Course Structure & Syllabus for

M. Tech. Nanotechnology

(CBCS 2023 Course)

As per NEP2020 Guidelines

Semester I												**Total Duration: 24 hrs./week.** **Total Marks: 500** **Total Credits: 20**
Sr. No.	**Course Code**	**Course**	**Teaching Scheme Hrs./Week**		**Examination Scheme (Marks)**							**Credits**
			L	**P**	**Theory**	**Internal Assessment**	**TW**	**PR**	**Oral**	**Total**		
1	C101	Physics of Nano science	04	--	50	50	-	--	--	100		04
2	C102	Physicochemical Nano-materials	04	--	50	50	-	--	--	100		04
3	C103	Nano computing and Simulation	04	--	50	50	--	--	--	100		04
4	C104	Elective - I	04	--	50	50	--	--	--	100		04
5	C105	Lab Practice - I	--	04	--	--	25	--	25	50		02
6	C106	Lab Practice - II	--	04	--	--	25	--	25	50		02
		Total	**16**	**8**	**200**	**200**	**50**	**--**	**50**	**500**		**20**

<u>List of Self Learning Courses and Open Elective</u>

Sr. No.	**Course Code**	**Elective - I**
1	C104.1	Nano Composite
2	C104.2	Nanotechnology in Food and Agriculture

Semester II								Total Duration: 24 hrs./week. Total Marks: 500 Total Credits: 20			
Sr. No.	Course Code	Course	Teaching Scheme Hrs./Week		Examination Scheme (Marks)						Credits
			L	P	Theory	Internal Assessment	TW	PR	Oral	Total	
1	C107	Nanofabrication and	04	--	50	50	-	--	--	100	04
2	C108	Nano Materials for Energy and Environment	04	--	50	50	-	--	--	100	04
3	C109	Nanotechnology for Biological Systems	04	--	50	50	--	--	--	100	04
4	C110	Elective - II	04	--	50	50	--	--	--	100	04
5	C111	Lab Practice – III	--	04	--	--	25	--	25	50	02
6	C112	Lab Practice - IV	--	04	--	--	25	--	25	50	02
		Tot	**16**	**8**	**200**	**200**	**50**	**--**	**50**	**500**	**20**

List of Self Learning Courses and Open Elective

Sr. No.	Course Code	Elective - II
1	C110.1	Nanomedicine
2	C110.2	Research Methodology

Semester III												**Total Duration: 08 hrs./week.** **Total Marks: 250** **Total Credits: 20**
Sr. No.	**Course Code**	**Course**	**Teaching Scheme Hrs./Week**		**Examination Scheme (Marks)**							**Credits**
			L	**P**	**Theory**	**Internal Assessment**	**TW**	**PR**	**Oral**	**Total**		
1	C201	Seminar	--	02	--	--	50	--	50	100		05
2	C202	Dissertation Stage - I	--	06	--	--	100	--	50	150		15
		Total	**--**	**08**	**--**	**--**	**150**	**--**	**100**	**250**		**20**

Semester IV												**Total Duration: 08 hrs./week.** **Total Marks: 250** **Total Credits: 20**
Sr. No.	**Course Code**	**Course**	**Teaching Scheme Hrs./Week**		**Examination Scheme (Marks)**							**Credits**
			L	**P**	**Theory**	**Internal Assessment**	**TW**	**PR**	**Oral**	**Total**		
1	C203	Dissertation Stage - II	--	08	--	--	150	--	100	250		20
		Total	**--**	**08**	**--**	**--**	**150**	**--**	**100**	**250**		**20**

M. Tech. Nanotechnology Semester-I Syllabus

Physics of NanoScience

(C101)

Designation of Course	**Physics of NanoScience**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory: - 04 Hours/ Week	End Semester Examination	50 Marks	04
Tutorial: - --Hours/ Week	Internal Assessment	50 Marks	
Practical: -- Hours/ Week	Term Work	-- Marks	00
	Oral/Practical	-- Marks	
	Total	**100 Marks**	**04**

Course Prerequisites: -	The students should have basic knowledge about 1. Atomic and molecular structure 2. Basic physics 3. Basic electronics
Course Objectives: -	To teach physics-based nano mechanics and apply the concepts of physics to Nanotechnology.
Course Outcomes: -	Students will be able to understand. 1. Molecular bonding, types, and theories 2. Quantum mechanics 3. Fundamentals of solid-state physics 4. Basics of electronics 5. Principles of lasers, properties 6. Advanced electrodynamics

Course Contents

Unit I	**Atomic and Molecular Physics**	**(10 Hrs.)**
Rutherford atom model, Electron orbits, Bohr atom, Energy levels and spectra, Atomic excitation and atomic spectra, Rotational & Vibrational energy levels, Rotational and Vibrational spectra. Electronic spectra of molecules. Bohr and Sommerfield atom models - Vector atom model - Pauli's exclusion principle - various quantum numbers - angular momentum and magnetic moment - coupling schemes - LS and JJ coupling - Bohr magneton, Hund's rule, Stern and Gerlach experiment, Zeeman Effect and stark Effect. Molecular bonding in homo and hetero nuclear molecules, polyatomic molecules, vibration and rotational levels, vibrations and Group frequencies.		
Unit II	**Quantum Mechanics**	**(10 Hrs.)**
Wave-particle duality, Schrodinger equation and expectation values, Uncertainty principle. Solutions of the one-dimensional Schrodinger equation for free particle, particle in a box, particle in a finite well. Reflection and transmission by a potential step and by a rectangular barrier. Theory of radiation, transition probability for absorption and emission, forbidden transitions, decays, lifetime concepts. Solution of Time independent Schrödinger equation at higher dimensions. Particle in a three-dimensional box, linear harmonic oscillator and its solution, density of states, free electron theory of metals. The angular momentum problem. The spin half problem and properties of Pauli spin matrices.		
Unit III	**Solid State Physics**	**(10 Hrs.)**
Amorphous, crystalline, crystals, polycrystals, symmetry. Unit Cells, Crystal Structures (Bravais Lattices), Crystallographic Directions, Crystallographic Planes, Miller Indices, Bragg's Law, X-ray Diffraction. Imperfections of crystal structure: point defects, Grain boundaries, phase boundaries, Dislocations: Screw, Edge and Mixed Dislocations. Free electron theory, Bloch theorem. Motion of electrons in solids, the effective mass of electron and hole, reduced, periodic and extended zone scheme, Fermi surfaces, Direct and indirect band gaps in semiconductors, and temperature dependence. Electronic, ionic, and orientational polarizabilities, Clausis-Mossotti relation, static and frequency dependence of dielectric constant, relation. Mean field theory, Heisenberg interaction,		

magnons, origin of domains in magnetic materials.		
Unit IV	**Electronics and Electronic devices**	**(10 Hrs.)**
Introduction to PN junction diode, Zener and avalanche breakdowns, Schottky barrier, Shockley diode & silicon control rectifier, Zener diodes, tunnel diodes, photodiodes. Operational amplifier and Applications– Ideal op-amp, the equivalent circuit of the op-amp, open loop op-amp configurations – inverting, non-inverting and differential amplifiers, lock-in amplifier. Active filters – types, first and second order active low and high pass filter. Oscillators – basic principles, types, phase shift oscillator, Wien bridge oscillator, triangular wave generator.		
Unit V	**Electrodynamics and Laser Technology**	**(10 Hrs.)**
Coulomb's law, Gauss's law, Electrostatic Potential Energy. Biot-Sevart law and Ampere Laws, faraday's law, Maxwell's Equations, Poynting Theorem, and Conservation Laws. Equation of plain progressive wave in vacuum and medium. Basic principles of lasers, properties of laser beams, population inversion in three and four-level lasers, resonance frequencies, modifications of the laser output, and single-mode operation. Laser materials and types of lasers, solid-state lasers, characteristics of dye lasers, and semiconductor lasers. Laser applications		

Term Work/Practical:

At least Five Assignment based on above syllabus.

