmentation, Principles of

Organization, Forms of ownership.

Unit III (4 Hours)

Financial Management

Financial Management- Objectives & Functions, Capital Generation & Management, Budgets and accounts, Taxation (Excise Tax, Service Tax, Income Tax, Value Added Tax and Custom Duty)

Unit IV (6 Hours)

Materials Management

Inventory Concept, its classification, functions of inventory, ABC Analysis, Economic Order Quantity Concept, graphical representation, determination of EOQ,Standard steps in Purchasing, Modern Techniques of Material Management, Material Resource Planning (MRP), Enterprise Resource Planning (ERP)

Unit V (6 Hours)

Quality Management

Quality Management System, Quality Control, Quality Circle, Quality Assurance, Total Quality and TQM, Kaizen,5'S',6 Sigma

Unit VI (6 Hours)

Industrial Legislation and Industrial Safety

Safety Management, Causes of accidents, Types of Industrial Accidents, Preventive measures, Safety procedures

Factory Act, Air (Prevention and Control of Pollution) Act, Minimum Wages Act, Workman Compensation Act.

Assignments

1. Types of business.
2. Globalization in India

3. Different principals of management.
4. Various types of organization
5. Various forms of ownership
6. Capital Generation for an organization.
7. ABC Analysis.
8. Standard purchase
9. Material Resource Planning (MRP), Enterprise Resource Planning (ERP)
10. Concepts of quality management.
11. Total Quality Management (TQM)
12. Kaizen approach in Quality management.
13. 5'S',6 Sigma
14. Factory Act
15. Minimum Wages Act, Workman Compensation Act

In addition to these above stated assignments concerned faculty member may design his/her own assignments

Text Books / References

1. Khanna. O.P., "Industrial Engineering & Management" Dhanpat Rai & Sons New Delhi.
2. Banga T. R. and Sharma S.C. "Industrial Engineering & Management" Khanna Publication
3. Saxena, S.C." Business Administration & Management" SahityaBhavan Agra
4. Newman W.H., Warren E. K. and McGil A. R., "The process of Management" Prentice- Hall

Syllabus for Unit Test:

Unit Test -I	UNIT – I ,II,III
Unit Test -II	UNIT – IV,V,VI

PLANT DESIGN PROJECT ENGINEERING AND COSTING

TEACHING SCHEME	**CREDITS ALLOTTED**
Lectures: 3 Hours/Week	Theory : 03
Practical : 2 Hour /Week	Practical: 01
Total : 5Hours/Week	Total credits: 04

Course Pre-requisites

Students should have basic knowledge of

1. Chemical Process Industry
2. Chemical design

Course Outcomes

After completion of the course students would be able to

1. Select appropriate process for a project.
2. Differentiate the equipment and able to prepare specification sheet.
3. Learn basic economic concept, to understand and apply this concepts in the project works undertaken and to chemical engineering situation by solving problem.
4. Evaluate the project cost including capital investment, product cost and the total project cost.
5. Solve problem on profitability and breakeven analysis.
6. Control and schedule of the project using CPME/PERT technique, calculations.

UNIT - I (06)

Introduction:

LDE with constant coefficients, Method of variation of parameters, Homogeneous Equations, Cauchy's and Legendre's DE. Simultaneous & Symmetric Simultaneous DE. Application to mechanical systems.

UNIT - I (06)

Introduction:

LDE with constant coefficients, Method of variation of parameters, Homogeneous Equations, Cauchy's and Legendre's DE. Simultaneous & Symmetric Simultaneous DE. Application to mechanical systems.

UNIT - II (06)

Optimization and feasibility of plant design, selection of process equipments: Standard versus special equipment selection criteria, and specification sheets. Importance of Laboratory development pilot plant, Indian boiler regulations, factories act.

UNIT - III (06)

Cost estimation:

Cash flow and cumulative cash position for industrial operations, factors affecting estimation of investment and production cost, total capital investment, fixed and working capital investment &their estimations, type of estimates, cost indexes, method for estimating capital investment. Insurance.

UNIT - IV (06)

Estimation of total product cost, Estimation of total product cost: manufacturing cost, general expenses, Manufacturing cost: direct production cost, fixed charges, plant overhead cost. Types of depreciation, Method for determining depreciation: straight line method, decline balance method, sum of the year digit method, shrinking fund method etc, payout period.

UNIT - V (06)

Profitability, alternative investments and replacement: Methods for profitability evaluation, Evaluation of Break Even Point and its significance, % rate of return, Practical factors in alternative investment and replacement Studies .

UNIT - VI (06)

Scheduling and Networking of Project Planning of project schedule by BAR CHART, Inventory control scheduling project using CPM/PERT methods. Network diagramming, earliest start time and earliest finish time, Advantages of CPM, Cost to finish the project earlier than normal cost.

Assignments

1. Write a report on plant design for any company for current year.
2. Write preliminary feasibility report for any industry.
3. Draw complete engineering drawing for any process industry.
4. Prepare specification sheet for equipments for any particular industry.
5. Give power point presentation of different types of cost for industry.
6. Draw a chart of how cash flow takes place in chemical industry.
7. Analyze cost index for last ten years and how it changes.
8. Understand basic concept of depreciation and apply to any chemical industry and calculate the values.
9. Apply a critical-thinking and problem-solving approach towards factories act.
10. Specify materials for construction and estimate the cost of investments for chemical industry.
11. Write complete report for a chemical industry which should include all the factors related to cost estimation.
12. Give power point presentation on knowledge of safety in chemical industry.
13. Give power point presentation on importance of break even analysis.
14. Prepare one network diagramming by using CPM method.
15. Gove a power point presentation on CPM and PERT for any particular industry.

