ANNA UNIVERSITY, CHENNAI

NON- AUTONOMOUS COLLEGES

AFFILIATED TO ANNA UNIVERSITY

M. TECH. NANOSCIENCE AND TECHNOLOGY

REGULATIONS 2025

PROGRAMME OUTCOMES (POs):

PO	Programme Outcomes
PO1	An ability to independently carry out research /investigation and development work to solve practical problems
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

PROGRAMME SPECIFIC OUTCOMES(PSOs):

PSO	Programme Specific Outcomes
PSO1	Students will be able to independently carry out research, investigations, and development activities aimed at solving real-world practical problems within their specialization.
PSO2	Students will demonstrate the ability to prepare, write, and present comprehensive technical reports, showcasing mastery of the subject matter beyond the undergraduate level.

ANNA UNIVERSITY, CHENNAI

POST GRADUATE CURRICULUM (NON.AUTONOMOUS AFFILIATED INSTITUTIONS)

Programme: M.Tech. Nanoscience and Technology **Regulations:** 2025

Abbreviations:

BS – Basic Science (Mathematics)
ES – Engineering Science (General (**G**), Programme Core (**PC**), Programme Elective (**PE**) & Emerging Technology (**ET**))
SD – Skill Development
SL – Self Learning

L – Laboratory Course
T – Theory
LIT – Laboratory Integrated Theory
PW – Project Work
TCP – Total Contact Period(s)

Semester I

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.	NT25101	Mathematical Modeling and Simulation	T	3	1	0	4	4	ES (PC)
2.	NT25102	Quantum Mechanics	T	3	0	0	3	3	ES (PC)
3.	NT25103	Physics and Chemistry of Materials	T	3	0	0	3	3	ES (PC)
4.	NT25104	Biological Nanostructures	T	3	1	0	4	4	ES (PC)
5.	NT25105	Computation and Simulation Laboratory	L	0	0	4	4	2	ES (PC)
6.	NT25106	Nanomaterial Synthesis Laboratory	L	0	0	4	4	2	ES (PC)
7.	NT25107	Technical Seminar	-	0	0	2	2	1	SD
Total Credits							**24**	**19**	

Semester II

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.	NT25201	Imaging Techniques for Nanotechnology	T	3	0	0	3	3	ES (PC)
2.	NT25202	Physiochemical Characterization of Nanomaterials	T	3	0	0	3	3	ES (PC)
3.	NT25203	Synthesis of Nanomaterials	T	3	0	0	3	3	ES (PC)
4.	--	Programme Elective I	T	3	0	0	3	3	ES (PE)
5.	--	Industry Oriented Course I	-	1	0	0	1	1	SD
6.	NT25204	Materials Structural Characterization Laboratory	L	0	0	4	4	2	ES (PC)
7.	NT25205	Physicochemical characterization Laboratory	L	0	0	4	4	2	ES (PC)
8.	--	Self Learning Course	---	-	-	-	-	1	-
9.	NT25206	Industrial Training	---	---	---	---	---	2	SD
						Total Credits	**21**	**20**	

Semester III

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.	--	Programme Elective II	T	3	0	0	3	3	ES (PE)
2.	--	Programme Elective III	T	3	0	0	3	3	ES (PE)
3.	--	Programme Elective IV	T	3	0	0	3	3	ES (PE)
4.	--	Programme Elective V	T	3	0	0	3	3	ES (PE)
5.	--	Industry Oriented Course II	---	1	0	0	1	1	SD
6.	NT25301	Project Work I	---	0	0	12	12	6	SD
						Total Credits	**25**	**19**	

Semester IV

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.	NT25401	Project Work II	---	0	0	24	24	12	SD
						Total Credits	**24**	**12**	

Total Credits for the Programme = 70

Programme Elective Courses (PE)

S. No.	Course code.	Course title	Periods per week			Total contact periods	Credits
			L	T	P		
1.	NT25001	Lithography and Nanofabrication	3	0	0	3	3
2.	NT25002	Nanocomposite Materials	3	0	0	3	3
3.	NT25003	Nanoelectronics and Sensors	3	0	0	3	3
4.	NT25004	Nanotechnology in Tissue Engineering	3	0	0	3	3
5.	NT25005	Nanotechnology in Agriculture and Food Industry	3	0	0	3	3
6.	NT25006	Nanomaterials for Energy and Environment	3	0	0	3	3
7.	NT25007	Nano Biophotonics	3	0	0	3	3
8.	NT25008	Nano Biosensors	3	0	0	3	3
9.	NT25009	Advanced Drug Delivery System	3	0	0	3	3
10.	NT25010	Processing and Properties of Nanostructured Materials	3	0	0	3	3
11.	NT25011	MEMS and NEMS	3	0	0	3	3
12.	NT25012	Semiconductor Nanostructures	3	0	0	3	3
13.	NT25013	Nano-toxicology	3	0	0	3	3
14.	NT25014	Nanotechnology in Health Care	3	0	0	3	3
15.	NT25015	Entrepreneurship	3	0	0	3	3

Semester I

NT25101	Mathematical Modeling and Simulation	L	T	P	C
		3	1	0	4

Course Objectives:

This course will help the students to

- Acquire the knowledge of solving system of linear equations using an appropriate numerical method.
- Approximate the functions using polynomial interpolation numerical differentiation and integration using interpolating polynomials.
- Acquire the knowledge of numerical solution of ordinary differential equation by single and multi step methods.
- Obtain the solution of boundary value problems in partial differential equations using finite differences.
- Study simulation and Monte-Carlo methods and their applications.

Matrices and Linear Systems of Equations: Solution of Linear Systems : Cramer's Rule, Gaussian elimination and Gauss Jordon methods, Cholesky decomposition method, Gauss Seidel iteration method, Eigenvalue problems : Power method with deflation for both symmetric and non symmetric matrices and Jacobi method for symmetric matrices.

Activity: Solve linear systems of equation using MATLAB.

Interpolation, Differentiation and Integration: Lagrange's interpolation, Newton's divided differences, Hermite's interpolation, Newton's forward and backward differences, Numerical differentiation, Numerical integration: Trapezoidal and Simpson's rules, Gaussian quadrature : 2 and 3 point rules.

Activity: Solve Interpolation, Differentiation and Integration of equation using MATLAB.

Differential Equations and Partial Differential Equations: Initial value problems for first and second order ODEs : Single step methods, Taylor's series method, Euler's and modified Euler's methods, Runge, Kutta method of fourth order, Multi step methods - Boundary value problems : Finite difference approximations to derivatives, Finite difference method of solving second order ODEs .Classification of second order PDE's, Finite difference approximations to partial derivatives, Elliptic equations : Solution of Laplace and Poisson equations, One dimensional parabolic equation, Bender Schmidt method

Activity: Solve Differential Equations and Partial Differential Equations of equation using MATLAB.

Simulation Andmonte Carlo Methods: Random numbers: Random number algorithms and generators, Estimation of areas and volumes by Monte Carlo techniques, Numerical integration, Computing volumes, Simulation: Loaded Die Problem, Birthday problem, Buffon's needle problem, Two dice problem and Neutron shielding problem

Activity: Solve Simulation Andmonte Carlo Methods Equations of equation using MATLAB.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (20%), Assignments (30%) and Internal Examinations (50%)

References:

1. Burden, R. L., & Faires, J. D. (2016). Numerical analysis. Cengage Learning.
2. Cheney, W., & Kincaid, D. (2014). Numerical mathematics and computing. Cengage Learning.
3. Jain, M. K., Iyengar, S. R. K., & Jain, R. K. (2014). Numerical methods for scientific and engineering computation. New Age International Pvt. Ltd.
4. Landau, D. P., & Binder, K. (2009). A guide to Monte Carlo simulations in statistical physics. Cambridge University Press.
5. Maki, D. P., & Thompson, M. (2011). Mathematical modelling with computer simulation. Cengage Learning.
6. Sastry, S. S. (2012). Introductory methods of numerical analysis. PHI Learning Pvt. Ltd.
7. Taha, H. A. (2018). Operations research. Pearson Education India.

	Description of CO	**PO**	**PSO1**	**PSO2**
CO1	Explain the numerical methods required for solving chemical engineering problems	PO1(3), PO2(2)	3	2
CO2	Solve the differential equations of chemical engineering processes	PO1 (3), PO2(2), PO4(2)	2	3
CO3	Apply Interpolation & optimization methods to solve equations arising from chemical engineering processes	PO1 (3), PO2(2), PO4(2)	2	1
CO4	Apply integration & differentiation numerical methods to solve chemical processes.	PO1 (3), PO2(2), PO4(2)	2	2

NT25102	Quantum Mechanics	L	T	P	C
		3	0	0	3

Course Objective:

- To learn basics of Quantum mechanics.
- To know more about time dependent and independent Schrodinger equation and approximation methods.
- To know the concept of Quantum computation

Basics of Quantum Mechanics: Wave-particle duality, group velocity, Phase velocity, De-Broglie wavelength, Uncertainty principle and Schrödinger equation.

Activity: Double-Slit Simulation – Use PhET simulation to observe electron interference. Calculate de Broglie wavelength for different particles (electron, proton, neutron).

Time Dependent and Time Independent Schrödinger Equation: Solutions of the one-dimensional Schrödinger equation for free particle, particle in a box, particle in a infinitely deep well potential, linear harmonic oscillator, Particle in a three dimensional box, density of states, free Electron theory of metals, The spin half problem and properties of Pauli spin matrices.

Activity: Particle in a Box Plotting – Solve and plot the wavefunctions and energy levels for a 1D infinite potential well using Python or Excel.

Approximate Methods: Time independent and time dependent perturbation theory for non-degenerate and degenerate energy levels, the variational method, WKB approximation, adiabatic approximation, sudden approximation.

Activity: Variational Method Practice – Use a trial wavefunction to estimate the ground state energy of a harmonic oscillator. Compare with exact value.

Quantum Computation: Concept of quantum computation, Quantum Q-bits, Introduction to nuclear spin, quantum confinement, quantum devices, single electron devices.

Activity: Quantum Circuit Simulation – Use IBM Quantum Lab or Qiskit to create a simple quantum circuit (e.g., apply Hadamard + CNOT gates) and observe qubit behavior.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (20%), Assignments (30%), Internal Examinations (50%)

References:

1. Beiser, A. (2009). *Modern physics*.
2. Bransden, B. H., & Joachain, C. J. (2000). *Quantum mechanics*.
3. Eisberg, R., & Resnick, R. (1985). *Quantum physics of atoms, molecules, solids, nuclei, and particles*.
4. Ghatak, A. (2004). *Quantum physics: Theory and applications*. Springer.
5. Shankar, R. (2000). *Principles of quantum mechanics*.
6. Cohen-Tannoudji, C., Diu, B., & Laloë, F. (1997). *Quantum mechanics* (Vols. 1 & 2).