Textbooks:

1. Solid State Physics by S O Pillai, New Age International (P) Ltd.

Reference Books:

1. Herzberg (D. van Nostrand Co., Inc)
2. Berkley Series, Vol. II (Tata McGraw Hill)
3. Modern Quantum Mechanics, J. J. Sakurai (Addison Wiley)
4. Quantum Mechanics, L. I. Schiff (McGraw Hill)
5. Quantum Physics, Robert Eisberg, and Robert Resnick
6. Classical Electrodynamics, J. D. Jackson (John Wiley) Introduction to Electrodynamics, D. Griffiths

Internal Assessment

Continuous Evaluation by Assignments / Presentation / Quiz / Test

Physicochemical Nanomaterials
(C102)

Designation of Course	Physicochemical Nanomaterials		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory: - 04 Hours/ Week	End Semester Examination	50 Marks	04
Tutorial: - --Hours/ Week	Internal Assessment	50 Marks	
Practical: -- Hours/ Week	Term Work	-- Marks	00
	Oral/Practical	-- Marks	
	Total	**100 Marks**	**04**

Course Prerequisites: -	The students should have basic knowledge about 1. Atomic and molecular structure 2. Basic chemistry
Course Objectives: -	1. To provide knowledge of various concepts related to Physical chemistry of Nanomaterials. 2. To provide knowledge of various concepts related to elementary statistical mechanics.
Course Outcomes: -	The students should be able to– Understand the physicochemical concepts of nanomaterials.

Course Contents

Unit I	**Nanomaterial Synthesis Methods**	**(10 Hrs.)**
Introduction to Nano scale materials - Atomic size -surfaces and dimensional space -Top down and bottom up. Synthesis and processing, method of nano structured material preparation – mechanical grinding, wet chemical synthesis – sol-gel processing, gas phase synthesis, gas condensation processing, chemical vapor condensation – nano composite synthesis – processing. Vapor (or solution) – liquid – solid (VLS or SLS) growth -Electrochemical Approaches: anodic oxidation of alumina films, porous silicon, and pulsed electrochemical deposition.		
Unit II	**Theory of Solution and Diffusion**	**(10 Hrs.)**
The theory of solutions, Free energy as a function of composition, Fick's Law, mechanisms of diffusion; generation of point defects; self-diffusion; the influence of the pressure and pressure gradient; Kirkendall effect; fast diffusion; influence of isotropic state; experimental methods of investigation of diffusion.		
Unit III	**Nanostructures**	**(10 Hrs.)**
Introduction, length scale of different structures, definition of nanoscience and nanotechnology, fullerenes, CNTs, graphenes and inorganic nanostructures, the evolution of Nanoscience, quantum dots and electronic structure of various nanophase materials. Clusters of metals and semiconductors, rare gas and molecular clusters, nanowires and nanorods, size dependent properties, size dependent absorption, phonons in nanostructures. Quantum dots - Nano wires-Nano tubes 2D and 3D films. Dendritic and supramolecular structures, metal nanocluster composites, glasses.		
Unit IV	**Phase Transformations and Spectroscopy**	**(10 Hrs.)**
Mechanisms of phase transformation; homogeneous and heterogeneous nucleation; spinodal decomposition; grain growth; precipitation in solid solution; transformation with constant composition; order-disorder transformations; Martensitic transformation. Spectroscopic methods for structure analysis such as mass spectrometry, nuclear magnetic resonance spectroscopy.		
Unit V	**Thermodynamics And Photochemistry**	**(10 Hrs.)**

The first and second laws of thermodynamics. Thermodynamic functions, heat capacity, enthalpy, entropy. Equilibrium in one phase system, real gasses, the reactions between gases, reactions of solid-state phases, Phase rule, Phase diagram, reaction kinetics, rate equations. Laws of Photochemistry, Fluorescence, Phosphorescence, Chemiluminescence, Jablonski diagram and quenching.

Term Work

At least Five Assignments based on above syllabus.

Textbooks: -

1. Physical Chemistry, 1st Edition –Ball
2. Physical Chemistry – Atkins Peter, Paula Julio

Reference books: -

1. Thermodynamics and Statistical Mechanics by John M. Seddon, J. D. Gale
2. Spectroscopic Methods In Organic Chemistry- Dudley H. Williams.
3. Fundamentals of Molecular Spectroscopy – Colin N. Banwell
4. Statistical Mechanics-Landau & Lifshitz
5. Nano structures and Nano materials: Synthesis, properties and applications - Guozhong Cao- Imperial College press.

Internal Assessment

Continuous Evaluation by Assignments / Presentation / Quiz / Test

NANOCOMPUTING AND SIMULATION
(C103)

Designation of Course	Nanocomputing and Simulation		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory: - 04 Hours/ Week	End Semester Examination	50 Marks	04
Tutorial: - --Hours/ Week	Internal Assessment	50 Marks	
Practical: - -- Hours/Week	Term Work	-- Marks	00
	Oral/Practical	-- Marks	
	Total	**100 Marks**	**04**

Course Prerequisites: -	The students should have knowledge of 1. Engineering Mathematics 2. Basic Programming
Course Objectives: -	Students will be able to apply simulation principles in the fields of nanotechnology.
Course Outcomes: -	The students 1. Must understand various numerical methods and probability distributions. 2. Must understand modelling and basics of simulation and use it to design a system. 3. Understand various applications of Monte Carlo Simulation

Course Contents

Unit I	Fundamental Principles of Numerical Methods and Probability	(10 Hrs.)
Root finding: Bisection, false position and Newton Raphson, **Interpolation and approximation**: Gaussian Methods, **Numerical integration:** Trapezoidal and Simpson’s Methods, **Data fitting:** Methods of Least Squares, Method of Moments, **ODE’s:** Euler’s Method, RK Methods. **Discrete Random Variable**, Expected Value and Variance of a Discrete Random Variable, **Continuous Random Variable**, Mean and Variance of Continuous Distribution, **Distributions:** Binomial, Poisson, Exponential, Geometric, Normal Distribution		
Unit II	**Modelling and basics of simulation**	**(10 Hrs.)**
Models, Types of mathematical model, comparisons and contrasts, Mechanical system modeling examples. **Simulation Basics,** when is simulation Is an appropriate tool, when is simulation not an appropriate tool, Advantages and Disadvantages of Simulation, Areas of Application, Steps in a Simulation Study Simulation and analytical methods, Basic **nature of simulation**, The simulation process, Types of system simulation, Generation **of random numbers:** Linear Congruential Method (LCM), Combined Linear Congruential Generators (CLCG).		
Unit III	**Monte Carlo Methods**	**(10 Hrs.)**
Value of Pi, Monte Carlo Integration, Drunkard Problem, Life of industrial equipment’s, Pure Pursuit problem, Trajectory system, simulation of water reservoir, simulation of Pendulum, Simulation of queuing systems, Simulation of inventory systems, Direct simulation Monte Carlo, Monte Carlo localization.		
Unit IV	**Mesoscopic Simulation Techniques**	**(10 Hrs.)**
Lattice Boltzmann Method (LBM), Dissipative Particle Dynamics (DPD). Introduction to Multiscale methods and applications.		