In addition to these above stated assignments concerned faculty member may design his/her own assignments

Term Work

Term work will consist of drawing of sheets

Standard symbols as per IS code

1. Process flow diagram
2. Piping and Instrumentation diagram
3. Plant layout and elevations
4. Utility diagram
5. Piping GA drawing
6. Piping isometrics
7. Draw any sheet by using Autocad.

Text Books / References

1. M.S.Peters and Timmerhaus, "Plant design and Economics for Chemical Engineers", McGraw Hill 3rd Edition.
2. F.C. Vibrandt and C.E. Dryden, "Chemical Engineering Plant Design", McGraw Hill Fifth Edition..
3. Coulson & Richardson's Chemical EngineeringVolume 6, Butterworth-Heinemann, 1999, 3rd Edition.
4. Industrial Engineering and Management by O. P. Khanna Dhanpat Rai & Sons, 1985 7th Edition
5. Project Engineering: Suhas Mokashi ,Mcmillan Publisher .

Syllabus for Unit Test

Unit Test -1 UNIT – I, II, III

Unit Test -2 UNIT – IV, V, VI

ELECTIVE III: ADVANCED OXIDATION PROCESSES

TEACHING SCHEME
Lectures: 3 Hours/Week
Practical : 2 Hour /Week
Total : 5Hours/Week

CREDITS ALLOTTED
Theory : 03
Practical: 01
Total credits: 04

Course Pre-requisites

Students should have basic knowledge of

1. Waste water treatment
2. Engineering Chemistry

Course Outcomes

After completion of the course students would be able to

1. Demonstrate the mechanism of various advanced oxidation processes (AOPs)
2. Understand the method of ozonation and photon induced AOPs
3. Learn the method of heterogeneous photocatalysis and its mechanism
4. Know the method of homogeneous and heterogeneous Fenton processes and its mechanism
5. Analyze emerging AOPs and their mechanism
6. Demonstrate the industrial applications of AOPs

UNIT - I (06)

Introduction to advanced oxidation processes (AOPs)

Conventional waste water treatment processes, Fundamentals and background of AOPs for water and wastewater treatment, basic reaction mechanism of AOPs, Role of hydroxyl radicals and their generation, Reaction kinetics and degradation mechanisms of organic pollutants by hydroxyl radicals, Effects of process parameters and scavenging media on degradation efficiency, oxidation potential of AOPs, merits and demerits of various AOPs

UNIT - II (06)

Ozonation and Photo induced AOPs:

Ozonation: background and fundamentals, reaction kinetics and mechanisms, Application of homogeneous and heterogeneous catalytic ozonation in water treatment

Fundamentals of UV irradiation, Absorption and bond dissociation energy, UV sources and their characteristics, choice of photo source–used in AOPs and their spectral distributions, mechanism of photo induced AOPs.

Photo induced AOPs: Oxidation using ultraviolet irradiation and hydrogen peroxide (UV/H2O2), oxidation using ultraviolet irradiation and ozone (UV/Ozone), oxidation using combination of ultraviolet irradiation, hydrogen peroxide and ozone (UV/ H2O2 /Ozone).

UNIT - III (06)

Heterogeneous photo-catalysis

Fundamentals of semiconductor photo-catalysis, various semiconductor particles used in photocatalytic applications, visible light driven photo-catalysts, photocatalytic reactions and kinetic studies and introduction to nano photo-catalysis.

Photocatalytic reactors, solar energy driven or artificial light photo reactors, solar collectors, design of slurry or supported catalyst reactors, comparing reactor efficiencies and reuse of catalyst.

UNIT - IV (06)

Homogeneous and heterogeneous Fenton processes

Fenton process, photo-fenton process, advanced fenton process, the mechanism of fenton based processes, merits and demerits of homogeneous and heterogeneous Fenton processes.

UNIT - V (06)

Emerging AOPs

Electrochemical oxidation, Ultrasound processes; principles of sonochemistry and acoustic cavitation, ultrasound cavitation and its combination with other AOPs, synergistic and antagonistic effects, hydrodynamic cavitation and its combination with other AOPs.

UNIT - VI (06)

Industrial applications of AOPs

Application of AOPs for industries such as textile, petroleum, pharmaceutical, petrochemical industry etc., decontamination of ground water, cost or economic analysis of various AOPs

Assignments

1. Write a report on current scenario of advanced oxidation processes.
2. Evaluate the use of solar or visible light driven photocatalysts.
3. Estimate synergistic effect of combining AOPs with cavitation based processes
4. Give power point presentation on semiconductor photocatalysis
5. Analyze the industrial applications of AOPs.
6. Understand the reaction mechanism of AOPs
7. Apply a critical-thinking towards scale-up aspects of AOPs.
8. Analyze recent advances in synthesis of mixed oxide photocatalysts.
9. Write a technical report on your visit to a waste water treatment plant.
10. Give power point presentation on the applications of emerging AOPs
11. Group discussion on the recent advances in advanced oxidation processes.
12. Make a complete chart of various operations involved in waste water treatment.

13. Assess the environmental or safety norms for disposal of waste water. In addition to these above stated assignments concerned faculty member may design his/her own assignments

Term Work :

Seminar should be based on recent advances in AOPs. Students may undertake studies in water and waste water treatment using AOPs. Design and scale-up aspects can be studied in detail. Termwork should be based on the technical report on these studies carried out by individual or small group of students.