	Description of CO	PO	PSO1	PSO2
CO1	Explain basic quantum concepts like wave-particle duality and uncertainty principle.	PO1(3), PO2(2)	2	3
CO2	Solve Schrödinger equations for different quantum systems.	PO1 (3), PO2(2), PO4(2)	2	1
CO3	Apply approximation methods to estimate energy levels in quantum systems.	PO1 (3), PO2(2), PO4(2)	3	2
CO4	Describe the basics of quantum computation and simulate simple quantum circuits.	PO1 (3), PO2(2), PO4(2)	2	2

NT25103	Physics and Chemistry of Nanomaterials	L	T	P	C
		3	0	0	3

Course Objectives:

- To gain knowledge on Physical and chemical aspects of Nanomaterials.
- To know about diffusion and surface defects, nanostructures and Nano systems

Physics Aspects: Size effect on thermal, electrical, electronic, mechanical, optical and magnetic properties of nanomaterials, surface area and aspect ratio- band gap energy- quantum confinement size effect.

Activity: Calculate & Compare Band Gap Energy — Use sample data or simulation to calculate band gap energy for nanoparticles of different sizes. Plot size vs band gap and explain quantum confinement effect.

Chemistry Aspects : Photochemistry and Electrochemistry of nanomaterials–Ionic properties of nanomaterials, Nanocatalysis-Nanoscale heat transfer-Electron transport in transition metals and semi conducting nanostructures.

Activity: Analyze Nanocatalysis Reaction — Study a case (real or simulated) of nanoparticle-catalyzed dye degradation. Identify how ionic properties and surface area influence catalytic efficiency.

Surface Defects and Diffusion in Nanostructures: Classifications of nanomaterials, Zero dimensional, one-dimensional, and two-dimensional nanostructures, Kinetics in nanostructured materials-multi layer thin films and super lattice-clusters of metals, semiconductors, and nanocomposites, Fick's Law, mechanisms of diffusion-influence of pressure and temperature, Kirkendall effect-surface defects in nanomaterials, effect of microstructure on surface defects-interfacial energy.

Activity: Diffusion Rate Estimation — Using Fick’s laws, calculate diffusion rates in a thin film nanostructure at different temperatures and pressures. Discuss the role of surface defects and Kirkendall effect.

Nanosystems: Nanoparticles through homogeneous and heterogeneous nucleation, Growth controlled by surface and diffusion process, Oswald ripening process, influence of reducing agents solid state phase segregation, Mechanisms of phase transformation, grain growth and sintering, precipitation in solid solution-Hume-Rothery rule.

Activity: Nucleation & Growth Simulation — Model homogeneous vs heterogeneous nucleation and Ostwald ripening through graphical or computer simulation tools. Relate growth control to reducing agents and sintering.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (20%), Assignments (30%), Internal Examinations (50%)

References:

1. Kolasinski, K. W. (2002). *Surface science: Foundations of catalysis and nanoscience*. Wiley.
2. Cao, G. (2004). *Nanostructures & nanomaterials: Synthesis, properties & applications*. Imperial College Press.
3. Gersten, J. I. (2001). *The physics and chemistry of materials*. Wiley.

4. Edelstein, A. S., & Cammarata, R. C. (1998). *Nanomaterials: Synthesis, properties and applications*. Institute of Physics Publishing.
5. Yang, S., & Shen, P. (2000). *Physics and chemistry of nanostructured materials*. Taylor & Francis.
6. Ozin, G. A., & Arsenault, A. C. (2005). *Nanochemistry: A chemical approach to nanomaterials*. Royal Society of Chemistry.
7. Atkins, P., & Julio, P. (n.d.). *Physical chemistry*.

	Description of CO	**PO**	**PSO1**	**PSO2**
CO1	Explain size-dependent physical properties and quantum confinement effects in nanomaterials.	PO1(3), PO2(2)	3	2
CO2	Describe chemical behaviors of nanomaterials including photochemistry, electrochemistry, and nanocatalysis.	PO1 (3), PO2(2), PO4(2)	2	2
CO3	Analyze surface defects, diffusion mechanisms, and their impact on nanostructured materials.	PO1 (3), PO2(2), PO4(2)	1	2
CO4	Understand nanosystem formation processes such as nucleation, growth, phase transformations, and sintering.	PO1 (3), PO2(2), PO4(2)	2	2

NT25104	Biological Nanostructures	L	T	P	C
		3	1	0	4

Course Objectives:

- Impart knowledge on the nanostructures and nanoscale phenomenon in cells.
- To understand the different three-dimensional DNA nanostructures and their uses.
- Familiarize the concepts involved in protein corona with reference to protein nanoparticles and enzyme nanotechnology.
- Acquaint with the glyco-metal, glyco-carbon nanoparticles and their fate.
- Explain the synthesis and applications of lipid-based nanostructures

Cellular Nanostructures: Cellular elements in developing functional nanostructures and nanomaterials, Nanopatterning, Cytoskeletal nanomechanics, Bacterial and viral nanostructured materials, Plant-derived nanostructures: types, evolution and applications, Phytochemicals in the genesis of nanoparticles.

Activity: Microscopy Image Identification - Analyze electron microscope images of plant-derived and bacterial nanostructures. Identify key features and discuss their biological functions.

DNA Nanoarchitecture: Genome structure and organization in prokaryotes and eukaryotes, Structure and function of nucleic acids, The Central Dogma of life, DNA tile assembly, brick assembly, 3D DNA nanostructures, Organic and inorganic DNA nanostructures, DNA aptamer and DNA origami, DNA varieties: A, B, and Z, Applications of DNA nanostructures.

Activity: Build a Paper DNA Origami Model - Use simple paper folding and cutting to create a basic DNA origami shape. Discuss how DNA's structure allows for such precise assembly.

Protein and Enzyme Nanoparticles: Proteins: Structure, classification and functions, Protein nanoparticles: Designing, synthesis strategy, ligands used and their applications, Enzymes and Enzyme nanoparticles: properties, structure: Preparation, immobilization, kinetic properties and applications of enzyme nanoparticles in day-day to life, Synzymes, ribozymes

Activity: Immobilization Simulation - Design a virtual experiment to immobilize enzymes on nanoparticles and predict how immobilization affects enzyme activity.

Nanoparticles of Other Biomolecules: Classification, Structure Properties and Functions of Lipids and Carbohydrates-Preparation and applications of biopolymers, Chitosan, cellulose, liposomes. Glycoconjugate nanoparticles, Types and advantages of Biolipid Nanostructures- Structure, function and significance of Membranous nanostructures and their role in cellular traffic.

Activity: Biopolymer Comparison Table - Compare properties and applications of chitosan, cellulose, and liposomes in a table format. Highlight their roles in drug delivery or tissue engineering.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (20%), Assignments (30%), Internal Examinations (50%)

References:

1. Barnard, A. S., & Guo, H. (Eds.). (2012). *Nature's nanostructures*. CRC Press.
2. Stroscio, M. A., & Dutta, M. (2004). *Biological nanostructures and applications of nanostructures in biology: Electrical, mechanical and optical properties*. Kluwer Academic Publishers.
3. Iglič, A., Drobne, D., & Kralj-Iglič, V. (2015). *Nanostructures in biological systems: Theory and applications*. CRC Press.
4. Mendes, P. M., Yeung, C. L., & Preece, J. A. (2007). Bio-nanopatterning of surfaces. *Nanoscale Research Letters, 2*(8), 373–384.
5. Häfeli, U. O., Arshady, R., & Kono, K. (2006). Smart nanoparticles in nanomedicine—the MML series. *Smart Nanoparticles in Nanomedicine*, 77.
6. Durán, N., Silveira, C. P., Durán, M., & Martinez, D. S. T. (2011). Mechanistic aspects in the biogenic synthesis of extracellular metal nanoparticles by peptides, bacteria, fungi, and plants. *Applied Microbiology and Biotechnology, 90*(5), 1609–1624.
7. Nelson, D. L., & Cox, M. M. (2012). *Lehninger principles of biochemistry* (5th ed.). W. H. Freeman.
8. De Robertis, E. D. P. (2010). *Cell & molecular biology* (8th ed.). Lippincott Publishers.
9. Lewin, B. (2007). *Genes* (9th ed.). CBS Publishers and Distributors.
10. Ki, Y. (2015). *3D DNA nanostructure*. Humana Press.
11. Bujold, K. E., Lacroix, A., & Sleiman, H. F. (2018). DNA nanostructures at the interface with biology. *Chem, 4*(3), 495–521.
12. Niemeyer, C. M., & Adler, M. (2002). Nanomechanical devices based on DNA. *Angewandte Chemie International Edition, 41*(20), 3779–3783.
13. Hawkins, M. J., Soon-Shiong, P., & Desai, N. (2008). Protein nanoparticles as drug carriers in clinical medicine. *Advanced Drug Delivery Reviews, 60*(8), 876–885.
14. Pundir, C. S. (2015). *Enzyme nanoparticles: Preparation, characterization, properties and applications*. William Andrew.
15. Aelman, C. (2013). *Peptide materials: From nanostructures to applications*. Wiley.
16. Sasso, L. (2012). *Self-assembled peptide nanostructures: Advances and applications in nanobiotechnology*. Pan Stanford Publishing.
17. Stine, K. J. (2015). *Carbohydrate nanotechnology*. Wiley.
18. Reichardt, N. C., Martín-Lomas, M., & Penadés, S. (2013). Glyconanotechnology. *Chemical Society Reviews, 42*(10), 4358–4376.
19. Tresset, G. (2009). The multiple faces of self-assembled lipidic systems. *PMC Biophysics, 2*(1), 1–25.
20. Gordillo-Galeano, A., & Mora-Huertas, C. E. (2018). Solid lipid nanoparticles and nanostructured lipid carriers: A review emphasizing on particle structure and drug release. *European Journal of Pharmaceutics and Biopharmaceutics, 133*, 285–308.

E-resource

https://nptel.ac.in/courses/118/106/118106019

	Description of CO	PO	PSO1	PSO2
CO1	Explain cellular nanostructures and their functions.	PO1(3), PO2(2)	3	2
CO2	Describe DNA-based nanostructures and uses.	PO1 (3), PO2(2), PO4(2)	2	1
CO3	Explain protein and enzyme nanoparticle design and applications.	PO1 (3), PO2(2), PO4(2)	2	3
CO4	Recognize biomolecule-derived nanoparticles and their roles.	PO1 (3), PO2(2), PO4(2)	2	2

NT25105	**Computation and Simulation Laboratory**	L	T	P	C
		0	0	4	2

Course Objective:

- To introduce the fundamentals of research design and methodology, data collection and analysis techniques
- To provide a comprehensive understanding of intellectual property rights and patents.