Unit V	Macroscopic Simulation	(10 Hrs.)
Continuum Equations – Deterministic and Stochastic PDE; Conservation of Energy or Momentum Principle, Basic of Finite Element Methods Introduction to Multiscale approaches -hierarchical & hybrid or concurrent methods Modeling of nanoparticles - electronic transport, mechanical properties, optical properties. Bio nanoparticles and polymer nanocomposites. Opportunities and challenges in Computer modelling of nanoparticles		

Term Work/Assignments

At least Five Assignments based on the above syllabus.

Textbooks:

1. Numerical Methods for Engineers, Steven Chapra, Raymond Canale, McGraw-Hill Education; 7th edition
2. System Simulation, D.S. Hira, S Chand & Company.

Reference Books

1. Applied Numerical Methods with MATLAB for Engineers and Scientists, Steven Chapra, McGraw-Hill India, 4th Edition.
2. System Simulation, Geffery Gordan, Prentice Hall India Learning Private Limited; 2nd edition,
3. Foundations of the Theory of Probability: Second English: Second English Edition, A.N. Kolmogorov, Dover Publications Inc.

Internal Assessment

Continuous Evaluation by Assignments / Presentation / Quiz / Test

ELECTIVE-I: NANO COMPOSITES
(C104.1)

Designation of Course	**Elective-I: Nano Composites**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory: - 04 Hours/ Week	End Semester Examination	50 Marks	04
Tutorial: - --Hours/ Week	Internal Assessment	50 Marks	
Practical: -- Hours/ Week	Term Work	-- Marks	00
	Oral/Practical	-- Marks	
	Total	**100 Marks**	**04**

Course Prerequisites: -	1. Students should have basic knowledge of Mathematics, Physics, Chemistry 2. The students should have the knowledge of basic of strength of material. 3. The students should have the knowledge of basic material properties
Course Objectives: -	1. To obtain the knowledge of properties, application and manufacturing technology of main composite materials. 2. Comprehension of the mechanisms which allow to obtain properties on the basis of material components and their architecture.
Course Outcomes: -	The students should be able to– 1. Understand Basic concepts and characteristics of composite materials. 2. Understand micromechanical and micromechanical behaviors of lamina. 3. Understand Hygrothermal effects on composite materials with different lamina. 4. Understand Macromechanical behaviors of a laminate. 5. Understand Manufacture and testing of composite materials

Course Contents

Unit I	**Basic concepts and characteristics of composite materials**	**(10 Hrs.)**
Definition and characteristics of composite materials, overview of advantages and limitations of composite materials, significance and objectives, sciences and technology, types and classification of typical composite materials, current status and future prospects		
Unit II	**Macromechanical and Micromechanical behaviors of lamina**	**(10 Hrs.)**
Stress-strain relations for anisotropic materials, engineering constants for orthotropic materials, stress-strain relations for a lamina of arbitrary orientation, biaxial strength theories. Mechanics of materials approach to stiffness, elasticity approach to stiffness, comparison of approaches to stiffness, mechanics of materials approach to strength.		
Unit III	**Hygrothermal effects**	**(10 Hrs.)**
Hygrothermal effects on mechanical behaviors, hygrothermal stress-strain relations, coefficients of thermal and moisture expansion of unidirectional lamina		
Unit IV	**Macromechanical behaviours of a laminate**	**(10 Hrs.)**
Classical lamination theory, lamina stress-strain behaviour, strain and stress variation in a laminate, laminate forces and moments, special cases of laminate, interlaminar stresses, design of laminates		
Unit V	**Manufacture and testing of composite materials**	**(10 Hrs.)**
Manufacturing: Stamp moulding, diaphragm forming, thermoforming, filament winding, pultrution, compression moulding, injection moulding. Testing: Determination of physical properties such as density, fibre volume ratio, void volume ratio, co-efficient of thermal expansion,		

determination of tensile, compressive and shear properties of unidirectional lamina, determination of interlaminar and intralaminar strength, biaxial testing, characterization of composites with stress concentration.

Term Work/ Assignments

1. Polymer matrix preparation
2. Polymeric nanocomposites characterization
3. Ceramic based nanocomposite preparation

Textbooks

1. Goyal, R. K. (2017). Nanomaterials and nanocomposites: synthesis, properties, characterization techniques, and applications. CRC Press.

Reference Books

1. Nanostructured Materials: Selected Synthesis Methods, Properties, and Applications, Philippe Knauth, Joop Schoonman
2. Polymeric Nanocomposites: Theory and Practice, By Sati N. Bhattacharya, Musa Rasim Kamal, Rahul K. Gupta, Hanser Verlag
3. Polymer Nanocomposites: Processing, Characterization, And Application, McGraw-Hill Prof Med/Tech
4. Introduction to Nanocomposite Materials: Properties, Processing, By Thomas E. Twardowski, Thomas Twardowski, DEStech Publications, Inc.
5. Handbook of Nanostructured Biomaterials and Their Applications in Nanobiotechnology - Hari Singh Nalwa.
6. Bio nanotechnology: Lessons from Nature by David S. Goodsell

Internal Assessment

Continuous Evaluation by Assignments / Presentation / Quiz / Test

ELECTIVE-I: NANOTECHNOLOGY IN FOOD AND AGRICULTURE
(C104.2)

Designation of Course	**Elective-I: Nanotechnology in Food and Agriculture**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory: - 04 Hours/ Week	End Semester Examination	50 Marks	04
Tutorial: - --Hours/ Week	Internal Assessment	50 Marks	
	Term Work	-- Marks	00
	Oral/Practical	-- Marks	
	Total	**100 Marks**	**04**

Course Prerequisites: -	The students should have knowledge of 1. Basic agriculture practices and soil systems 2. Food packaging systems 3. Approaches used for agri waste and crop pathogen prevention
Course Objectives: -	1. Provide sound understanding about types of agri practices, disease detection tools, targeted treatments. 2. To understand various Nanotechnology based systems involved in food sector
Course Outcomes: -	The students should be able to understand– 1. Precision farming 2. Biopolymer-based carrier systems in health foods 3. Types of nanoparticle mediated drug delivery 4. Nanotechnology-based food and health food products and food packaging materials Nanocapsules, nanoshells, polymers for drug delivery 5. Risk assessment approaches used by FAO/WHO

Course Contents

Unit I	**Strategic applications of Nanotechnology in agriculture**	**(10 Hrs.)**
Precision farming for basic agriculture, real time monitoring of soil conditions, combating the crop pathogens and the treatment of waste. Development of innovative products in food production, processing, preservation and packaging and applications in agriculture, animal feed and agrochemicals, disease detection tools, targeted treatments		
Unit II	**Impact of Nanotechnology in the food sector**	**(10 Hrs.)**
Nanotechnology-based food and health food products and food packaging materials, Nano-enabled food contact materials (FCMs) and packaging, Polymer composites with various nanomaterials, coatings containing nanoparticles		
Unit III	**Nanosensors in food sector**	**(10 Hrs.)**
Intelligent packaging concepts based on nanosensors, use of nanodiagnostic tools for detection and monitoring in food production, sensing applications, biosensors for detection of herbicides, pesticides and pathogens.		
Unit IV	**Encapsulation technology for nano-delivery systems**	**(10 Hrs.)**
Use of micelles, liposomes or biopolymer-based carrier systems, processed nanostructures, inorganic and organic nanomaterials in health food products, surface functionalized nanomaterials.		