Text Books / References :

1. Simon Parsons, Advanced oxidation processes for water and wastewater treatment, IWA Publishing, 2004.
2. Thomas Oppenlander, Photochemical Purification of Water and Air: Advanced Oxidation Processes (AOPs): Principles, Reaction Mechanisms, Reactor Concepts, Wiley-VCH Publishing, 2003.
3. Vincenzo Belgiorno, Vincenzo Naddeo and Luigi Rizzo, Water, wastewater and soil treatment by Advanced Oxidation Processes (AOP), Lulu Enterprises, 2011.
4. Jean-Pierre Franc, Jean-Marie Michel, “Fundamentals of Cavitation”, Kluwer Academic Publishers, Dordrecht.
5. T. J. Mason and J. P. Lorimer, “Applied sonochemistry: Uses of power ultrasound in chemistry and processing”, Wiley-VCH publishers.

Syllabus for Unit Test

Unit Test -1	UNIT – I, II, III
Unit Test -2	UNIT – IV, V, VI

ELECTIVE III: FUEL CELL TECHNOLOGY

TEACHING SCHEME	CREDITS ALLOTTED
Lectures : 3 Hours/Week	Theory : 03
Practical : 2 Hour /Week	Practical : 01
	Total credits : 04

Course Pre-requisites

Students should have knowledge of

1. Chemistry, Physics, Thermodynamics

Course Outcomes

After completion of the course students will be able to

1. Define the concept of fuel cell.
2. Express various types of fuel cell.
3. Distinguish between the fuel cell and electrochemical cell.
4. Express the thermodynamics of fuel cell system.
5. Learn the process of fuel processing
6. Develop enough skills to design systems or components of fuel cells.

UNIT-I (06)

Introduction to Fuel Cell Technology

Fuel cell definitions, Need of fuel Cell, Principal of fuel cell technology, Basics Electrochemistry of fuel cell, Calculation of cell potential: activities or concentrations, electrochemical potential; The movement of ions in solution: diffusion and migration, Conductivity and mobility, Liquid junction potentials, ion-selective electrodes.

UNIT-II (06)

Classification of Fuel Cells

Alkaline Fuel Cells, Phosphoric Acid Fuel Cells, Solid Oxide Fuel Cells, Molten Carbonate Fuel Cells, Direct Methanol Fuel Cells, Proton Exchange Membrane Fuel Cells

UNIT-III (06)

Fuel Cell Components

Electrolytes, Catalysts, Current collector/ bipolar plate.

Fuel cell characterization

Possible ways of characterization, In-situ characterization especially I-V characteristics and electrochemical impedance spectroscopy; Cyclic voltammetry; Current interruption technique, Ex-situ characterization especially electrolyte and bipolar plate

UNIT-IV (06)

Fuel Cells Thermodynamics

Gibb's free energy; reversible and irreversible losses; Fuel cell efficiency, Nernst equation, Effect of temperature, pressure, concentration on Nernst potential, Calculations of electrochemical potential.

UNIT-V (06)

Fuel Processing

Processing Hydrogen from Alcohols, Producing Hydrogen from Hydrocarbons, Hydrogen from Other Sources, Gas Clean-up, Challenges and Opportunities for Research in Fuel Processing

UNIT-VI (06)

Fuel Cell System and system integration

Hydrogen Production, Hydrogen Storage, Methods of Hydrogen Storage, Prediction of Hydrogen Uptake in Carbon Materials, Blance of plant and Power electronic and system integration

Tutorials/Assignments:

The internal assessment shall consist of minimum SIX assignments.

1. Questions involving classification of Fuel Cells.
2. Prepare one assignment considering any one type of fuel cell.
3. Conducting surprise MCQ test for students
4. Apply a critical-thinking and problem-solving approach towards the principles of fuel cell.
5. Enhancement in collaborative learning is done through, group assignments that will be given to encourage students to work with classmates to discuss and complete homework assignments
6. Students have to study any five research papers related to specific topic and prepare/present power point presentation
7. Brief report on 'Environmental, health and ethical concerns that are associated with Fuel Cell Technology.
8. Group discussions on any/all of the following topics:
   a) Classification of Fuel Cells.
   b) Current scientific and technical advances
   c) Electrochemical Cell Vs Fuel Cell
9. Preparation of a brief report on applicability of fuel cells in chemical engineering operations
10. Write a report on innovations in fuel cell technology in current year.
11. Learning on performance characteristics of fuel cell power plant and its components.
12. Identify the operational issues and challenges for all major types of fuel cells and give the presentation on it.
13. Conducting open-book class test.

In addition to these above stated assignments concerned faculty member may design his/her own assignments

Term Work

Term work will consist of the Seminar :

Seminar should be based on theory. Students may undertake studies in design and development, analysis, synthesis, construction and fabrication of equipment, treatment plants. Critical review on product and system generation of new concept, idea and improvement in existing process related to subject. Term work should be based on the technical report on these studies carried out by individual or small group of students.