List of Experiments:

1. Numerical programme to plot the first four Eigen functions of a one - dimensional rectangular potential well with infinite potential barrier.
2. Numerical solution of the Schrodinger wave equation for a rectangular potential well with infinite potential barrier using numerical programme.
3. Toy model in molecular electronics: IV characteristics of a single level molecule
4. To determine the lattice constant and lattice angles for atomically resolved STM image of HOPG (Highly Oriented Pyrolytic Graphite using offline Scanning Probe Imaging Processor (SPIP) Software.
5. To determine the surface roughness of raw and processed AFM images of glass, silicon and films made by different methods using offline SPIP software.
6. Simulation of I-V Characteristics for a single Junction circuit with a single quantum Dot using MOSES 1.2 Simulator.
7. Study of Single Electron Transistor using MOSES1.2 Simulator.
8. Simple Mathematical Operation, Basic Command in MATLAB, 2D lot, 3D plot, curve fitting interpolation, Simulink, introduction, physics with Simulink
9. Equations modelling for circular motion, circular motion in Simulink, electronics in Simulink, introduction to logic gates, logical gates in Simulink

Weightage: Continuous Assessment: 60%, End Semester Examinations: 40%

Assessment Methodology: Project (30%), Assignment (10%), Practical (30%), Internal Examinations (30%)

Equipment Required:
Glassware for reactions and spot tests, Ostwald/Ubbelohde viscometer,

	Description of CO	PO	PSO1	PSO2
CO1	Apply numerical methods to solve quantum and nanoscale device problems.	PO1(3), PO2(2)	3	2
CO2	Analyze nanoscale data using microscopy and simulation software.	PO1 (3), PO2(2), PO4(2)	2	1
CO3	Utilize MATLAB and SPIP software for analysis of atomic-scale structures and surface properties.	PO1(3), PO2(2)	1	1

NT25106	Nanomaterial Synthesis Laboratory	L	T	P	C
		0	0	4	2

Course Objectives:

- Experiment various nanomaterial synthesis techniques and characterize the materials by different instrumental analysis methods.

List of Experiments

1. Chemical synthesis of Ag nanoparticles; UV-Visible absorption of the colloidal sol; Mie formalism; Estimation of size by curve fitting
2. Chemical synthesis of CdS nanoparticles; Optical absorption spectra; Band gap Estimation
3. Microwave assisted polymerization synthesis of ZnO nanowires
4. Sol gel synthesis of metal oxide (ZnO,TiO_2,CdO) nanoparticles:
5. Sol-gel spin coating route to SnO_2 nano thin films: surface roughness measurement by AFM
6. Electro spraying route to carbon nanofibers: surface morphology by SEM
7. Hydrothermal synthesis of ZnS Nano rods: Nano rods formation by SEM analysis
8. Mechanical ball milling technique to oxide ceramics preparation: crystallite size measurement by XRD.

Weightage: Continuous Assessment: 60%, End Semester Examinations: 40%

Assessment Methodology: Project (30%), Assignment (10%), Practical (30%), Internal Examinations (30%)

	Description of CO	PO	PSO1	PSO2
CO1	Demonstrate the synthesis of metal and metal oxide nanoparticles using diverse chemical and physical methods.	PO1(3), PO2(2)	3	2
CO2	Apply various analytical techniques like UV-Vis spectroscopy, SEM, AFM, and XRD for nanoparticle characterization.	PO1(3), PO2(2), PO4(2)	2	2
CO3	Interpret optical and structural properties of nanomaterials to assess their size, morphology, and band gap.	PO1(3), PO2(2), PO4(2)	1	2

NT25201	Imaging Techniques for Nanotechnology	L	T	P	C
		3	0	0	3

Course Objective:

- To introduce the student to the most important aspects of optical Microscopic techniques
- To provide a comprehensive understanding of Electron Microscopy Techniques for NanoTechnology
- To provide a comprehensive understanding of Atomic force Microscopic Techniques
- To provide a comprehensive understanding and application of quantum mechanical concepts for imaging of Nanomaterials

Concepts of Optical Microscopy- resolution limit, depth of field/focus in optial microscope, imaging, types of aberrations, Optical microscopy (OM) — reflected/transmitted light microscopy, numerical aperture, principles of image formation, dark field, polarized light and phase contrast microscopy and applications of each in metallurgical and materials engineering, sample preparation for optical microscopy and limitations.

Electron Microscopy: Advantages/disadvantages as Comparison of OM and electron Microscope, deBroglie wave particle duality, types of electron gun, SEM, its working and construction, concept of magnification as applied to SEM, electron-matter interaction, imaging modes - atomic number and topological contrast, accelerating voltage on SEM imaging, detectors, chemical analysis of phases using SEM (EDS). Principles of transmission electron microscopy - Modes of operation — construction, ray-diagram, working, sample preparation — contrast mechanisms (mass-thickness, phase and diffraction contrast), imaging modes, Diffraction in imperfect crystals – HRTEM use in nanostructures.

Atomic Force Microscopy: Basic concepts-Interaction force-AFM and the optical lever- AFM tip on nanometer scale structures- force curves, measurements and manipulations-feedback control-different modes of operation –contact, non-contact and tapping mode-Imaging and manipulation of samples in air or liquid environments-Imaging soft samples. Scanning Force Microscopy-types -Magnetic Force microscopy

Scanning Tunneling Microscopy: Principle of Particle in a box Principle-applications: STM Instrumentation- importance of STM for surface and molecular manipulation, 3D map of electronic structure.

Course Outcome:

Upon completion of the course, the students will be able to

CO1: Understand fundamental principles types optical microscope and its application
CO2:Understand the electron specimen interaction mechanisms, electron Microscopy techniques and applications
CO3:Understand the essentials of van der Waals forces in studying the 3D images of nanostructures
CO4: Understand the concepts of tunneling Microscope and its application

Assessment Weightage:
Ass 1: 20% (theory 15%+ activity 5%); Ass 2: 20% (theory 15%+ activity 5%)

References:

1. J. Goldstein, D. Newbury, D. Joy, C. Lyman, P. Echlin, E. Lifshin, L. Sawyer and J.Michael, "Scanning Electron Microscopy and X-ray Microanalysis" 3rd Edition, Springer Science, Berlin 2003.
2. Ray Egerton: "Physical Principles of Electron Microscopy" Springer Science, Berlin, 2005.
3. D. Brandon and W. Kaplan: "Microstructural Characterization of Materials", John Wiley and Sons, London, 2008.
4. Douglas B. Murphy : "Fundamentals Of Light Microscopy And Electronic Imaging", John Wiley and Sons, London, 2001

Course Outcome	Statement	Program Outcome					
		PO1	PO2	PO3	PO4	PO5	PO6
CO1	Understand fundamental principles types optical microscope and its application	3	3	2	3		
CO2	Understand the electron specimen interaction mechanisms, electron Microscopy techniques and applications	3	3	2	3		
CO3	Understand the essentials of van der Waals forces in studying the 3D images of nanostructures	2				3	3
CO4	Understand the concepts of tunneling Microscope and its application	2				3	3
Overall CO		3	3	2	3	3	3

NT25202	Physicochemical Characterization of Nanomaterials	L	T	P	C
		3	0	0	3

Course Objective:

- To make students to learn advanced analytical methods to study the nanomaterials.
- To help them gain knowledge about qualitative and quantitative analysis techniques
- employed for studying nanomaterials.
- To understand the mechanical analytical techniques used to study nanomaterials.

Spectroscopic and Diffraction Methods:
Introduction to Molecular Spectroscopy and Differences with Atomic Spectroscopy-Infrared (IR) Spectroscopy and Applications- Microwave Spectroscopy- Raman Spectroscopy and CARS Applications-Electron Spin Resonance Spectroscopy- NMR Spectroscopy- X-ray powder diffraction – single crystal diffraction techniques - Determination of accurate lattice parameters - structure analysis -profile analysis - particle size analysis using Scherer formula - Electron and neutron diffractions.

Thermal Analysis Methods:
Principle and Instrumentation of Thermogravimetry, Differential Thermal Analysis and Differential scanning calorimetry-Importance of thermal analysis for nanostructures.

Qualitative and quantitative analysis:
Electron Energy Loss Spectroscopy; High Resolution Imaging Techniques, Atom probe field ion microscopy-X-Ray Photoelectron Spectroscopy - X-ray fluorescence (XRF) -EDAX and WDA analysis – EPMA – ZAP corrections.

Nanomechanical analysis:
Nanoindentation principles- elastic and plastic deformation -mechanical properties of materials in small dimensions- models for interpretation of nanoindentation load displacement curves-Nanoindentation data analysis methods-Hardness testing of thin films and coatings- BET analysis.

Course Outcomes:

Upon completion of this course,
CO1: Students will get knowledge on advanced analytical techniques for nanomaterials
CO2: They will gain knowledge about qualitative and quantitative analysis techniques employed for studying nanomaterials
CO3: Understand the mechanical analytical techniques used to study nanomaterials

Assessment Weightage:

Ass 1: 20% (theory 15%+ activity 5%); Ass 2: 20% (theory 15%+ activity 5%)

References:

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, 1996.
4. B.W.Mott, "Micro-Indentation Hardness Testing", Butterworths, London, 1956

COURSE ARTICULATION MATRIX:

Course Outcomes	Statement	Program Outcome					
		PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	Students will learn about advanced analytical methods to study the nanomaterials.	3	3		3		
CO2	Students will learn about qualitative and quantitative analysis techniques employed for studying nanomaterials.	3	3		3		
CO3	Understand the mechanical analytical techniques used to study nanomaterials	3	3		3		
Overall CO		3	3		3		

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

NT25203	Synthesis of Nanomaterials	L	T	P	C
		3	0	0	3

Course Objective:

- To explore the basic concepts and ideas involved in the synthesis of nanomaterials via physical approaches and to implement different strategies for synthesizing 0, 1D, 2D nanomaterials.
- To explore the basic concepts and ideas involved in the synthesis of nanomaterials via chemical approaches and to implement different strategies for synthesizing 0, 1D, 2D nanomaterials.
- To explore the basic concepts and ideas involved in the synthesis of Nanoporous Materials for multifunctional applications
- To explore the role and application of nanomaterials in various fields.

Physical Approaches: Introduction to synthesis of nanostructure materials, bottom-up approach and top-down approach– process variables in milling, Mechanism of alloying, Mechanochemical processing - Inert gas condensation technique – arc plasma and laser ablation, Vapor deposition and different types of epitaxial growth techniques (CVD, MOCVD, MBE, ALD)- pulsed laser deposition, Sputtering- Magnetron sputtering - Lithography: Photo/UV/EB/FIB techniques, Dip pen nanolithography, Etching process : Dry and Wet etching, micro contact printing.

Chemical Approaches: Sol gel method, Solvothermal and hydrothermal routes, precipitation, Spray pyrolysis, Electro spraying and spin coating routes, Self-assembled monolayers (SAMs), Langmuir-Blodgett (LB) films, micro emulsion polymerization- Template based synthesis of nanomaterials- Electrochemical deposition, Electrophoretic deposition

Nanoporous Materials: Zeolites and Mesoporous materials - Synthesis, properties and applications, Role of nanomaterials and nanomembranes in water purification - Carbon nanotubes and graphene - Core shell nanostructures and hybrid nanocomposites.