Unit V	Health aspects	(10 Hrs.)
Assessment of human health risks associated with the use of nanotechnologies and nanomaterials in the food and agriculture sectors, safety, current risk assessment approaches used by FAO/WHO, environmental, ethical, policy and regulatory issues.		

Term Work/Assignments

1. Intelligent food packaging concepts, animal feed and agrochemicals, disease detection tools
2. Encapsulation of nano-particulate systems

Text Books: -

1. Nanotechnology in the Agri-food Sector, Lynn J. Frewer , Willem Norde, Arnout Fischer and Frans Kampers, 2011

Reference Books

1. Bionanotechnology: Lessons from Nature by David S. Goodsell, 2014
2. Nanomedicine, Vol. IIA: Biocompatibility by Robert A. Freitas, 2015
3. Handbook of Nanostructured Biomaterials and Their Applications in Nanobiotechnology - Hari Singh Nalwa 2014
4. Nanobiotechnology; ed. C.M. Niemeyer, C.A. Mirkin. 2017.

Internal Assessment

Continuous Evaluation by Assignments / Presentation / Quiz / Test

LAB PRACTICE-I
(C105)

Designation of Course	Lab Practice-I		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory: --- Hours/ Week	End Semester Examination	-- Marks	00
Tutorial: - --Hours/ Week	Internal Assessment	-- Marks	
Practical: - 04 Hours/ Week	Term Work	25 Marks	02
	Oral/Practical	25 Marks	
	Total	**50 Marks**	**02**

Course Prerequisites: -	The students should have knowledge of 1. Basic knowledge of Physics and Chemistry 2. Basic knowledge of manufacturing of materials 3. Basics of Polymers and ceramics
Course Objectives: -	At the end of the course students will 1. Develop self-learning attitude. 2. Interact with various libraries, resource persons to get information about a selected topic.
Course Outcomes: -	The students should be able to– 1. To read, understand and outline an advanced information in the related field.

Course Contents

1. Preparation of nano particles by mechanical grinding/wet chemical synthesis/sol-gel method
2. Nano Characterization- optical (UV-VIS spectroscopy) and structural (XRD) characterization of synthesised nano particles
3. Basic properties of lasers-monochromacity and divergence
4. Fundamentals for synthesis of chalcogenides
5. Temporary preparation of cell / tissues
6. Biological Synthesis of nanoparticles (bacteria, fungi and plants)
7. Demonstration of Cytotoxicity/cell viability- Tryphan blue dye exclusion
8. Absorbance spectra of biomolecules (DNA, proteins)
9. Demonstration of nanoparticles-based drug delivery in cell line
10. Biosynthesis and applications of nanomaterials in Biomedical domain

Term work/ Oral

Term work and oral will be based on above syllabus.

LAB PRACTICE-II
(C106)

Designation of Course	Lab Practice-II		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory: --- Hours/ Week	End Semester Examination	-- Marks	00
Tutorial: - --Hours/ Week	Internal Assessment	-- Marks	
Practical: - 04 Hours/ Week	Term Work	25 Marks	02
	Oral/Practical	25 Marks	
	Total	**50 Marks**	**02**

Course Prerequisites: -	The students should have knowledge of 1. Composite materials 2. Nano materials and charters tics of nano materials 3. Diffusion processes
Course Objectives: -	At the end of the course students will 1. Develop self-learning attitude. 2. Interact with various libraries, resource persons to get information about a selected topic.
Course Outcomes: -	The students should be able to– 1. To read, understand and outline an advanced information in the related field.

Course Contents

1. Synthesis of nanocomposites-doping and core-shell
2. FTIR Spectroscopy of synthesised nanocomposites
3. Study of luminescence-photo-of quantum dots
4. Practical on Diffusion, Kirkendall effect, chemistry of surfactants
5. Demonstration on Collision theory, order of reactions, photochemistry of nanomaterials
6. Production of Nano wires-Nano tubes 2D and 3D films Nano and mesopores, Synthesis of nanostructures/deposition of thin films
7. experimental methods of investigation of diffusion,
8. Reactivity of solids, Quantum chemistry
9. Practical and Study of OP AMP in different modes such as inverting, non-inverting and differential amplifiers
10. Study of active filters –first and second order active low and high pass filter

Term work/ Oral
Term work and oral will be based on above syllabus.

M. Tech. Nanotechnology Semester-II Syllabus

NANO FABRICATION AND CHARACTERIZATION
(C107)

Designation of Course	Nano Fabrication and Characterization		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory: - 04 Hours/ Week	End Semester Examination	50 Marks	04
Tutorial: - --Hours/ Week	Internal Assessment	50 Marks	
Practical: - --Hours/ Week	Term Work	-- Marks	00
	Oral/Practical	-- Marks	
	Total	**100 Marks**	**04**

Course Prerequisites: -	The students should have knowledge of 1. Nanoscale phenomena 2. Basic spectroscopy 3. Approaches used for nanomaterial synthesis and characterization
Course Objectives: -	1. Provide sound understanding about various concepts involved in fabrication of nanomaterials and 2. types of approaches used and give practical experience for fabrication for advanced synthesis methods
Course Outcomes: -	The students should be able to understand– 1. MEMS and NEMS devices 2. Lithography and Nano porous materials 3. Microscopic and spectroscopic techniques 4. Mechanical characterization techniques

Course Contents

Unit I	**Micro and nano fabricated devices**	**(10 Hrs.)**
Introduction to Nanofabrication: Overview of nanofabrication techniques, top-down and bottom-up approaches for nanofabrication Fabrication of Nano-Mechanical Devices: Techniques for fabricating mechanical devices, including cantilevers, resonators, and nano-mechanical sensors Nano porous Materials – Silicon - Zeolites, meso porous materials – nano-membranes, carbon nanotubes, transparent conducting oxides –molecular sieves – nano-sponges Overview of current applications of nanofabrication in various fields, including electronics, photonics, biosensors, and nanomedicine		
Unit II	**Lithographic techniques**	**(10 Hrs.)**
Thin Film Deposition: Introduction to physical and chemical deposition techniques for thin film formation, including evaporation, sputtering, and chemical vapor deposition. Etching Techniques: Introduction to wet and dry etching techniques, including plasma etching, reactive ion etching, and deep reactive ion etching. Mask and its application, Photo lithography, X-ray lithography, deep UV lithography, electron-beam lithography, focused ion beam lithography, optical projection lithography, Nano-imprint lithography, electron and ion projection lithography, proximity probe lithography, near-field optical lithography		
Unit III	**Metrology And Characterization- Microscopy**	**(10 Hrs.)**
Electron Microscopy: Scanning electron microscopy – Transmission electron microscopy – Scanning tunneling electron microscopy – Image collection in electron microscopes – Environmental transmission electron microscopy – Electron energy loss spectroscopy at the		