Text Books / References

1. B. Viswanathan, M. Aulice Scibioh, "Fuel Cells: Principles and Applications", CRC Press, 1 edition, 2008.
2. James Larminie, Andrew Dicks, "Fuel Cell Systems Explained", 2nd Edition, John Wiley & Sons Ltd, New York, 2003
3. O'Hayre, R. P., S. Cha, W. Colella, F. B. Prinz, "Fuel Cell Fundamentals", Wiley, NY, 2006
4. "Fuel cell: a handbook", U S Department of energy.
5. Bokris John O'm, Srinivasan S., "Fuel cells-their electrochemistry", McGraw Hill 1969.
6. Appleby A.J. Fralkes F. R., "Fuel cell handbook", Van Nostrand Reinhold, 1989
7. Basu, S. (Ed) "Fuel Cell Science and Technology", Springer, N.Y. 2007
8. Liu, H., "Principles of fuel cells", Taylor & Francis, N.Y. 2006

Syllabus for Unit Test

Unit Test -1	UNIT – I, II, III
Unit Test -2	UNIT – IV, V, VI

ELECTIVE III: MEMBRANE SEPARATION

TEACHING SCHEME	CREDITS ALLOTTED
Lectures: 3Hours/Week	Theory : 03
Term work: 2 Hour/Week	Tutorial : 01

Course Pre-requisites

1. Basic chemistry, Physical chemistry, Mass transfer, Fluid flow operations, Chemical Engineering Thermodynamics

Course Outcomes

1. Explain basics of membrane and select proper material depending upon application
2. Explain the methods of membrane preparation and characterization
3. Determine suitable process for size based separation and explain its transport mechanism
4. Understand the transport through non-porous membranes and define membranes for desired application
5. Explain basics and preparation of membrane for other specialized membrane processes
6. Design suitable module and parameters for the desired application

UNIT - I (06)

Introduction and Membrane Materials

Introduction, historical development of membrane processes, definition of membrane, permeation, retention and selectivity, membrane processes, their categorization, material for membrane preparation, polymeric material, inorganic materials, mechanical, thermal and chemical stability of membrane based on material, choice of polymer for membrane preparation based on application

UNIT - II (06)

Membrane Preparation and Characterizations

Preparation of synthetic membranes: phase inversion membranes, preparation of composite membranes, preparation of inorganic membranes

Characterization: Porous membranes – electron microscopy, atomic force microscopy, mercury intrusion, bubble point method, permeability method, solute rejection characteristic; non-porous membranes – permeability, surface analysis, wide angle X-ray, DCS/DTA, density measurement

UNIT - III (06)

Processes using porous membranes

Transport mechanism in porous membranes – Knudsen flow, friction model, sieving mechanism

Processes: Microfiltration – membranes details, characteristics, industrial applications; Ultrafiltration - membranes details, characteristics, industrial applications; Nano-filtration - membranes details, characteristics, industrial applications.

UNIT - IV (06)

Solution-diffusion based membrane processes

Transport mechanism – Solution-diffusion mechanism, solubility, diffusivity, effect of temperature, interaction polymer crystallinity of solubility and diffusivity; Free volume theory

Processes: Reverse osmosis - membranes details, characteristics, industrial applications; Gas separation - membranes details, characteristics, industrial applications; Pervaporation - membranes details, characteristics, industrial applications

UNIT - V (06)

Other membrane processes

Dialysis - membranes details, their preparation, characteristics, transport mechanism, industrial applications; Electrodialysis - membranes details, their preparation, characteristics, industrial applications; Membrane distillation - membranes details, their preparation, characteristics, industrial applications; Membrane bioreactor - membranes details, their preparation, characteristics, industrial applications; Liquid membranes - membranes details, ionic liquids, their preparation, characteristics, industrial applications; ion exchange - membranes details, their preparation, characteristics, industrial applications

UNIT - VI (06)

Membrane modules and process design

Selection of process depending upon applications, plate and frame module, spiral wound module, tubular module, capillary module, hollow fiber module, comparison between module configuration, system design, cross flow operations, hybrid dead end/cross flow operations, cascade operations, Process parameters, Energy requirements.

Term work / Practical

1. Preparation of microfiltration membranes by phase inversion and their transport analysis.
2. Preparation of UF membranes and their transport analysis
3. Study of prepared porous membranes for bubble point analysis
4. Study of porous membranes for rejection analysis
5. Surface characterization of membrane by instrumental methods
6. Preparation of asymmetrically skinned membrane and analyze it for pervaporation
7. Preparation of thin film composite membranes and analyze its transport properties

8. Preparation of symmetric membrane and analyze its transport and rejection properties
9. Study variation in fouling characteristics between dead end and cross flow method
10. Study separation characteristics of reverse osmosis membranes
11. Preparation of hollow fiber membranes and study its permeation characteristics
12. Study dialysis /electrodialysis membrane transport characteristics
13. Study preparation of membrane bio-reactor and its effect of fermentation system

    In addition to these above stated term-work concern faculty member may design his/her own term-work or practicals.

Assignments

1. Detail of membrane material, preparation, characterization, module and process design for anyone application
2. Technical interview based on knowledge of membrane technology.
3. Students have to study any five NPTEL/you-tube videos related to membrane technology and prepare/present power point presentation.
4. Group discussions on membrane science and technology related topics.
5. Prepare a report on innovations in membrane technology and their practical importance.
6. Conducting open-book class test.
7. Conducting surprise Multiple choice questions (MCQs) test for students
8. Students have to study any five research papers related to specific topic and prepare/present power point presentation
9. With the help of this subject knowledge, write a report on how you would apply your concepts in industry.
10. Case study on emerging trends in process/product innovation considering membrane technology.
11. Students have to visit chemical industry and make a detailed report on membrane technologies used in the process.

12. Write a report on your visit to research and development laboratory of national/international repute.
13. Write a report on membrane technologies for addressing the problems of Water and Energy.

    In addition to these above stated assignments concern faculty member may design his/her own assignments.