Application Of Nanomaterials: Overview of nanomaterials properties and their applications, nanopaints, nano coating, nanomaterials for renewable energy, Nanoelectronics – Nanobots- Biological Applications.

Course Outcomes:

Upon completion of this course, the student would

CO1: Gain knowledge on the physical approaches on synthesis of nanostructured materials.

CO2: Gain knowledge on the chemical approaches on synthesis of nanostructured materials.

CO3: acquire knowledge about various kind of nanoporous materials and its synthesis methods.

CO4: Gain clear knowledge on the application and implementation of nanomaterials to solve the societal problems

Assessment Weightage:

Ass 1: 20% (theory 15%+ activity 5%); Ass 2: 20% (theory 15%+ activity 5%)

References:

1. Guozhong Cao, Nanostructures and Nanomaterials: Synthesis, Properties and Applications, Imperial College Press, London 2004.
2. T. Pradeep, Nano: The Essentials Understanding nanoscience and nanotechnology, Tata Mc GrawHill Publishing Company Limited NEW DELHI, 2007.
3. A S Edelstein and R C Cammarata, Nanomaterials Synthesis, Properties and Applications, IOP Publishing Ltd 1996.
4. Frank J. Owens and Charles P.Poole, The Physics and Chemistry of Nano Solids, Wiley-Interscience, 2008

5. Mechanical Alloying and Milling C. Suryanarayana
6. Chapter 9 :Nanocapsule formation by electrospraying from book Nanoencapsulation Technologies for the Food and Nutraceutical Industries
7. Nanoemulsions: formation, properties and applications Ankur Gupta, H. Burak Eral, T. Alan Hattona and Patrick S. Doyle Cite this: DOI: 10.1039/c5sm02958a
8. The evolution of 'sol–gel' chemistry as a technique for materials synthesis. A. E. Danks,a S. R. Hallb and Z. Schnepp. ***Mater. Horiz.,*** 2016, 3, 91, www.rsc.li/materials-horizons
9. 3rd International Conference on Materials Processing and Characterisation (ICMPC 2014) Carbon Nanotubes and Their Growth Methods Rajesh Purohit, Kuldeep Purohit, Saraswati Rana, R. S. Rana and Vivek Patel
10. Arc discharge synthesis of carbon nanotubes: Comprehensive review Neha Arora , N.N. Sharma, Diamond & Related Materials 50 (2014) 135–150
11. Review Vertically Aligned Carbon Nanotube Membranes: Water Purification and Beyond, Jeong Hoon Lee , Han-Shin Kim, Eun-Tae Yun , So-Young Ham, Jeong-Hoon Park , Chang Hoon Ahn, Sang Hyup Lee and Hee-Deung Park, Membranes 2020, 10, 273; doi:10.3390/membranes10100273
12. A Review: Fundamental Aspects of Silicate Mesoporous Materials, Zeid A. ALOthman, Materials 2012, 5, 2874-2902; doi:10.3390/ma5122874
13. Recent Advances in Nanoparticle Preparation by Spray and Microemulsion Methods, Recent Patents on Nanotechnology 2009, 3, 99-115
14. A compound of ZnO/PDMS with photocatalytic, self-cleaning and antibacterial properties prepared via two-step method, Applied Surface Science 550 (2021) 149286

Course Articulation Matrix

Course Outcomes	Statement	Program Outcome					
		PO1	PO2	PO3	PO4	PO5	PO6
CO1	Gain knowledge on the physical approaches on synthesis of nanostructured materials.	3	3				3
CO2	Gain knowledge on the chemical approaches on synthesis of nanostructured materials.	3	3				3
CO3	acquire knowledge about various kind of nanoporous materials and its synthesis methods.	3	3				3
CO4	Gain clear knowledge on the application and implementation of nanomaterials to solve the societal problems	3	3				3

NT25204 Materials Structural Characterization Laboratory L T P C
0 0 4 2

Course Objectives

- To learn imaging techniques to study structural morphology of nanomaterials.
- To analysis the crystal structure and interpretation via XRD analysis

1. Determination of size and lateral dimensions of various samples (pollen grains, strands of hair) using a high magnification optical microscope.
2. SEM analysis of powder, thin films, porous materials
3. SEM interpretation of powder, thin films, porous materials
4. Surface topography analysis using AFM : powder, thin films, porous materials
5. Surface topography interpretation of powder, thin films
6. XRD analysis of powder sample.
7. XRD interpretation of powder samples: Determination of lattice parameters and crystallite size.

Course Outcomes:

CO1: Will get experience in analysing the microstructure of various samples using OM

CO2: Able to interpret SEM and AFM images

CO3: XRD interpretations of Nanopowders are gained and crystallanity can be analysed

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcome					
		PO1	PO2	PO3	PO4	PO5	PO6
CO1	Will get experience in analyzing the nanomaterials		3		3	3	
CO2	Able to interpret SEM and AFM images		3		3	3	
CO3	XRD interpretations of Nanopowders are gained and crystallinity can be analysed		3		3	3	
Overall CO			3		3	3	

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

NT25205	**Physicochemical Characterization Laboratory**	L	T	P	C
		0	0	4	2

Course Objective:

- To learn spectroscopic analysis and interpretation of Nanostructures.
- To learn about the thermal analysis and interpretation for nanomaterials.
- To fabricate the DSSC, supercapacitor and analyse the performance analysis

1. FTIR analysis of Nanostructures
2. FTIR interpretation of results
3. RAMAN Analysis of Nanostructures
4. RAMAN interpretation of results
5. TGA analysis of nanomaterials
6. TGA interpretation of results
7. DSC analysis of nanomaterials
8. DSC interpretation of results
9. UV-vis analysis of nanomaterials
10. UV-vis interpretation of nanomaterials
11. Preparation of CdS quantum dots loaded photoanode, fabrication of Quantum dot sensitized solar cells and performance analysis of the cell.
12. Preparation of GO and rGO, fabrication of an EDLC based electrode materials and electrochemical performance analysis of the electrode.

Course Outcomes:

Upon completion of this course,

CO1: Students can able to analyse and interpret various spectroscopic techniques
CO2: Optical properties of QDs and graphene based materials can be analysed
CO3: Students can able to characterize the fabricated device and interpret the results.

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcome					
		PO1	PO2	PO3	PO4	PO5	PO6
CO1	Students can able to analyze and interpret various spectroscopic techniques.		3		3	3	
CO2	Students will analyse about the Optical properties of QDs and graphene based materials.		3		3	3	
CO3	Students can able to characterize the fabricated device and interpret the results.		3		3	3	
Overall CO			3		3	3	

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

NT25001	Lithography and Nanofabrication	L	T	P	C
		3	0	0	3

Course Objectives

- To learn lithographic techniques.
- To obtain knowledge on nanofabrication of devices using lithography.

Semiconductor Processing and Microfabrication

Introduction to semiconductor device processing - Necessity and different types of clean rooms-construction and maintenance of a clean room — Microfabrication process flow diagram — Chip cleaning, coating of photoresists, patterning, etching, inspection — Process integration - Etching techniques- Reactive Ion etching- RIE reactive ion etching- Magnetically enhanced RIE- IBE Ion beam etching.

Photolithography and Patterning of Thin Films

Lithography -Optical lithography - different modes - Optical projection lithography - Multistage scanners — resolution and limits of photolithography — Resolution enhancement techniques - Photomask- Binary mask- Phase shift mask - Attenuated phase shift masks - alternating phase shift masks - Off axis illumination- Optical proximity correction - Sub resolution assist feature enhancement-Optical immersion lithography

Direct Writing Methods-Imprint and Maskless Optical Lithography

Maskless optical projection lithography — types, Advantages and Limitations — required components - Zone plate array lithography - Extreme ultraviolet lithography — Light sources - Optics and materials issues- Nanoimprint lithography (NIL)- NIL - hot embossing - UV-NIL- Soft Lithography- Moulding/Replica moulding:

Eb, X-Ray And Ion Beam And Soft Lithography

Scanning electron-beam lithography- Electron sources, and electron optics system mask less EBL-parallel direct-write e-beam systems-electron beam projection lithography - Scattering with angular limitation projection e-beam lithography— Projection reduction exposure with variable axis immersion lenses-Ion beam lithography- Focusing ion beam lithography - Ion projection lithography-PDMS stamps - Printing with soft stamps- Edge lithography - Dip-Pen Lithography-set up and working principle — Self-assembly — LB films — Rapid prototyping.

Course Outcomes

CO1: Will realize the importance of miniaturization and nanofabrications
CO2: Will learn about various types of lithographic techniques
CO3: The students will able to understand the merits and de-merits of each lithographic techniques used for nanofabrication

Assessment Weightage:

Ass 1: 20% (theory 15%+ activity 5%); Ass 2: 20% (theory 15%+ activity 5%)

References:

1. Chris Mack, Fundamental Principles of Optical Lithography: The Scienceof Microfabrication, Wiley, 2008.
2. D. S. Dhaliwal et al., PREVAIL –“Electron projection technology approach for next generation lithography”, IBM Journal Res. & Dev. 45, 615 (2001).
3. M. Baker et al., “Lithographic pattern formation via metastable state rare gas atomic beams”, Nanotechnology 15, 1356 (2004).
4. H. Schift et al., “Fabrication of polymer photonic crystals using nanoimprint lithography”, Nanotechnology 16, 261, (2005).
5. R.D. Piner, “Dip-Pen” Nanolithography, Science 283, 661 (1999).

Course Outcomes	Statement	Program Outcome					
		PO1	PO2	PO3	PO4	PO5	PO6
CO1	Will realize the importance of miniaturization and nanofabrications	3	3	2	3		
CO2	Will learn about various types of lithographic techniques	3	3	2	3		
CO3	The students will able to understand the merits and de- merits ofeach lithographic techniques used for nanofabrication	3	3	2	3		
Overall CO		3	3	2	3		

NT25002	Nanocomposite Materials	L	T	P	C
		3	0	0	3

Course Objective:

- To learn about Fundamentals aspects of nanocomposites and explore the fabrication technologies of nanocomposites.
- To elucidate on advantages of nanotechnology-based applications in each industry.

Ceramic Based Hybrid Nanocomposites

Nomenclature, Properties, features, and processing of ceramic nanocomposites. Designing, stability and mechanical properties of ceramic nanocomposites, applications of super hard nanocomposites. Natural nanocomposite systems - spider silk, bones, shells; organic-inorganic nanocomposite formation through self-assembly. Biomimetic synthesis of nanocomposites material; Use of synthetic nanocomposites for bone, teeth replacement.