nanometer scale – In-situ nano measurements - Qualitative approach. Electron Energy Loss Spectroscopy; High Resolution Imaging Techniques- HREM, Atom probe field ion microscopy Scanning Probe microscopy – Atomic manipulations – Atomic absorption microscopy-atomic force microscopy –Optical microscopy – Confocal microscopy – Scanning near field optical microscopy.		
Unit IV	**Spectroscopic Techniques**	**(10 Hrs.)**
Optical absorption and emission spectroscopy – Basics Molecular Spectroscopy and Differences-With Atomic Spectroscopy-Infrared (IR) Spectroscopy and Applications- Microwave Spectroscopy- Raman Spectroscopy and CARS Applications-Electron Spin Resonance Spectroscopy; New Applications of NMR Spectroscopy; Dynamic Nuclear Magnetic Resonance; Double Resonance Technique. Spectroscopy of semiconductors – Excitons – Infrared surface spectroscopy – Raman spectroscopy – Brillouin spectroscopy – Dynamic Light Scattering (DLS) – NMR Spectroscopy – ESR spectroscopy – Mossbauer spectroscopy, Secondary ion mass (SIMS) spectrometry – Matrix assisted laser desorption ionization mass spectrometry (MALDIMS).		
Unit V	**Nano indentation Mechanical Characterization**	**(10 Hrs.)**
Nano indentation principles- elastic and plastic deformation -mechanical properties of materials in small dimensions- models for interpretation of Nano indentation load-displacement curves-Nano indentation data analysis methods-Hardness testing of thin films and coatings- MD simulation of Nano indentation. Mechanical Characterization –Neutron and X- ray diffraction – Debye Scherrer formula – Dislocation density – Micro strain macromolecular crystallography using synchrotron radiation – Role for neutron scattering in nano science - Photoluminescence - Thermo luminescence – X-ray absorption Fine Structure (XAFS) – Extended X- ray absorption fine structure (EXAFS) – Electron scattering for chemical Analysis (ESCA). X-ray diffraction (XRD), X-Ray Photoelectron Spectroscopy, X-ray powder diffraction – single crystal diffraction techniques - Determination of accurate lattice parameters – structure analysis - profile analysis - particle size analysis using Scherer formula. X-Ray Characterization of Nano materials – EDAX and WDA analysis – EPMA – ZAP corrections.		

Term Work/ Assignments

At least Five Assignment based on above syllabus.

Textbooks:-

1. G. Cao, Nanostructures & Nanomaterials: Synthesis, Properties &Applications, Imperial College Press, 2004.

Reference Books: -

1. B. D.Cullity, “Elements of X-ray Diffraction”, 4th Edition, Addison Wiley, 1978.
2. M. H.Loretto, “Electron Beam Analysis of Materials”, Chapman and Hall, 1984.
3. R.M.Rose, L.A.Shepard and J.Wulff, “The Structure and Properties of Materials”, Wiley Eastern Ltd,
4. B.W.Mott, “Micro-Indentation Hardness Testing”, Butterworths, London, 1956.
5. Charles P Poole Jr and Frank J Ownes, “Introduction to Nanotechnology”, John Wiley Sons, 2003.
6. Mick Wilson, Kamali Kannangara, Geoff Smith, Michelle Simmons, Burkar Raguse, “Nanotechnology:Basic sciences and emerging technologies”, Overseas Press, 2005.
7. Willard, “Instrumental Methods of Analysis”, 2000.
8. Ewing. Etal, “Instrumental Methods for Chemical Analysis”, 2000.
9. George, Preparation of Thin Films, Marcel Dekker, Inc., New York. 2005.

10. W.Gaddand, D.Brenner, S.Lysherski and G.J.Infrate(Eds.), Handbook of NanoScience, Engg. and Technology, CRC Press, 2002
11. Nanofabrication towards biomedical application: Techniques, tools, Application and impact – Ed. Challa S., S. R. Kumar, J. H. Carola.
12. S.P. Gaponenko, Optical Properties of semiconductor nanocrystals, Cambridge University Press, 1980.

Internal Assessment

Continuous Evaluation by Assignments / Presentation / Quiz / Test

NANOMATERIALS FOR ENERGY AND ENVIRONMENT
(C108)

Designation of Course	**Nanomaterials for Energy and Environment**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory: - 04 Hours/ Week	End Semester Examination	50 Marks	04
Tutorial: - --Hours/ Week	Internal Assessment	50 Marks	
Practical: - -- Hours/Week	Term Work	-- Marks	00
	Oral/Practical	-- Marks	
	Total	**100 Marks**	**04**

Course Prerequisites: -	The students should have basic knowledge about 1. Atomic and molecular structure 2. Basic physics 3. Basic chemistry
Course Objectives: -	1. To impart the knowledge on applications of nanotechnology in the field of Energy sector. 2. To provide the knowledge on applications of nanotechnology in the field of Environmental Science and Technology.
Course Outcomes: -	The students should be able to– 1. Understand how nanomaterials can be used for a diversity of energy sector and environment rationales.

Course Contents

Unit I	**Introduction**	**(10 Hrs.)**
Sustainable energy - Materials for energy - greenhouse effect - CO2 emission - Energy demand and challenges. Sources, Types and mechanism – Solar, Thermoelectric, Piezoelectric; Electro dynamical and Biological; Energy harvesting devices and applications. Nanomaterials for energy harvesting.		
Unit II	**Renewable Energy Technology**	**(10 Hrs.)**
Solar energy: Photovoltaic fundamentals, Solar cell technologies, Types – Dye sensitized, Quantum dot, Copper indium gallium selenide (CIGS), Hybrid, Organic and Plasmonic solar cells. Development and implementation of renewable energy technologies. Nano, micro and meso scale phenomena and devices. Energy conversion, transport and storage. High efficiency Photovoltaic solar cells. High performance thermoelectric systems - Integration and performance of DSSC Quantum dots based solar cells.		
Unit III	**Nanomaterials In Fuel Cell and Storage Technology**	**(10 Hrs.)**
Fuel Cells - fundamentals, classifications, Operating principles and design considerations, thermodynamics and kinetics of fuel cell process, performance evaluation of fuel cell, Fuel cell applications. Nanomaterials as electrode materials for fuel cells. Micro-fuel cell technologies, integration and performance for micro-fuel cell systems - thin film and microfabrication methods - design methodologies - micro-fuel cell power sources – Super capacitors - Specific energy-charging/discharging - EIS analysis.		
Unit IV	**Hydrogen Storage and Photocatalysis**	**(10 Hrs.)**
Hydrogen storage methods - metal hydrides - size effects - hydrogen storage capacity - hydrogen reaction kinetics - carbon-free cycle- gravimetric and volumetric storage capacities - hydriding/dehydriding kinetics - multiple catalytic effects - degradation of the dye - nanomaterials based photocatalyst design - kinetics of degradation.		
Unit V	**Environmental Applications & Impacts of Nanomaterial**	**(10 Hrs.)**

Environmental impacts of nanomaterials - Exposure and risk assessment, Nanomaterials as adsorbents - Nanocomposite membrane systems for water remediation: Membrane fabrication; Membrane reactors & Active Membrane systems –Eco-toxicological impacts of nanomaterials - Lifecycle assessment of nanomaterials.