Text Books/Reference Books

1. Basic principle of membrane technology Marcel Mulder, Kluwer Academic Press
2. Membrane technology and applications, Richard W. Baker, John Wiley and Sons, Ltd.
3. Handbook of industrial membrane technology, Mark C. Porter (Ed.), Noyes Publications.
4. Membrane separation systems – recent developments and future directions, R. W. Baker, E. L. Cussler, W. Eykamp, W. J. Koros, R. L. Riley, H. Strathman, Noyes Data Corporation
5. Membrane technology in the chemical industry, S. P. Nunes, K.-V. Peinemann (Eds.), Wiley-VCH Verlag GMBH

Syllabus for Unit Test

Unit Test -1	UNIT – I, II, III
Unit Test -2	UNIT – IV, V, VI

ELECTIVE III: PETROLEUM REFINERY ENGINEERING

TEACHING SCHEME	CREDITS ALLOTTED
Lectures: 3 Hours/Week	Theory : 03
Practical : 2 Hour /Week	Practical: 01
Total : 5Hours/Week	Total credits: 04

Course Pre-requisites

Students should have basic knowledge of

1. Chemical Process Industry
2. Mass Transfer

Course Outcomes

After completion of the course students would be able to

1. Know the composition of crude oil and its products, along with its properties and characterization methods.
2. Demonstrate knowledge of petroleum products, quality control and understand processing of crude oil.
3. Understand the thermal and catalytic cracking process.
4. Learn the process of catalytic reforming, Hydrotreating and Hydrocracking.
5. Get conversant with the process of purification and fractionation of crude oil.
6. Analyze theoretical and practice skills in environmental issues of petroleum refinery.

UNIT - I (06)

Introduction

Introduction to petroleum refinery, Classification of Crude oil, Characterization of crude oil, Composition of crude Physical properties

L6: Crude oil; analysis and distillation, Introduction to refinery "feedstock/s" and refinery products. ASTM nomenclature (ASTM test numbers and their meaning)Introduction to various codes required for petroleum industry

UNIT - II (06)

Evaluation of crude oil properties and Design of crude oil distillation column:

Dehydration and desalting of crude. Crude Assay ASTM TBP distillations evaluation of crude oil properties.API gravity various average boiling points and mid percent curves Evaluation of properties of crude oil and its fractions. Design concept of crude oil distillation column design.

UNIT - III (06)

Thermal and Catalytic cracking:

Coking and thermal process, delayed coking, Catalytic cracking, cracking reactions, cracking feedstock, Effect of process, FCC cracking, catalyst ,New designs for fluidized bed catalytic cracking

UNIT - IV (06)

Catalytic Reforming :

Objective and application of catalytic reforming, process reforming Catalysts, Reformer feed reforming reactor design continuous and semi regenerative process. Hydrotreating and Hydrocracking reactions.

UNIT - V (06)

Iso merization, Alkylation and Polymerization:

Isomerization process, Reactions, Effects of process variables. Alkylation process, Feedstock, reactions, products, catalysts and effect of process variables. Polymerization: Objectives, process, Reactions, catalysts and effect of process variables. Visbreaking

UNIT - VI (06)

Environmental issues and New Trends in petroleum refinery operations:

Ecological consideration in petroleum refinery, Waste water treatment, control of air pollution, New trends in refinery, Alternative energy sources. Safety aspects in petroleum industry

Assignments

1. Write a report on petroleum refining and energy demand in current year.
2. Discover the methods used to create clean and reformulated fuels
3. Evaluate the use of catalysts in petroleum refining..
4. Estimate refinery CAPEX and OPEX
5. Give power point presentation on vertical integration in petroleum industry
6. Learning on different areas of study in upstream, midstream and downstream industry.
7. Analyze worldwide distribution of oil and gas reserves in current year.
8. Understand basic procedures and role of all fundamental systems used in petroleum drilling..
9. Apply a critical-thinking and problem-solving approach towards the principles of petroleum engineering.
10. Specify materials for construction and estimate the cost of investments for crude pil distillation column.
11. Write a technical report on your visit to a petroleum refinery.
12. Give power point presentation on knowledge of safety and pollution control in the refining industries.
13. Group discussion on the recent advances in petroleum refinery processes.
14. Make a complete chart of operations involved in petroleum industry.
15. Assess the economic environment of the petroleum industry.

In addition to these above stated assignments concerned faculty member may design his/her own assignments

Term Work:

Term work will consist of the Seminar :

Seminar should be based on theory. Students may undertake studies in design and development, analysis, synthesis, construction and fabrication of equipment, treatment plants. Critical review on product and system generation of new concept, idea and improvement in existing process related to subject. Termwork should be based on the technical report on these studies carried out by individual or small group of students.

Text Books/Reference Books

1. B.K.Bhaskar Rao., "Modern Petroleum Refining Processes", 2ndEd., Oxford and IBH publishing Co. Pvt. Ltd., New Delhi 1990.
2. W.C. Edmister "Applied Hydrocarbon Thermodynamics", Gulf Publishing, Houstan, Texas, 1961.
3. Gas Production Engineering" S.Kumar Gulf publishing Co., 1987.
4. Petroleum Exploration Hand Book by Moody, G.B.
5. Standard Handbook of petroleum and Natural Gas Engineering. 2nd Edition. William C Lyons, Gary C Plisga. Gulf Profession.
6. W.L. Nelson, "Petroleum Refinery Engineering", McGraw Hill, 1964.