Metal Based Nanocomposites

Metal-metal nanocomposites, some simple preparation techniques, and their properties. Metal-Oxide or Metal-Ceramic composites, Different aspects of their preparation techniques and their final properties and functionality.

Polymer Based Nanocomposites

Preparation, characterization and thermodynamical aspects of formation of diblock Copolymer based nanocomposites, applications; Polymer Carbon nanotubes-based composites, their mechanical properties, and industrial possibilities.

Nanocomposite Technology

Nanocomposite membrane structures- Preparation and applications. Nanotechnology in Textiles and Cosmetics-Nano-fillers embedded polypropylene fibers – Soil repellence, Lotus effect - Nano finishing in textiles (UV resistant, anti-bacterial, hydrophilic, self-cleaning, flame retardant finishes), Sun-screen dispersions for UV protection using titanium oxide – Colour cosmetics. Nanotechnology in Food Technology - Nanopackaging for enhanced shelf life - Smart/Intelligent packaging.

Course Outcomes

Upon completion of this course, the student shall be able to

CO1: Gain fundamental aspects and fabrication technologies of Ceramic based hybrid nanocomposites and biomimetic ceramic hybrid Nanocomposites

CO2: Gain knowledge about processing of metal-based nanocomposites and its industrial application

CO3: Gain knowledge about processing of polymer-based nanocomposites and its application

CO4 : Design, build nanocomposite materials for engineering applications

Assessment Weightage:

Ass 1: 20% (theory 15%+ activity 5%); Ass 2: 20% (theory 15%+ activity 5%)

References:

1. Introduction to Nanocomposite Materials. Properties, Processing, Characterization-Thomas E. Twardowski. 2007. DEStech Publications. USA.
2. Nanocomposites Science and Technology - P. M. Ajayan, L.S. Schadler, P. V.Braun 2006.
3. Physical Properties of Carbon Nanotubes- R. Saito 1998.
4. Carbon Nanotubes (Carbon , Vol 33) - M. Endo, S. Iijima, M.S. Dresselhaus 1997.
5. The search for novel, superhard materials- Stan Vepr¡ek (Review Article) JVST A, 1999
6. Nanometer versus micrometer-sized particles-Christian Brosseau, Jamal BeN Youssef, Philippe Talbot, Anne-Marie Konn, (Review Article) J. Appl. Phys, Vol 93, 2003
7. Diblock Copolymer, - Aviram (Review Article), Nature, 2002
8. Bikramjit Basu, Kantesh Balani Advanced Structural Ceramics, A John Wiley & Sons, Inc.,
9. P. Brown and K. Stevens, Nanofibers and Nanotechnology in Textiles, Woodhead publication, London, 2006
10. The Fundamentals of Hard and Superhard Nanocomposites and Heterostructures Chapter · June 2010 DOI: 10.1201/b11764-2

Course Outcomes	Statement	Program Outcome					
		PO1	PO2	PO3	PO4	PO5	PO6
CO1	Gain fundamental aspects and fabrication technologies of Ceramic based hybrid nanocomposites and biomimetic ceramic hybrid Nanocomposites	3	3	2	3		
CO2	Gain knowledge about processing of metal-based nanocomposites and its industrial application	3	3	2	3		
CO3	Gain knowledge about processing of polymer-based nanocomposites and its application	2				3	3
CO4	Design, build nanocomposite materials for engineering applications	2				3	3
	Overall CO	3	3	2	3	3	3

NT25003	Nanoelectronics and Sensors	L	T	P	C
		3	0	0	3

Course Objective:

- To learn about overview of nanoelectronics.
- To study the basic components of electronic systems.
- To learn about sensor fabrication and applications.

Overview of Nano-Electronics:

Nano-scale electronics; Foundation of nano-electronics –New Ohm's law, low dimension transport, quantum confinement, Coulomb blockade and quantum dot; Ballistic transport and Quantum interferences; Landauer formula, quantization of conductance, example of Quantum point contact.

Two-Terminal junction transistors and gate:

Basic CMOS process flow; MOS scaling theory; Issues in scaling MOS transistors; Requirements for non-classical MOS transistor; PMOS versus NMOS; Design and construction of MOS capacitor-MOS transistor and capacitor characteristics-Metal gate transistors – motivation, basics and requirements; quantum transport in nanoMOSFET;
Ultrathin body silicon on insulator (SOI) – double gate transistors- surround gate FET; compound semiconductor MOSFET –Hetero-structures MOSFET.

sensors and actuators

Basic types and working principles of sensors and actuators; Characteristic features: Range, Resolution, Sensitivity, Error, Repeatability, Linearity and Accuracy, Impedance, Nonlinearities, Static and Coulomb Friction, Eccentricity, Backlash, Saturation, Deadband, System Response, First Order System Response, Under-damped Second Order System Response, Frequency Response.

Memory Devices:

Nano ferroelectrics – Ferroelectric random-access memory –Fe-RAM circuit design – ferroelectric thin film properties and integration – calorimetric -sensors – electrochemical cells – surface and bulk acoustic devices – gas sensitive FETs – resistive semiconductor gas sensors –electronic noses – identification of hazardous solvents and gases – semiconductor sensor array.

Course Outcomes:

Upon completion of this course,

CO1: Students will gain knowledge in basics of nanoelctronics.
CO2: Students will gather idea about materials and techniques used for sensor components.
CO3: Students will acquire information about fabrication of different sensors.

Assessment Weightage:

Ass 1: 20% (theory 15%+ activity 5%); Ass 2: 20% (theory 15%+ activity 5%)

References:

1. W. Ranier, "Nano Electronics and Information Technology", Wiley, (2003).
2. K.E. Drexler, "Nano systems", Wiley, (1992).
3. M.C. Petty, "Introduction to Molecular Electronics"1995.
4. Vladimir V. Mitin, Vieatcheslov A. Kochelap, Micheal A. Stroscio, Introduction to Nanoelectronics, Cambridge University Press, London, 2008.
5. Vinod Kumar Khanna, Nanosensors:Physical, Chemical and Biological, CRC Press, London,2014.

1. Supriyo Datta, Lessons from Nanoelectronics, World Scientific, Hong Kong, 2012
2. https://doi.org/10.1142/9789814335300_0001(https://www.worldscientific.com/series)

Course Outcomes	Statement	Program Outcome					
		PO1	PO2	PO3	PO4	PO5	PO6
CO1	Students will gain knowledge in basics of nanoelctronics.	3	3	2	3		
CO2	Students will gather idea about materials and techniques used for sensor components.	3	3	2	3		
CO3	Students will acquire information about fabrication of different sensors.	3	3	2			
Overall CO		3	3	2	3		

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

NT25004	Nanotechnology In Tissue Engineering	L	T	P	C
		3	0	0	3

Course Objective:

- To learn about nanomaterials for tissue engineering
- To study about various types of nanobiomaterials
- To learn about recent development and application of tissue engineering

Nanomedicine And Tissue Engineering: Relationship of Nanomedicine and Tissue Engineering, Nano drug Delivery Systems for Tissue Regeneration,
Synthesis of polymeric nano materials for tissue engineering, Chitosan as Biomaterial for Tissue Engineering, Skeletal Tissue Engineering, Nanotechnology Approaches to Regenerative Engineering.

Nanofiber Technologies For Regenerative Medicine: Introduction, History of Electrospinning, Experimental Setup and Basic Principle, Effects of Parameters on Electrospinning, Biomedical Applications of Electrospun Nanofibers ,Cancer Detection and Diagnosis, Pharmaceutical Nanotechnology; Structural and Functional Requirements for Musculoskeletal Tissues, Nanofibers as 3D Scaffolds for Tissue Regeneration, Extracellular Matrix Analogs for Cartilage Regeneration, Bioactive Nanofibers and Methods of Immobilizing Biomolecules, Gene Delivery Through Nanofibers, Techniques to Improve Porosity and Cell Infiltration on Nanofiber Scaffolds, Nanofiber Scaffolds for Interface Regeneration

Regeneration Of Sensory System: Biomaterials and Nanotechnology for Tissue Engineering: Neural Regeneration, Tissue Engineering Therapies for Ocular Regeneration, Bioartificial Pancreas, Progress in Tissue Engineering Approaches toward Hepatic Diseases Therapeutics Additive Manufacturing-Based Tissue Engineering, Laser-Assisted Bioprinting for Tissue Engineering, Translational Aspects of Tissue Engineering, Tissue-Engineered Medical Products

Dermal Tissue Engineering: Current Trends: Introduction, Nanotopography-Guided Skin Tissue Engineering, Stem Cells for Skin Tissue Engineering, Scarless Foetal Skin Wound Healing, Preparation of Self-Assembled Hydrogels, Hydrogels Characteristics for Cells, Self-Assembled Hydrogels, Significance of Natural and Synthetic Polymer for Hydrogels, Recent Development of Self-Assembled Hydrogel, Future of Nanotechnology in Tissue Engineering

Course Outcomes:

Upon completion of this course, the student shall be able to

CO1: Students will acquire knowledge in basics of nanotechnology tissue engineering
CO1: Students will acquire knowledge of regeneration tissue engineering of sensory system
CO3: Students will gain information about recent trends in application of tissue engineering

Assessment Weightage:

Ass 1: 20% (theory 15%+ activity 5%); Ass 2: 20% (theory 15%+ activity 5%)

References:

1. By Swaminathan Sethuraman, Uma Maheswari Krishnan, Anuradha Subramanian, Biomaterials and Nanotechnology for Tissue Engineering, CRC Press Taylor & Francis,2020.
2. A,K. gaharwar, S.Sant, M.J. Hancock and S.A. Hacking, Nanomaterials in tissue engineering: Fabrication and applications, Woodhead Publishing, Oxford, 2013.
3. Sarah Afaq, Arshi Malik, Mohammed Tarique Application of Nanoparticles in Tissue Engineering springer verlag, Singapore, 2022,

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcome					
		PO1	PO2	PO3	PO4	PO5	PO6
CO1	Students will acquire knowledge in basics of nanotechnology tissue engineering	3	3		3		
CO2	Students will acquire knowledge of regeneration tissue engineering of sensory system	3	3		3		
CO3	Students will gain information about recent trends in application of tissue engineering	3	3		3		
	Overall CO	3	3		3		

NT25005	Nanotechnology In Agriculture and Food Industry	L	T	P	C
		3	0	0	3

Course Objective:

- To study the basic interaction of different molecules which are helpful in both food and agricultural activities
- To understand the importance of nanomaterials and devices in precision farming, advanced materials used in agriculture and food industries.

Nanotechnology In Crop Production: Fertilizer – types and mode of action; Nanofertilizer – nano urea ,nano DAP and nano micronutrient fertilizer- Nanomaterials as soil conditioners – zeolites, nanoclays, superabsorbent polymers, nanocomposites; antitranspirants; Nanosensors for monitoring soil moisture; Effect of nanoparticles in seed vaiability and storage – carbon based, TiO_2, aluminium, silver, copper, ZnO nanoparticles; Smart delivery systems for nanofertilizer release;

Nanotechnology In Pest Management: Introduction to pest management; nanomaterials for pest management; Nanoherbicide, nanopesticide and nanofungicide- its application, mode of action and evaluation; nanoparticles and mesoporous nano materials for smart delivery; Nanosensors for pest management; Assessment of efficacy and safety on nontarget organisms;.