Term Work

At least Five Assignments based on above syllabus.

Text books:-

1. Mark R. Wiesner, Jean-Yves Bottero, Environmental Nanotechnology: Applications and Impacts of Nanomaterials, McGraw Hill, New York, 2007.

Reference/ Textbooks

1. J. Twidell and T. Weir, Renewable Energy Resources, Taylor & Francis Group, 2014 (4 th Edition).
2. Ram B. Gupta, Hydrogen Fuel, CRC Press, Taylor and Francis Group, New York, 2009
3. Gregor Hoogers, Fuel Cell Technology Handbook, CRC Press, Taylor and Francis Group New York, 2003.
4. Zhen Fang, Richard L Smith, Xinhua Qi, Production of Hydrogen from Renewable Resources, Springer, London, 2016.
5. Handbook of Fuel Cells: Fuel Cell Technology and Applications, Wolf Vielstich, Arnold Lamm, Hubert Andreas Gasteiger, Harumi Yokokawa, Wiley, London, 2003
6. Caye M. Drapcho, Nghiem Phu Nhuan and Terry H. Walker, Biofuels Engineering, McGrawHill Companies, 2008.
7. Viswanathan, B and M Aulice Scibioh, Fuel Cells – Principles and Applications, Universities Press, 2006

Internal Assessment

Continuous Evaluation by Assignments / Presentation / Quiz / Test

NANOTECHNOLOGY FOR BIOLOGICAL SYSTEMS
(C109)

Designation of Course	Nanotechnology for Biological Systems		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory: - 04 Hours/ Week	End Semester Examination	50 Marks	04
Tutorial: - --Hours/ Week	Internal Assessment	50 Marks	
Practical: - Hours/ Week	Term Work	-- Marks	00
	Oral/Practical	-- Marks	
	Total	**100 Marks**	**04**

Course Prerequisites: -	The students should have basic understanding of 1. Structures and functions of basic components of prokaryotic and eukaryotic cells 2. Enzymes 3. Biomolecules
Course Objectives: -	1. To enhance the knowledge of cell and molecular biology for synthesis of nanomaterials and applications in Biotechnology and 2. To give practical experience of nanomaterials biosynthesis
Course Outcomes: -	The students should be able to understand– 1. Cell morphologies and organelles, DNA transcription and protein translation, various techniques for biosynthesis of nano materials using bacteria, virus, plants. 2. Applications of Nanotechnology in Agriculture, Environment and Biomedical domain

Course Contents

Unit I	**Cell- structure, types and organelles**	**(10 Hrs.)**
Introduction to cell: the basic unit of life-Prokaryotic and eukaryotic cells, Types of cells: plants, animals, bacteria, viruses and fungi – cell organelles and their functions, Technology and innovation in cell biology, Nanotechnology as a tool for cell biology.		
Unit II	**Biomolecules: Carbohydrates, Lipids, Nucleic acids and Proteins, Bio nanostructures**	**(10 Hrs.)**
Carbohydrates and Lipids: Classifications, structure and types and functions biological membranes, Lipid bi-layer. Amino acids and proteins: structure and reactions of amino acids (hydrophilic and hydrophobic), structure of proteins (primary, secondary, tertiary and quaternary), Enzyme chemistry: kinetics of enzyme catalysis. Expression of genetic information (Transcription, translation), Nucleic acids: RNA- Structure, components and types, DNA- Structure, components, physical and chemical properties, DNA Transcription and Protein Translation. DNA-Protein nanostructures, Biomimetic fabrication of DNA-based metallic nanowires, oligomers conjugates and networks, DNA nanostructures for mechanics and computing.		
Unit III	**Immune system, Cytoskeleton and Molecular motors**	**(10 Hrs.)**
Basic immunology: Adaptive and innate immunity, cells of immune system, Antigens, and antibodies: Structure, types and functions, modulating the Immune system using Nanotechnology. Cytoskeleton: microtubules, intermediate filaments, and microfilaments; cell motility, Cell signaling, Molecular motor proteins: ATP synthase F1 motor, Bacterial Flagellar motor, Proton motive forces, ion channels, chimeric kinesin and myosin motors, G-protein trans membrane receptors		

Unit IV	Bio-synthesis of nanomaterials	(10 Hrs.)
Biological methods of synthesis: Use of bacteria, fungi, actinomycetes for nanoparticle synthesis, Magnetotactic bacteria for natural synthesis of magnetic nanoparticles; S-layer proteins, Viruses as components for the formation of nanostructured materials; Synthesis process and applications, Green approach for nanomaterial synthesis using plant extracts		
Unit V	**Novel Applications of Bio-Nanotechnology**	**(10 Hrs.)**
Interactions between biomolecules and nanoparticle surface, Different types of inorganic materials used for the synthesis of hybrid nano-bio assemblies, An overview about role of Bio-Nanotechnology in Diagnostics and Therapeutic applications, Environmental and Agricultural domain.		

Term Work/ Practicals

1. Demonstration of Cytotoxicity/cell viability- Tryphan blue dye exclusion
2. Absorbance spectra of biomolecules (DNA, proteins)
3. Demonstration of nanoparticles-based drug delivery in cell line

Textbooks: -

1. Bionanotechnology: Lessons from Nature by David S. Goodsell
2. Nanomedicine, Vol. IIA: Biocompatibility by Robert A. Freitas

Reference Books

1. Nelson, D.L., Fox.M.M., “Lehninger Principles of Biochemistry”, W.H.Freeman,
2. Watson, James, T.Baker, S.Bell, A.Gann, M.Levine, And R.Losick.“Molecular Biology of the gene”, san francisco: Addison-Wesley
3. Nanomedicine, Vol. IIA: Biocompatibility by Robert A.
4. Nanofabrication towards biomedical application: Techniques, tools, Application and impact – Ed. Challa S., S. R. Kumar, J. H. Carola.
5. Branden, Carl-Ivar, and John Tooze. Introduction to Protein Structure. 2nd ed. New York: Garland Pub., 1991.
6. Creighton, E, Thomas, “Proteins: Structures and Molecular Properties”, 2nd Ed. New York: W.H. Freeman, 1992.
7. Handbook of Nanostructured Biomaterials and Their Applications in Nanobiotechnology - Hari SinghNalwa
8. Nanobiotechnology; ed. C.M.Niemeyer, C.A. Mirkin.