Syllabus for Unit Test

Unit Test -1 UNIT – I, II, III
Unit Test -2 UNIT – IV, V, VI

ELECTIVE IV: BIO-SEPARATION

TEACHING SCHEME	CREDITS ALLOTTED
Lectures: 3 Hours/Week	Theory : 03
Practical : 2 Hour /Week	Practical: 01
Total : 5Hours/Week	Total credits: 04

Course Pre-requisites

Students should have basic knowledge of

1. Basic biology
2. Analytical chemistry and techniques.

Course Outcomes

After completion of the course students would be able to

1. Define concept of bio-separation, physico-chemical basis of bio-separation.
2. Explain low resolution bio-separation techniques.
3. Describe high resolution bio-separation techniques.
4. Discuss separation techniques like precipitation, crystallization, etc.
5. Recognize the emerging bio-separation techniques like expanded-bed chromatography, hybrid bio-separations, etc.
6. Apply bio-separation knowledge for purification of β amylase, aspartic acid, etc.

UNIT - I (06)

INTRODUCTION TO BIOSEPARATION:

An overview of bio-separation, Separation of cells and other insolubles from fermented broth. bioproduct purification, characteristics of biological mixtures, physico-chemical basis of bio-separation.

UNIT - II (06)

LOW RESOLUTION BIO-SEPARATION TECHNIQUES:

Cell disruption, Centrifugation, Liquid-liquid extraction, Leaching, Filtration, Supercritical fluid extraction, Micro-filtration, Ultra-filtration, Adsorption, Sedimentation

UNIT - III (06)

HIGH RESOLUTION BIO-SEPARATION TECHNIQUES:

Ultra-centrifugation, Different electrophoresis techniques viz. Isoelectric focusing, Affinity separation, Chromatographic techniques viz. Paper, Gel; Ion exchange, Affinity, GLC, HPLC. Dialysis.

UNIT - IV (06)

OTHER SEPARATION TECHNIQUES:

Zone refining, Molecular sieves, Adductive crystallization, Reactive extraction, Precipitation method using ammonium sulfate, organic solvents, high molecular weight polymers, Reverse osmosis, Foam separation., Aqueous two phase systems,

UNIT - V (06)

EMERGING BIO-SEPARATION TECHNIQUES:

Membrane and monolith chromatography, Expanded-bed chromatography, High-resolution ultrafiltration, Hybrid bio-separations, Introduction to SEP box and Hyphenated techniques.

UNIT - VI (06)

APPLICATIONS OF BIO-SEPARATIONS -CASE STUDIES:

Purification of β amylase, aspartic acid, insulin; Food and Beverages: Beer, Citric acid; Bio-chemicals: Butanol.

Assignments

1. Give fifteen minutes presentation (seminar) on particular topic and prepare a report.

2. Prepare a mini report of any topic given above.
3. Write a report on the recent advances in chromatographic processes with reference to the current year.
4. Prepare a model for any of the topic given above.
5. Evaluate efficiencies of different chromatographic techniques.
6. With the help of this subject knowledge, write a guideline report on how you would apply your concepts in industry.
7. Search out some industries related to bio-separation.
8. Write a technical report on your visit to a process industry.
9. Technical interview based on the knowledge of analytical techniques.
10. List out all the principles of the analytical techniques.
11. Perform any one chromatographic technique.
12. Find out different types of proteins with structure.
13. Prepare a report on downstream processing.

In addition to these above stated assignments concerned faculty member may design his/her own assignments.

Term Work

Term work will consist of the experiments listed below, out of which any eight experiments are to be performed in laboratory by the students.

1. Gas chromatography.
2. Study of membrane separation and its application in industry.
3. Study of sedimentation and its application in industry.
4 Study of reactive extraction.
5. Material analysis using paper chromatography
6. Study of high-resolution ultrafiltration.
7. Study of gel electrophoresis.
8. To study molecular sieves.
9. To estimate efficiency of Centrifugation.
10. Study of adductive crystallization.

In addition to these above stated experiments concerned faculty member may design his/her own experiments related to course.

Text Books/Reference Books

1. Belter P A, Cussler E L, and Wei Shou Hu, "Bio-separation–Downstream Processing for Biotechnology", Wiley India Pvt. Ltd., 2011.
2. Prasad N K, "Downstream Process Technology-A New Horizon in Biotechnology", Prentice Hall of India, New Delhi, 2012.
3. Pauline M Doran "Bioprocess Engineering Principles", Academic Press, London, USA, 2012.
4. B Sivasankar, "Bio-separations: Principles and Techniques", Phi Learning Pvt. Ltd., 2009.
5. Ajay Kumar, Abishek Awasthi "Bio-separation Engineering: Comprehensive DSP Volumen" I.K International Publishing House Pvt. Ltd., New Delhi, 2009.

Syllabus for Unit Test

Unit Test -1	UNIT – I, II, III
Unit Test -2	UNIT – IV, V, VI

ELECTIVE IV: ENERGY ENGINEERING

TEACHING SCHEME	CREDITS ALLOTTED
Lectures: 3 Hours/Week	Theory : 03
Total : 3Hours/Week	Total credits: 03

Course Pre-requisites

Students should have basic knowledge of

1. Unit operations, Heat Transfer, Mass Transfer
2. Basic Mathematics and Numerical Techniques.

Course Outcomes

After completion of the course students would be able to

1. Know the basic energy sources viz conventional and non conventional.
2. Evaluate Energy balance and efficiency of any thermal system.
3. Understand the basic need for pinch analysis and HEN.
4. Formulate the problem for given energy system.
5. Model the given energy system and optimize it.
6. Understand different applications of non conventional energy systems.