Nanotechnology In Food Processing: Introduction and scope; Nanobased smart delivery system for nutraceuticals and its release mechanism; Nano cochleates – formulation methods and mechanism of release; Nanoclusters; Nanolaminates- properties, preparation, and application; Nanoemulsions – preparation and application; Nanoencapsulation technology- materials used, principle, release mechanism and advantages;

Nanotechnology In Food Packaging and Fate Of Nanoparticles: Nanocomposites; Nanostructured layers; Nanomaterials for food preservation; Nano bio active packaging for enhanced shelf life; Nanotechnology in intelligent packaging; Nanosensors for food safety monitoring. Nanoparticles – mode of action, bioaccumulation, and its interaction with biological systems; Fate of nanoparticles in the environment; Health hazards of nanomaterials in the workplace; Nanoethics, safe handling and precautionary protocol

COURSE OUTCOMES:

CO1: Student will learn the basic interaction of different molecules which are helpful in both food and agricultural activities
CO2: Understand the importance of Nanotechnology in pest management
CO3: Understand the importance of Nanotechnology in food processing
CO4: Students will understand the importance of Nanotechnology in Food Packaging and fate of Nanoparticles

Assessment Weightage:

Ass 1: 20% (theory 15%+ activity 5%); Ass 2: 20% (theory 15%+ activity 5%)

References:

1. C.R.Chinnamuthu, B. Chandrasekaran C. Ramasamy- Nanotechnology Applications in Agriculture, 2008.
2. S.Choudary, Applied Nanotechnology in Agriculture. Arise Publications.ISBN:978-93-80162-54-6, 2011
3. Jain, P., S.Arora and T.Rai,. - Flavour encapsulation and its application, Beverage and Food World 24 (4), 21-24, 1997
4. Günter Oberdörster, Eva Oberdörster, Jan Oberdörster. 2005. NANOTOXICOLOGY: An Emerging Discipline Evolving from Studies of Ultrafine Particles Environ Health Perspect. July; 113(7): 823–839
5. Nancy A.Monteiro-Reviere and C.Lang Tran, Nanotoxicology-Charachterization, Dosing and

Health Effects.Informa HealthCare, New York. 434p. 2009.
6. Monique A. V. Axelos (Editor), Marcel Van de Voorde (Editor), Nanotechnology in Agriculture and Food Science; ISBN: 978-3-527-69773-1; March 2017; 450p

Course Outcomes	Statement	Program Outcome					
		PO1	PO2	PO3	PO4	PO5	PO6
CO1	Student will learn the basic interaction of different molecules which are helpful in both food and agricultural activities	3	3	2	3		
CO2	Understand the importance of Nanotechnology in pest management	3	3	2	3		
CO3	Understand the importance of Nanotechnology in food processing	2				3	3
CO4	Students will understand the importance of Nanotechnology in Food Packaging and fate of Nanoparticles	2				3	3
	Overall CO	3	3	2	3	3	3

NT25006	Nanomaterials For Energy and Environment	L	T	P	C
		3	0	0	3

Course Objective:

- To be aware of the challenges and demand for Energy
- To study about the nanomaterials used in Energy applications
- To enhance our knowledge on the role of nanomaterials in remediation applications and its impact on the environment.

Renewable Energy Technology

Sustainable energy - Materials for energy – Greenhouse effect - CO_2 emission - Energy demand and challenges. Development and implementation of renewable energy technologies. Nano, micro and mesoscale 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.

Nanomaterials In Fuel Cell And Storage Technology

Micro-fuel cell technologies, integration and performance for micro-fuel cell systems - thin film and microfabrication methods - design methodologies - micro-fuel cell power sources - Supercapacitors - Specific energy- charging/discharging - EIS analysis.

Hydrogen Production, Storage And Photocatalysis

Hydrogen production – water electrolysis – photo dissociation – photocatalytic splitting of water 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.

Nanomaterials For Environmental Applications

Nanomaterials as adsorbents - Nanocomposite membrane systems for water remediation: Membrane fabrication; Membrane reactors & Active Membrane systems -Ecotoxicological impacts of nanomaterials - Lifecycle assessment of nanomaterials.

Course Outcomes:

CO1: Students will gain familiarity with renewable energy technologies updated with nano devices and different fabrication methodologies
CO2: Kinetic studies of dye degradation using nanophotocatalysts will be learned
CO3: Students get acquainted with the application of nanomaterials and its impacts in environmental systems

Assessment Weightage:
Ass 1: 20% (theory 15%+ activity 5%); Ass 2: 20% (theory 15%+ activity 5%)

References:

1. J. Twidell and T. Weir, Renewable Energy Resources, Taylor & Francis Group, 2014 (4th Edition).
2. Ram B.Gupta, Hydrogen Fuel,CRC Press, Taylor and Francis Group, New York, 2009
3. Gregor Hoogers, Fuel Cell Technology Hand Book, CRC Press, Taylor and Francis Group New York, 2003.
4. Hand Book of Fuel Cells: Fuel Cell Technology and Applications, Wolf Vielstich, Arnold Lamm, Hubert Andreas Gasteiger, Harumi Yokokawa, Wiley, London, 2003
5. Zhen Fang, Richard L Smith, Xinhua Qi, Production of Hydrogen from Renewable Resources, , Springer, London, 2016
6. Mark R. Wiesner, Jean-Yves Bottero, Environmental Nanotechnology: Applications and Impacts of Nanomaterials, McGraw Hill, New York, 2007.

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcome					
		PO1	PO2	PO3	PO4	PO5	PO6
CO1	Students will gain familiarity with renewable energy technologies updated with nano devices and different fabrication methodologies	3	3		3		
CO2	Kinetic studies of dye degradation using nanophotocatalysts will be learned	3	3		3		
CO3	Students get acquainted with the application of nanomaterials and its impacts in environmental systems	3	3		3		
	Overall CO	3	3		3		

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

NT25007	Nano Biophotonics	L	T	P	C
		3	0	0	3

Course Objective:

- To learn about Fundamentals of light and optics
- To study the concepts of optical based imaging techniques.
- To learn about recent development in optical sensors.

Basics of Light And Molecular Spectroscopy
Interaction of light with cells, tissues, non-linear optical processes with intense laser beams, photo-induced effects in biological systems- UV-VIS spectroscopy of biological systems, single molecule spectra and characteristics –IR and Raman spectroscopy and Surface Enhanced Raman Spectroscopy for single molecule applications.

Cellular Imaging Techniques Light microscopy, wide-field, laser scanning, confocal, multiphoton, fluorescence lifetime imaging, FRET imaging, Frequency-Domain lifetime imaging. Cellular Imaging, Imaging of soft and hard tissues and other biological structures.

Optical Force Spectroscopy Generation optical forces – Optical trapping and manipulation of single molecules and cells in optical confinement - Laser trapping and dissection for biological systems – single molecule biophysics, DNA protein interactions.

Sensors And Optical Techniques Biosensors, fluorescence immunoassay, flow cytometry, Fluorescence correlation spectroscopy, Fluorophores as cellular and molecular tags.

Course Outcomes:

Upon completion of this course, the student shall be able to

CO1: Students will gain knowledge in basics of light and molecular spectroscopy
CO2: Students will gather knowledge about Cellular Imaging Techniques
CO3: Students will gather knowledge about Optical tweezers and optical scissors
CO4: Students will acquire information about Biophotonics and advanced optical sensors

Assessment Weightage:

Ass 1: 20% (theory 15%+ activity 5%); Ass 2: 20% (theory 15%+ activity 5%)

References:

1. Laser Tweezers in Cell Biology in Methods in Cell Biology, Vol.55, Michael P.
2. Sheetz(Ed.), Academic Press 1997.
3. 2. P.N. Prasad, Introduction to Biophotonics, John-Wiley, 2003.
4. G. Marriot & I. Parker, Methods in Enzymology, Vol.360,2003.

Course Outcomes	Statement	Program Outcome					
		PO1	PO2	PO3	PO4	PO5	PO6
CO1	Students will gain knowledge in basics of light and molecular spectroscopy	3	3		3		
CO2	Students will gather knowledge about Cellular Imaging Techniques	3	3		3		
CO3	Students will gather knowledge about Optical tweezers and optical scissors	3	3		3		
CO4	Students will acquire information about Biophotonics and advanced optical sensors	3	3		3		
	Overall CO	3	3		3		

NT25008	Nano Biosensors	L	T	P	C
		3	0	0	3

Course Objective:

- To learn about principles, components and fabrication of biosensors
- To study about various types of biosensors
- To learn about recent development and application of biosensor.

Essentials of Biosensors: General principle, component, characteristics. Types- Calorimetric Biosensor, Potentiometric Biosensor, Amperometric Biosensor, Optical Biosensor, Piezo-electric Biosensor. Detection systems. Techniques used for microfabrication -microfabrication of electrodes-on chip analysis.

Protein Based Biosensors: Nano structure for enzyme stabilization – single enzyme nano particles – nano tubes microporus silica – protein based nano crystalline. Diamond thin film for processing.

DNA Based Biosensor: Heavy metal complexing with DNA and its determination, sensing in water and food samples – DNA zymo Biosensors.

Applications of Biosensors: Nanoscale biosensors. Nanobiosensors for cellular biosensing and sensing of rare cells. Detection of pathogens in food and water samples; Designed protein pores and protein cages -as components of biosensors. Biosensors for pharma and medicine, bioremediation, defense and food technology, wearable biosensor.

Course Outcomes:

Upon completion of this course, the student shall be able to

CO1: Students will acquire knowledge in basics of Biosensors
CO2: Students will gain idea about fabrication techniques of biosensors
CO3: Students will gain information about recent trends in nanobiosensors and application in various fields

Assessment Weightage:

Ass 1: 20% (theory 15%+ activity 5%); Ass 2: 20% (theory 15%+ activity 5%)

References:

1. J.Cooper, C.Tass Biosensors: A Practical Approach, Oxford Univ Press, 2004.
2. Cs. Kumar, Nanomaterials for Biosensors, Wiley – VCH, 2007.
3. G.K. Knoff, A.S. Bassi, Smart Biosensor Technology, CRC Press, 2006.

Course Outcomes	Statement	Program Outcome					
		PO1	PO2	PO3	PO4	PO5	PO6
CO1	Students will acquire knowledge in basics of Biosensors	3	3		3		
CO2	Students will gain idea about fabrication techniques of biosensors	3	3		3		
CO3	Students will gain information about recent trends in nanobiosensors and application in various fields	3	3		3		
Overall CO		3	3		3		

NT25009	Advanced Drug Delivery Systems	L	T	P	C
		3	0	0	3

Course Objective:

- To learn about Fundamentals of drug delivery systems
- To study the materials and techniques used in Delivery systems
- To learn about Recent development in the area of devices and therapy.