Internal Assessment

Continuous Evaluation by Assignments / Presentation / Quiz / Test

ELECTIVE-II: NANO MEDICINE
(C110.1)

Designation of Course	**Elective-II: Nano Medicine**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory: - 04 Hours/ Week	End Semester Examination	50 Marks	04
Tutorial: - --Hours/ Week	Internal Assessment	50 Marks	
Practical: - 02 Hours/ Week	Term Work	-- Marks	00
	Oral/Practical	-- Marks	
	Total	**100 Marks**	**04**

Course Prerequisites: -	The students should have knowledge of 1. Nanoscale phenomena 2. Types and properties of nanomaterials 3. Approaches used for nanomaterial synthesis
Course Objectives: -	1. Provide sound understanding about types of nano delivery systems, nanoscale diognostics, pharmacological applications, and gene therapy. **2.** To understand various mechanisms involved in tumor detection and targeting.
Course Outcomes: -	The students should be able to understand– 1. Types of nanomaterial with biological applications 2. Drug delivery systems 3. Types of nanoparticle mediated drug delivery 4. Synthesis and applications of nanoliposomes, polymeric nanoparticulates 5. Nanocapsules, nanoshells, polymers for drug delivery 6. Gene therapy, tumor detection and targeting

Course Contents

Unit I	**Nanomedine: Overview**	**(10 Hrs.)**
Applications of nano-medicine: Bio- Pharmaceuticals, biological implants, diagnostic tools, Genetic testing – imaging – nanoparticles probe		
Unit II	**Drug delivery systems**	**(10 Hrs.)**
Microfabricated drug delivery systems: micro needles- micropumps-microvalves-implantable microchips,		
Unit III	**Nanocarriers**	**(10 Hrs.)**
Nanocarriers: drug delivery: sustained / controlled/ targeted. **Nano-bio-Systems:** Diagnosis, Characterization and Testing of Nano-Bio Systems		
Unit IV	**Nanoparticulate Systems**	**(10 Hrs.)**
Polymeric nanoparticulate systems: polymeric micelles as drug carriers – dendrimers as nanoparticulate drug carriers - nanocapsules preparation, characterization, and therapeutic applications		
Unit V	**Liposomes as carrier systems**	**(10 Hrs.)**
Liposomes for genetic vaccines and cancer therapy - recent advances in microemulsions as drug delivery vehicles, lipoproteins as pharmaceutical carriers, solid lipid nanoparticles as drug carriers Tumor detection and targeting in vivo, Gene Therapy using nanoparticles		

Term Work/ Practicals

1. Biosynthesis of nano-liposomes
2. Bio synthesis of nano-particulate systems for drug delivery

Textbooks:-

1. G. Cao, Nanostructures & Nanomaterials: Synthesis, Properties & Applications, Imperial College Press, 2004.

Reference Books

1. J.George, Preparation of Thin Films, Marcel Dekker, Inc., New York. 2005.
2. W.Gaddand, D.Brenner, S.Lysherski and G.J.Infrate(Eds.), Handbook of NanoScience, Engg. and Technology, CRC Press, 2002
3. Nanofabrication towards biomedical application: Techniques, tools, Application and impact – Ed. Challa S., S. R. Kumar, J. H. Carola.

Internal Assessment

Continuous Evaluation by Assignments / Presentation / Quiz / Test

ELECTIVE II: -RESEARCH METHODOLOGY
(C110.2)

Designation of Course	Elective II: RESEARCH METHODOLOGY		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory: - 04 Hours/ Week	End Semester Examination	50 Marks	04
Tutorial: - --Hours/ Week	Internal Assessment	50 Marks	
Practical: -- Hours/ Week	Term Work	-- Marks	00
	Oral/Practical	-- Marks	
	Total	**100 Marks**	**04**

Course Prerequisites: -	The students should have knowledge of 1. Basic Statistics
Course Objectives: -	1. To illustrate what is the exact meaning of research and a correct way to define it. 2. To develop the understanding of the basic frame work of research process. 3. Explore small and large data-sets to create testable hypotheses and identify appropriate statistical test 4. Perform correlation, regression analysis and appropriate statistical tests
Course Outcomes: -	After the completion of course, students will be able to 1. Interpret the meaning of research problem and methodology for research. 2. Apply research process in designing of research problem. 3. Utilize experimental error analysis for quality research

Course Contents

Unit I	**Getting Started: Ideas, Resources, and Ethics**	**(10 Hrs.)**
Selecting a Problem, Reviewing the Literature: Library Research, Journals, Psychological Abstracts, PsycINFO and PsycLIT, Social Science Citation Index and Science Citation Index, Other Resources, Reading a Journal Article: Abstract, Introduction, Method, Results, Discussion Ethical Standards in Research		
Unit II	**Introduction and Descriptive Statistics**	**(10 Hrs.)**
Introduction to Frequency Distributions, Frequency Distribution Tables, Frequency Distribution Graphs, The Shape of a Frequency Distribution Central Tendency : Mean, Median, Mode, Selecting a Measure of Central Tendency, Central Tendency and the Shape of the Distribution Variability : The Range, Standard Deviation and Variance for a Population, Standard Deviation and Variance for Samples		
Unit III	**Foundations of Inferential Statistics**	**(10 Hrs.)**
Introduction to z-Scores, z-Scores and Location in a Distribution, Using z-Scores to Standardize a Distribution, Other Standardized Distributions Based on z-Scores, Computing z-Scores for a Sample.		
Unit IV	**Probability and Samples**	**(10 Hrs.)**
Introduction to Probability ,Probability and the Normal Distribution ,Probabilities and Proportions for Scores from a Normal Distribution Probability and the Binomial Distribution, Samples and Populations ,The Distribution of Sample Means ,Probability and the Distribution of Sample Means		
Unit V	**Introduction to Hypothesis Testing**	**(10 Hrs.)**
The Logic of Hypothesis Testing ,Uncertainty and Errors in Hypothesis Testing ,An Example of a Hypothesis Test ,Directional (One-Tailed) Hypothesis Tests Concerns About Hypothesis Testing: Measuring Effect Size		

Text books: -

1. Research Methodology: Methods and Trends, by Dr. C. R. Kothari, New Delhi: New Age International (P) Ltd., 2nd Rev. Edition, 2004.

Reference Books

1. Research Methodology: An Introduction by Wayne Goddard and Stuart Melville, Juta and Company Ltd, 2004.
2. Statistical Methods by S.P. Gupta, Sultan Chand and Sons, New Delhi, 44th Revised Edition 2014.
3. Theory and Design for Mechanical Measurements by Richard S. Figliola, Donald E. Beasley John Wiley & Sons, Inc, 6th Edition, 2015.
4. Research methodology: an Introduction for Science & Engineering students, by Stuart Melville and Wayne Goddard, Kenwyn, South Africa: Juta& Co. Ltd., 1st Edition, 1996.

Internal Assessment

Continuous Evaluation by Assignments / Presentation / Quiz / Test

LAB PRACTICE-3

(C111)

Designation of Course	Lab Practice-III		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory: --- Hours/ Week	End Semester Examination	-- Marks	00
Tutorial: - --Hours/ Week	Internal Assessment	-- Marks	
Practical: - 04 Hours/ Week	Term Work	25 Marks	02
	Oral/Practical	25 Marks	
	Total	**50 Marks**	**02**

Course Prerequisites: -	The students should have knowledge of 1. Nano polymers 2. Composite materials 3. Electro chemical processes
Course Objectives: -	At the end of the course students will 1. Develop self-learning attitude. 2. Interact with various libraries, resource persons to get information about a selected topic.
Course Outcomes: -	The students should be able to– 1. To read, understand and outline an advanced information in the related field.