Unit I (6 Hours)

Basic Energy Sources :

Fossil fuels, Nuclear fuels. Conventional & Renewable Energy

Energy Sources: prospecting, extraction and resource assessment and their peculiar characteristics. Direct use of primary energy sources, Conversion of primary into secondary energy sources such as Electricity, Hydrogen, And Nuclear energy etc. Energy Conversion through fission and fusion, Nuclear power generation etc.

Unit II **(6 Hours)**

Energy Managment Part II

Importance of energy management. Energy auditing: methodology, analysis of past trends (plant data), closing the energy balance, laws of thermodynamics, measurements, portable and on line instruments. Steam Systems: Boiler -efficiency testing, excess air control, Steam distribution & use- steam traps, condensate recovery, flash steam utilization. Thermal Insulation.

Unit III **(6 Hours)**

Energy Managment Part III

Energy conservation in Pumps, Fans (flow control), Compressed Air Systems, Refrigeration& air conditioning systems. Heatexchanger networking- concept of pinch, target setting, problem table approach, composite curves.

Unit IV **(6 Hours)**

Energy Systems Analysis:

Case studies of optimization in Energy systems problems. Dealing with uncertainty- probabilistic techniques. Trade-offs between capital & energy using Pinch Analysis. Case studies

Unit V **(6 Hours)**

Application of Non-conventional energy systems in Industry:

Solar energy Applications, Wave Energy and Ocean Thermal Energy, Wind Energy, Biomass Energy, Energy from Waste.

Unit VI **(6 Hours)**

Economic Analysis:

Initial and annual cost, basic definitions, present worth calculations, economic analysis of add on solar system, Energy audit

Assignments

1. Write a report on the recent advances in Energy Efficiency.
2. Give fifteen minutes presentation (seminar) on particular topic and prepare a report.
3. Compare the industrial data for energy utilization used in 5 different industries.
4. Write a report on your heat transfer equipments to minimize energy loss.
5. Present a seminar on Pinch Technology and HEN.
6. Present a seminar on thermal equipments involved in industry.
7. Prepare a model on non conventional energy sources and applications.
8. Write a energy audit for any single industry.

Text Books/References :

1. J. Twidell and T. Weir, Renewable Energy Resources, E & F N Spon Ltd, London, 1986.
2. D. Y. Goswami, F. Kreith and J. F. Kreider, Principles of Solar Engineering, Taylor and Francis, Philadelphia, 2000
3. L.C.Witte, P.S.Schmidt, D.R.Brown , Industrial Energy Management and Utilisation, Hemisphere Publ, Washington,1988.
4. I.G.C.Dryden, Butterworths, The Efficient Use of Energy, London, 1982
5. Freris L.L., Wind Energy Conversion Systems, Prentice Hall 1990.
6. S.S.RaoOptimisation theory and applications, Wiley Eastern, 1990
7. Beveridge and Schechter,Optimisation Theory and Practice,Mcgraw Hill, 1970
8. Shenoy U. V., Heat Exchanger Network Synthesis: Processes Optimization by Energy
9. Fowler, J.M., Energy and the environment, 2nd Edn., McGraw Hill, New York, 1984

Syllabus for Unit Test:

Unit Test -I	UNIT – I ,II,III
Unit Test -II	UNIT – IV,V,VI

ELECTIVE - IV: GREEN TECHNOLOGY

TEACHING SCHEME		CREDITS ALLOTTED	
Lectures	: 3 Hours/Week	Theory	: 03
Practical	: 2 Hour /Week	Practical	: 01
Total	: 5 Hours/Week	Total credits	: 04

Course Pre-requisites

Course Pre-requisites:

1. Students should have basic knowledge of chemistry and pollution control.

Course Outcomes:

After completion of the course students will be able to:

1. Identify the major environmental issues and describe the need for green technology.
2. Explain green technology principles and protocols.
3. Identify and explain the green synthetic methods.
4. Explain biochemical conversion and bio-photolysis.
5. Explain criteria for choosing appropriate green energy technologies, Green innovation & sustainability.
6. Explain the green house effects, global warming, carbon footprint and ways to overcome them using green technology.

Unit I **(6 Hours)**

Introduction and need for green technology:

Overview of Major Environmental Issues, Global Environmental Issues. Air Quality Issues. Water Quality Issues, Ecology, Natural Resources, Waste: Production, Prevention, Problems and Source of waste, cost of Waste, Waste minimization technique, waste treatment and recycling. Description of Risk. Value of Risk Assessment in the Engineering Profession. Risk-Based Environmental Law. Risk Assessment Concepts. Hazard Assessment, Risk Characterization. Role of Industry, Government and Institutions in green technology.

Unit II **(6 Hours)**

Green technology principals and protocols:

Importance, advantages and disadvantages of green technologies, factors affecting green technologies, the twelve basic principles of green chemistry. Sustainable development, atom economy, reduction of toxicity. Use of Renewable Feedstock, Reduction of Derivatives, Catalysis, Design for Degradation, Real-time Analysis for Pollution Prevention, Inherently Safer Chemistry for Accident Prevention.

Unit III **(6 Hours)**

Green synthetic methods:

Microwave synthesis, electro-organic synthesis, Design and development of environmentally friendly chemical pathways: challenges and opportunities. Materials for green chemistry and technology: Catalysis, environmental friendly catalysts, Bio-catalysis, biodegradable polymers, alternative solvents,

Unit IV **(6 Hours)**

Biochemical conversion:

Anaerobic digestion, alcohol production from biomass; Chemical conversion process: hydrolysis and hydrogenation; Biophotolysis: Hydrogen generation from algae biological pathways; Storage and transportation; Applications

Unit V **(6 Hours)**

Green synthetic methods:

Criteria for choosing appropriate green energy technologies, life cycle cost; the emerging trends – process/product innovation, Eco/green technologies for addressing the problems of Water, Energy, Health, Agriculture and Biodiversity- WEHAB (eco-restoration/ phyto-remediation, ecological sanitation, renewable energy technologies).