Theory of Advanced Drug Delivery: Fundamentals of Nanocarriers - Size, Surface, Magnetic and Optical Properties, Pharmacokinetics and Pharmacodynamics of Nano drug carriers. Critical Factors in drug delivery. Transport of Nanoparticles - In Vitro and Ex Vivo Models.

Polymers: Dendrimers- Synthesis -Nanoscale containers- Dendritic Nanoscaffold Systems-Biocompatibility of Dendrimers, Gene transfection. pH based targeted delivery- chitosan and alginate. Copolymers in targeted drug delivery- PCL, PLA, PLGA.

Nanocarriers: LIPID Based Nanocarriers -Liposomes, niosomes and solid lipid nanoparticles. Ligand based delivery by liposomes. Cubosomes; biomembranes based carrier systems, Microbes and Antibody Based Nanocarriers - Bacterial dependent delivery of vaccines. Drug delivery and subcellular targeting by virus, Drug packaging and drug loading. Delivery of therapeutics by antibodies and antibody bioconjugates.

Devices For Drug Delivery: Fabrication and Applications of Microneedles, Micropumps, microvalves. Implantable microchips.

Course Outcomes:

Upon completion of this course, the student shall be able to

CO1: Students will gain knowledge in basics of drug delivery systems
CO2: Students will gather idea about materials and techniques used for drug coating and delivery
CO3: Students will acquire information about recent trends equipments and delivery systems

Assessment Weightage:

Ass 1: 20% (theory 15%+ activity 5%); Ass 2: 20% (theory 15%+ activity 5%)

References:

1. M. Salzman Drug Delivery: Engineering Principles for Drug Therapy, Oxford University Press, 2001.
2. A.M. Hillery, Drug Delivery and Targeting, CRC Press, 2002.
3. B. Wang, Drug Delivery: Principles and Applications, Wiley Intersceince, 2005.
4. Ram B. Gupta, Uday B. Kompella , Nanoparticle Technology for Drug Delivery, Taylor& Francis, 2006.

Course Outcomes	Statement	Program Outcome					
		PO1	PO2	PO3	PO4	PO5	PO6
CO1	Students will gain knowledge in basics of drug delivery systems	3	3	2	3		
CO2	Students will gather idea about materials and techniques used for drug coating and delivery	3	3	2	3		
CO3	Students will acquire information about recent trends equipments and delivery systems	3	3	2	3		
Overall CO		3	3	2	3		

NT25010	Processing And Properties of Nanostructured Materials	L	T	P	C
		3	0	0	3

Course Objective:

- To learn basic material science with special emphasize on nanomaterials
- To know about processes in handling polymers and nanostructured materials.
- To understand various forms of nanomaterials and polymers for special applications.

Deformation processing and Metal Forming:
Classification of engineering materials - Tensile testing – Stress strain curve – Flow stress - Mechanical properties – Formability - Deformation processes - Mechanics of metal working – Metal forming - forging, rolling, extrusion, wire drawing – Superplastic forming – Bulk nanostructured materials by Severe Plastic Deformation (SPD) - Comparison of processes.

Microstructural Properties and Processing of Polymers:
Defects in solids – classifications of defects – Microstructure – grain size, grain boundary, effects of processing and defects – Processing, microstructure, properties correlations – Mechanical Properties and processing - grain size evolution and grain size control; Hall Petch relation - Engineering plastics – Pellets and sheets – Glass transition temperature of polymers –Melt flow index – Polymer processing tools and process conditions - injection moulding, thermoforming, vacuum and pressure assisted forming.

Processing of Powders of Metals and Ceramics:
Metal/Ceramic Powder synthesis - Selection and characterization of powders – compacting and sintering - Production of Porous and Dense Composite Components: Advanced composite materials - Metal- polymer- and ceramic- based composites and their properties – Fabrication of composite materials.

Processing of Functional Nanomaterials:
Properties of nanocrystalline materials required for structural, energy, environmental, textile and catalytic applications; processing techniques; techniques for retaining the nanocrystalline structure in service. Pervoskite structures, catalytic applications.

Course Outcomes:

Upon completion of this course, the student shall be able to

CO1: Acquire knowledge on the deformation and microstructural properties of the Nanomaterials
CO2: Gain knowledge about processes of polymers and nanostructured materials.
CO3: Understand the functional properties of nanomaterials and polymers for various applications.

Assessment Weightage:

Ass 1: 20% (theory 15%+ activity 5%); Ass 2: 20% (theory 15%+ activity 5%)

References:

1. H. Cottrell "The Mechanical Properties of Matter", John Wiley, New York, 1964.
2. R. Asthana, A. Kumar and N. Dahotre "Materials Science in Manufacturing" Butterworth Heinemann, Elsevier 2006.
3. G. E. Dieter, adapted by D Bacon, "Mechanical Metallurgy", McGraw Hill, Singapore, 1988.

4. K. A. Padmanabhan, “Mechanical Properties of Nanostructured Materials”, Materials Science and Engineering, A 304-306 (2001) 200-205.
5. H. Gleiter, “Nanocrystalline Materials”, Progress in Materials Science Vol. 33,
6. C. Koch, “Nanostructured Materials: Processing, Properties and Applications”, 2nd Edition, 2007.

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcome					
		PO1	PO2	PO3	PO4	PO5	PO6
CO1	Students will Acquire knowledge on the deformation and microstructural properties of the Nanomaterials	3	3		3		3
CO2	Students will Gain knowledge about processes of polymers and nanostructured materials.	3	3		3		3
CO3	Students will Understand the functional properties of nanomaterials and polymers for various applications.	3	3		3		3
Overall CO		3	3		3		3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

NT25011	MEMS AND NEMS	L	T	P	C
		3	0	0	3

Course objectives:

- To learn about Micro fabrication and scaling of MEMS
- To study the Microsystem and materials used in MEMS Technology
- To learn about Biological MEMS Technology

MEMS Microfabrication

Historical Development of Microelectronics, Evolution of Microsensors, Evolution of MEMS, Emergence of Micromachines, Modeling - Finite Element Analysis, CAD for MEMS, Fabrication — ALD, Lithography Micromachining, LIGA and Micromolding, Saw-IDT Microsensor Fabrication, Packaging — Challenges, Types, Materials and Processes.

Microsystems and Materials for MEMS

Microsensors, microaccelerometer, microfluids, Mechanics for Microsystems design-Thermomechanics, fracture mechanics, thin film mechanics, Microfluid mechanics-Materials for mems and pro mems-silicon-metals and polymers-Substrate Materials for MEMS- Silicon-quartz-ceramics-Bulk metallic glasses-Sharp Memory alloys, Carbon based MEMS

Scaling Issues In Mems and Evalution of NEMS

Introduction to Scaling Issues, Scaling effects on a cantilever beam, scaling of electrostatic actuators, scaling of thermal actuator. Influence of scaling on material properties. Atomic scale precision engineering- Nano Fabrication techniques – NEMS for sensors and actuators

Commercial and Technological Trends

Recent trends in MEMS and NEMS - Commercial trends in miniaturization — High density chip analysis-Micro-accelerometers micro- resonators-lab-in-chip for DNA and protein analysis – Nano HPLC system nanopatches.

Course Outcomes:

CO1: Students would gain knowledge in microfabrication techniques and scaling process

CO2: Would acquire knowledge about the Microsystem and materials used in MEMS Technology

CO3: Students would acquire information about recent trends in MEMS and BioMEMS techniques

Assessment Weightage:

Ass 1: 20% (theory 15%+ activity 5%); Ass 2: 20% (theory 15%+ activity 5%)

References:

1. Marc Madou, Fundamentals of Microfabrication, CRC Press 1997.
2. MEMS and Microsystems design and manufacture, Tai-Ran Hsu,Tata Mc Graw Hill2011.
3. Sergey Edward Lyshevski, Nano- and Microelectromechanical Systems, CRC Press2000.
4. Vijay Varadan, Xiaoning Jiang, and Vasundara Varadan, Microstereo lithography *and* other Fabrication Techniques for 3D MEMS*,* Wiley 2001.
5. Tai-Ran Hsu, MEMS and Microsystems: Design and Manufacture, McGraw-Hill 2001.
6. Ken Gilleo. MEMS/MOEMS Packaging: Concepts, Designs, Materials and Processes. McGraw-Hill, 2005.

Course Outcomes	Statement	PO1	PO2	PO3	PO4	PO5	PO6
CO1	Students would gain knowledge in microfabrication techniques and scaling process	3	1	3	–	2	–
CO2	Students would acquire knowledge about the microsystem and materials used in MEMS technology	2	1	3	–	2	–
CO3	Students would acquire information about recent trends in MEMS and BioMEMS techniques	2	2	3	–	1	–

NT25012	Semiconductor Nanostructures	L	T	P	C
		3	0	0	3

Course Objective:

- To gain knowledge about basic semiconductor metals & its characteristics
- To know the physical & quantum aspects of semiconductor.
- To obtain a basic idea about energizing material & its effects

Semiconductor fundamentals:
Introduction to Semiconductor physics – Band gap- Semiconducting Materials - Elemental-compound- Wide band gap semiconductors - Basic Concept of Nanoelectronics- New Perspectives- New Ohm's Law- Density of states- Fermi Function- Types of Conductance- Diffusive- Ballistic Conductance- Electron Tunneling- Coloumb blockade

Semiconductor nanostructures and their preparation techniques:
Types of Semiconductor Nanostructures- Quantum confinement. Quantum well- Nanowires- Quantum dots – - effect of strain on band-gap in epitaxial quantum dots, single particle conductance Fabrication techniques- electro-deposition, pyrolytic synthesis, self-assembly strategies-CVD- MBE approaches.

Semiconductor nanowires:
Nanowires of Si, Ge and SiGe and their properties- Application in Integrated Circuits- FETs-, Si NW FET-Ballistic Transport.

Optical applications of semiconductors:
Optical luminescence and fluorescence from direct band gap semiconductor nanoparticles, surface-trap passivation in core-shell nanoparticles, carrier injection, LED and solar cells, electroluminescence, barriers to nanoparticle lasers, doping nanoparticles, Mn-ZnSe phosphors, light emission from indirect semiconductors, light emission form Si nanodots.

Course Outcomes:

Upon completion of this course, the student shall be able to

CO1: Get an idea about basic and advanced concepts in semiconductors.

CO2: Acquire knowledge about the physical and quantum aspects of semiconductors.

CO3: Gain the ideas about the applications of semiconductor nanostructures.