Course Contents

1. Practical on Numerical Algorithms -Numerical Programs -Numerical Software
2. Practical on MATLAB OR Mathematica (and their open source counterparts-Scilab and Octave); examples from nano-optics and nano-electronics
3. Practical on manufacturing of Bulk and nano polymer matrix composite materials
4. Demonstration of emulsion polymerization, templated synthesis, and confined nucleation and/or growth
5. Synthesis of nanoparticles by chemical combustion route
6. Practical on Nanofabrication of porous Silicon
7. Fabrication of nanofibers by electrospinning
8. Demonstration of M based nanolithography and nanomanipulation, E beam lithography
9. micromachining, e-beam writing, and scanning probe patterning.
10. Demonstration of anodic oxidation of alumina films, porous silicon, and pulsed electrochemical deposition.

Term work/ Oral

Term work and oral will be based on above syllabus.

LAB PRACTICE-4
(C112)

Designation of Course	**Lab Practice-IV**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory: --- Hours/ Week	End Semester Examination	-- Marks	00
Tutorial: - --Hours/ Week	Internal Assessment	-- Marks	
Practical: - 04 Hours/ Week	Term Work	25 Marks	02
	Oral/Practical	25 Marks	
	Total	**50 Marks**	**02**

Course Prerequisites: -	The students should have knowledge of 1. Microscopy and spectroscopy 2. X-ray diffraction 3. Micro chemistry
Course Objectives: -	At the end of the course students will 1. Develop self-learning attitude. 2. Interact with various libraries, resource persons to get information about a selected topic.
Course Outcomes: -	The students should be able to– 1. To read, understand and outline an advanced information in the related field.

Course Contents

1. Demonstration of Optical absorption and emission spectroscopy
2. Demonstration Electron Microscopy: Scanning electron microscopy – Transmission electron microscopy.
3. Practical on High Resolution Imaging Techniques- HREM,
4. Practical on Atomic force microscopy
5. Demonstration of Magnetic properties by PPMS/VSM/SQUID
6. Practical on X-ray powder diffraction – single crystal diffraction techniques
7. Use of particle size analysis using Scherer formula.
8. Practical on Dielectric properties by PPMS
9. Thin film and microfabrication methods for Micro-fuel cell
10. Demonstration and power generation - microchannel battery - micro heat engine

Term work/ Oral
Term work and oral will be based on above syllabus.

M. Tech. Nanotechnology Semester-III Syllabus

SEMINAR
(C201)

Designation of Course	Seminar		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory: --- Hours/ Week	End Semester Examination	-- Marks	00
Tutorial: - --Hours/ Week	Internal Assessment	-- Marks	
Practical: - 02 Hours/ Week	Term Work	50 Marks	05
	Oral/Practical	50 Marks	
	Total	**100 Marks**	**05**

Course Prerequisites: -	The students should have knowledge of 1. Knowledge of Mathematics & Science 2. Basic concepts of Engineering Fundamentals
Course Objectives: -	At the end of the course students will 1. Develop self-learning attitude. 2. Interact with various libraries, resource persons to get information about a selected topic. 3. Be familiar with various refereed national/international journals. 4. Improve their oral and written communication skills and will be conversant with technical writing.
Course Outcomes: -	The students should be able to– Upon completion of this course the student will be able to: 1. To read, understand and outline an advanced information in the related field. 2. Prepare and build a problem statement and undertake the research work. 3. Present and elaborate the work before the experts in conferences, meetings, etc.

Course Contents

Seminar shall consists of the in depth study of a topic, related to the field of Nanotechnology and should have research orientation. The student should know recent developments and applications in the chosen field of study.

The topic of study/research is mutually decided by the student and the supervisor, and a detailed technical report will be prepared. The study is to be presented in front of the committee of examiners, faculty, and students of the department.

Term work/ Oral

Term work and oral will be based on above syllabus/topic of study.

Dissertation Stage I
(C202)

Designation of Course	Dissertation Stage I		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory: - -- Hours/ Week	End Semester Examination	-- Marks	00
Tutorial: - --Hours/ Week	Internal Assessment	-- Marks	
Practical: - 06 Hours/ Week	Term Work	100 Marks	15
	Oral/Practical	50 Marks	
	Total	**150 Marks**	**15**

Course Prerequisites: -	The students should have knowledge of 1. Knowledge of Mathematics & Science 2. Basic concepts of Engineering Fundamentals
Course Objectives: -	At the end of the course students will 1. Exposed to self-learning various topics**.** 2. Learn to survey the literature such as books, national/international refereed journals and contact resource persons for the selected topic of research. 3. Address issues of research design, methodology, ethics and theoretical arguments, and locate a piece of research within these 4. Apply the knowledge about research design and methods that have gained from the taught components to develop your dissertation project
Course Outcomes: -	The students should be able to 1. Students will learn to survey the relevant literature such as books, national/international refereed journals and contact resource persons for the selected topic of research. 2. Students will be able to use different experimental techniques. 3. Students will be able to use different software/ computational/analytical tools. 4. Students will be able to design an experimental setup.

Course Contents

The Project Work should preferably be a problem with research potential and should involve scientific research, design, generation/collection, and analysis of data, determining solution and must preferably bring out the individual contribution. The examination shall consist of the preparation of report consisting of a detailed problem statement and a literature review. The preliminary results (if available) of the problem may also be discussed in the report. The work must be presented in front of the examiners panel set the university. The candidate must be in regular contact with his guide and the topic of dissertation must be mutually decided by the guide and student.

Term work/ Oral

Term work and oral will be based on above syllabus/topic of dissertation.

M. Tech. Nanotechnology Semester-IV Syllabus

Dissertation Stage II
(C203)

Designation of Course	Dissertation Stage II		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory: - -- Hours/ Week	End Semester Examination	-- Marks	00
Tutorial: - --Hours/ Week	Internal Assessment	-- Marks	
Practical: - 08 Hours/ Week	Term Work	150 Marks	20
	Oral/Practical	100 Marks	
	Total	**250 Marks**	**20**

Course Prerequisites: -	The students should have knowledge of 1. Knowledge of Mathematics & Science 2. Basic concepts of Engineering Fundamentals
Course Objectives: -	At the end of the course students will 1. Address issues of research design, methodology, ethics and theoretical arguments, and locate a piece of research within these 2. Apply the knowledge about research design and methods that have gained from the taught components to develop your dissertation project
Course Outcomes: -	The students should be able to 1. Students will be able to design and develop an experimental set up/ equipment/test rig. 2. Students will be able to conduct tests on existing setups/equipment's and draw logical conclusions from the results after analyzing them. 3. Students will be able to either work in a research environment or in an industrial environment. 4. Students will develop attitude of lifelong learning and will develop interpersonal skills to deal with people working in diversified field. 5. Students will learn to write technical reports and research papers to publish at national and international level. 6. Students will develop strong communication skills to defend their work in front of technically qualified audience

Course Contents

It is a continuation of Dissertation Stage-I work started in semester III. He has to submit the report in prescribed format. The dissertation should be presented in standard format as provided by the department. The candidate has to prepare a detailed project report consisting of introduction of the problem, problem statement, literature review, objectives of the work, methodology (experimental set up or numerical details as the case may be) of solution and results and discussion.

The report must bring out the conclusions of the work and future scope for the study. The work must be presented in front of the examiners panel consisting of an approved external examiner, an internal examiner and a guide, co-guide etc. as decided by the University. The candidate must be in regular contact with his guide.

Term work/ Oral

Term work and oral will be based on above syllabus/topic of dissertation.