Unit VI **(6 Hours)**

Green house effect and Global warming:

Greenhouse gas emissions, impacts, mitigation and adaptation, carbon credit, carbon footprint ; future energy Systems- clean/green energy technologies; International agreements/conventions on energy and sustainability - United Nations Framework Convention on Climate Change (UNFCC), Kyoto protocol; sustainable development, Environmental reporting and ISO 14001; climate change business and ISO 14064; green financing; financial initiative by UNEP]

Term Work

Term work will consist of the seminars on the following topics.

1. Major Environmental Issues and need for green technology
2. Green technology principals and protocols
3. Green synthetic methods
4. Biochemical conversion and Biophotolysis
5. Green innovation & sustainability
6. Green house effect and Global warming

Assignments:

1. Technical interview based on knowledge of green technology.
2. Students have to study any five NPTEL videos related to green technology and prepare/present power point presentation.
3. Group discussions on any one of the following topics.
   a) Major Environmental Issues.
   b) Green innovation & sustainability.
   c) Global warming
4 Prepare a report on innovations in green technology and their practical importance.
5 Conducting open-book class test.

6 Conducting surprise Multiple choice questions (MCQs) test for students

7 Students have to study any five research papers related to specific topic and prepare/present power point presentation

8 With the help of this subject knowledge, write a report on how you would apply your concepts in industry.

9 Case study on emerging trends in process/product innovation considering green technology.

10 Students have to visit chemical industry and make a detailed report on green technologies used in the process.

11 Write a report on your visit to research and development laboratory of national/international repute.

12 Write a report on eco/green technologies for addressing the problems of Water and Energy.

13 Write a report on eco/green technologies for addressing the problems of Water, Energy, Health, Agriculture and Biodiversity (WEHAB).

In addition to these above stated assignments concern faculty member may design his/her own assignments.

Text Books/References :

1 Paul Anastas, John C.Warner, John Warner Joint; Green Chemistry: Theory & Practice New Edition; Oxford University press, USA, 2000.

2 Mukesh Doble and Anil Kumar Kruthiventi, Green Chemistry and Engineering, Elsevier, Burlington, USA, 2007.

3 Allen, D.T., Shonnard, D.R, Green Engineering: Environmentally Conscious Design of Chemical Processes. Prentice Hall PTR 2002.

4 Baird, C. and Cann, M., Environmental Chemistry, 4th Edition, W.H. Freeman and Company, New York, 2008.

5 Paul T. Anastas, Walter Leitner, Phillip G. Jessop, Chao-Jan Li, Peter Wasserscheid, Annegret Stark; Handbook of Green Chemistry, 3 Volume set, Green solvents; Wiley-VCH.

6 Paul T. Anastas, Istvan T. Horvath ; Green Chemistry for a sustainable future; Wiley-Blackwell publishers, 2010.

7 V.K. Ahluwalia, M. Kidwai; New Trends in Green Chemistry; Kluwer Academic Publishers.

Syllabus for Unit Test:

Unit Test - I	UNIT– I, II, III
Unit Test - II	UNIT– IV, V, VI

RULES REGARDING ATKT, CONTINUOUS ASSESSMENT AND AWARD OF CLASS

Standards of Passing and ATKT Rules

1. For all courses, both UE (Universtiy Evaluation) and IA (Internal Assessment) constitue separate heads - of - passing (HoP). In ordar 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 course is atleast 6.0 (50% Aggregate). The GPA for a course will be calculated only if the learner passes at the UE.
2. A student who fail 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 backlog candidate and clear the HoP.

Rules of ATKT

1. A student is allowed to carry backlog of courses prescribed for B.Tech Sem - I, III, V, VII to B.Tech Sem - II, IV, VI, VIII respectively.
2. A student is allowed to keep term of Sem - III, if he/she is failing in any number of subjects of Sem I & II.
3. A student is allowed to keep term of Sem - V, if he/she is failing in any number of subjects of Sem - III & IV but passed in all subjects of Sem - I & II.
4. A student is allowed to keep term of Sem - VII, if he/she is failing in any number of subjects of Sem - V & VI but passed in all subjects of Sem - III & IV.

Award of Class for the Degree Considering CGPA

Award of Honours

A student who has completed the minimum credits specified for the programme 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 at the End of the Programme are as given below.

Range of CGPA	Final Grade	Performance Descriptor	Equivalent Range of Marks (%)
9.50 ≤ CGPA ≤ 10.00	0	Outstanding	80 ≤ Marks ≤ 100
9.00 ≤ CGPA ≤ 9.49	A+	Excellent	70 ≤ Marks ≤ 80
8.00 ≤ CGPA ≤ 8.99	A	Very Good	60 ≤ Marks ≤ 70
7.00 ≤ CGPA ≤ 7.99	B+	Good	55 ≤ Marks ≤ 60
6.00 ≤ CGPA ≤ 6.99	B	Average	50 ≤ Marks ≤ 55
5.00 ≤ CGPA ≤ 5.99	C	Satisfactory	40 ≤ Marks ≤ 50
CGPA Below 5.00	F	Fail	Marks Below 40