Assessment Weightage:
Ass 1: 20% (theory 15%+ activity 5%); Ass 2: 20% (theory 15%+ activity 5%)

References:

1. Nanoelectronics lectures series- Supriyo Dutta- NanoHub
2. Encyclopedia of Nanoscience and Nanotechnology- Hari Singh Nalwa, 2004.
3. Springer Handbook of Nanotechnology - Bharat Bhusan, 2004.
4. Handbook of Semiconductor Nanostructures and Nanodevices Vol 1-5- A.A. Balandin, K. L. Wang 2006.
5. Nanostructures and Nanomaterials - Synthesis, Properties and Applications, Cao, Guozhong, 2011.

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcome					
		PO1	PO2	PO3	PO4	PO5	PO6
CO1	Students will get an idea about basic and advanced concepts in semicoductors.	3	3		3		
CO2	Students will Gain knowledge about processes of polymers and nanostructured materials.	3	3		3		
CO3	Students will gain the ideas about the applications of semiconductor nanostructures.	3	3		3		
Overall CO		3	3		3		

]1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

NT25013	Nanotoxicology	L	T	P	C
		3	0	0	3

Course Objective:

- To make students learn various concepts of toxicity, and its effects.
- To help them gain knowledge about the toxicity in Nanoscience, and their effects on Human.
- To enhance knowledge on the nanotoxicology - prevention and remedies.

Introduction To Toxicology: Concept of Toxicology-Types of toxicity based on route of entry, nature of the toxin. Toxicodynamics – Dose vs Toxicity Relationships. Toxico kinetics – ADME, LADMET hypothesis. Genotoxicity and carcinogenicity – Mechanisms and Tests. Organ toxicity – Respiratory, dermal, hepato, neuro and nephro.

Nanoparticles and biological interactions: Characteristics of Nanoparticles that determine Potential Toxicity. Bio-distribution of nanoparticles. Interation of Nanoparticles with Biomembrane and genes. Evaluation of Nanoparticle transfer using placental models. Nanomaterial toxicity – Pulmonary, dermal, hepato, neuro, ocular and nephro; Estimation of Nanoparticle Dose in Humans. In vitro toxicity studies of ultrafine diesel exhaust particles; Toxicity studies of carbon nanotubes.

Protocols In Toxicology Studies: Methods for toxicity assessment – Cyto, Geno, hepato, neuro, nephrotoxicity. Assessment of toxicokinetics. Assessment of oxidative stress and antioxidant status.

Safety Assessment And Regulatory Framework: Types, species and strains of animals used in toxicity studies. Dosing profile for animal models. Studies on toxicology, pathology and metabolism in mouse and rat. Laws and Regulations Governing Animal Care and Use in Research. Risk assessment of Nanoparticle exposure. Prevention and control of nanoparticles exposure. Regulation and recommendations.

Course Outcomes:

Upon completion of this course, the student shall be able to

CO1: Students will get knowledge on nanotoxicology and their effects on human and animals
CO2: They will acquire knowledge about various prevention methods
CO3: Gaining knowledge on the remedies for nanotoxicology

Assessment Weightage:
Ass 1: 20% (theory 15%+ activity 5%); Ass 2: 20% (theory 15%+ activity 5%)

References:

1. John H. Duffus, Howard G. J. Worth, 'Fundamental Toxicology', The Royal Society of Chemistry 2006.
2. Nancy A. Monteiro-Riviere, C. Lang Tran., 'Nanotoxicology: Characterization, Dosing and Health Effects',Informa Healthcare publishers, 2007.
3. Lucio G. Costa, Ernest Hodgson, David A. Lawrence, Donald J. Re
4. Shayne C. Gad, 'Animal models in toxicology', Taylor & Francis Group, LLC 2007.
5. P. Houdy, M. Lahmani, F. Marano, 'Nanoethics and Nanotoxicology', Springer-Verlag Berlin Heidelberg 2011.
6. A Reference handbook of nanotoxicology by M.Zafar Nyamadzi 2008.
7. Andreas Luch, 'Molecular, Clinical and Environmental, Toxicology

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcome					
		PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	Students will get knowledge on nanotoxicology and their effects on human and animals	3	3		3		
CO2	They will acquire knowledge about various prevention methods	3	3		3		
CO3	Gaining knowledge on the remedies for nanotoxicology	3	3		3		
Overall CO		3	3		3		

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

NT25014	Nanotechnology In Health Care	L	T	P	C
		3	0	0	3

Course Objective:

- To be introduced to recent advancements in nano medicine.
- To learn about nano diagnostics.
- To learn developments in nanostructured materials used for medical implants.

Nanobiotechnology and Nanoimmunodiagnostics: Biology of cultured cells. Stem Cell technology. Nanotechnology in gene therapy. PCR, ELISA, DNA Profiling and Blotting techniques-Nanoprobes. Nanoimmuno assay and nano-immuno sensors- Bio-Barcode Assay- use of magnets, gold, DNA and antibodies. Immunodiagnostics for cancer and central nervous system disorders.

Nanotechnology Based Medical Diagnostics: Improved diagnosis by in vivo imaging - detection of tumors, plaque and genetic defects. Nanobot medical devices. Cantilever Sensors.

Prosthetic And Medical Implants: Prosthesis and implants. neural, ocular, cochlear, dental implants. implants and prosthesis of skin, limb, bone. Artficial organ and Organ transplant. Nano fibre scaffold technology.

Biomedical Applications Of Nanotechnology: Nano-bioconjugates and their significance. Nanoscaffolds. Magnetic Nanoparticles. Multifunctional Inorganic and organic nanoparticles and their biomedical applications.

Course Outcomes:

Upon completion of this course, the student shall be able to

CO1: Comprehend the nanoparticles-based gene therapy, nanoprobing and profiling techniques and their application

CO2: Understand the use of metal nanoparticles and antibodies in diagnosis of biomarkers with high sensitivity

CO3: Be aware of the principle and uses of cantilever sensors and imaging of plaques and tumors

CO4: Completely understand the ocular, cochlear, dental implants and nanofiber technology

CO5: Have knowledge on functionalized nanoscaffolds, magnetic, organic and inorganic nanoparticles

Assessment Weightage:

Ass 1: 20% (theory 15%+ activity 5%); Ass 2: 20% (theory 15%+ activity 5%)

References:

1. Brian, R Eggins, Chemical Sensors and Biosensors; Wiley; New York, 2002.
2. L Gorton, Biosensors and modern biospecific analytical techniques, Wilson & Wilson’s Comprehensive Analytical Chemistry Elsevier, Amsterdam, London; 2005.
3. David Wild; The Immunoassay Handbook; 3rd ed.; Amsterdam: Elsevier; 2005.
4. Allen J Bard and Larry R Faulkner; Electrochemical Methods: Fundamentals and Applications; Wiley, New York, 2nd ed.; 2001.
5. Vladimir M. Mirsky, Ultrathin Electrochemical Chemo- and Biosensors: Technology and Performance in Springer Series on Chemical Sensors and Biosensors; Springer, Berlin; 2004

Course Articulation Matrix:

Course Outcomes	Statement	Program Outcome					
		PO1	PO2	PO3	PO4	PO5	PO6
CO1	Comprehend the nanoparticles-based gene therapy, nanoprobing and profiling techniques and their application	3	3		3		
CO2	Understand the use of metal nanoparticles and antibodies in diagnosis of biomarkers with high sensitivity	3	3		3		
CO3	Be aware of the principle and uses of cantilever sensors and imaging of plaques and tumors	3	3		3		
CO4	Completely understand the ocular, cochlear, dental implants and nanofiber technology						
CO5	Have knowledge on functionalized nanoscaffolds, magnetic, organic and inorganic nanoparticles						
Overall CO		3	3		3		

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

NT25015 **Entrepreneurship** L T P C
3 0 0 3

Objectives:

- To equip and develop the learners entrepreneurial skills and qualities essential to undertake business.

Fundamentals of Entrepreneurship and Entrepreneurial Ecosystem: The Entrepreneur – Definition – Characteristics of Successful entrepreneur. Entrepreneurial scene in India; MSME; Analysis of entrepreneurial growth in different communities – Case histories of successful entrepreneurs. Similarities and Distinguish between Entrepreneur and Intrapreneur, Case histories of successful technology and nano-based entrepreneurs (India and global).

Business Innovation, Technology Management and Intellectual Property: Types of Innovation – Creating and Identifying Opportunities for Innovation – innovation in science and nanotechnology domains - Design Thinking- The Technological Innovation Process – Creating New Technological Innovation and Intrapreneurship – Licensing – Patent Rights – Innovation in Indian Firms.

New Venture Creation: Identifying Opportunities for New Venture Creation: Environment Scanning – Idea generation techniques for high-tech products and services Creating, Shaping, Recognition, Seizing and Screening of Opportunities. Feasibility Analysis: Technical feasibility of nano-based products and processes – Marketing Feasibility: Marketing Methods – Pricing Policy and Distribution Channels.

Business Planning, Startup Models and Commercialization Strategies: Benefits of a Business Plan – Elements of the Business Plan – Developing a Business Plan – Guidelines for preparing investor-ready business plans: Structure, financial projections, and pitch decks - Start-ups and e-commerce Start-ups. Business Model Canvas: Application to nano-technology ventures, deep-tech startups, and research spin-offs.

Venture Financing and Institutional Support: Capital structure and working capital Management: Financial appraisal of new project - Cost analysis, break-even analysis, NPV, IRR, and risk assessment., Role of Banks – Credit appraisal by banks. Institutional Finance to Small Industries – Incentives – Institutional Arrangement and Encouragement of Entrepreneurship in India.

On completion of this course, students will;

1. Analyze entrepreneurial ecosystems, policies, and community-based growth patterns to assess opportunities for technology-driven ventures.
2. Evaluate innovation strategies, IP frameworks, and commercialization pathways relevant to nanoscience and advanced technology domains.
3. Design and create comprehensive business plans and business models for nano-technology and deep-tech startups.
4. Develop entrepreneurial solutions by integrating scientific knowledge, innovation frameworks, and business strategies for sustainable technology enterprises.

CO PO MAPPING

	Description of CO	PO	PSO1	PSO2
CO1	Analyze entrepreneurial ecosystems, policies, and community-based growth patterns to assess opportunities for technology-driven ventures	PO1(2) PO2 (1) PO3(2)	2	1
CO2	Evaluate innovation strategies, IP frameworks, and commercialization pathways relevant to nanoscience and advanced technology domains.	PO1(3) PO2 (2) PO3(3)	3	2
CO3	Design and create comprehensive business plans and business models for nano-technology and deep-tech startups.	PO1(3) PO2 (3) PO3(3)	3	3
CO4	Develop entrepreneurial solutions by integrating scientific knowledge, innovation frameworks, and business strategies for sustainable technology enterprises.	PO1(3) PO2 (2) PO3(3)	3	2

Reading List

1. http://www.jimssouthdelhi.com/sm/BBA6/ED.pdf
2. http://www.cengage.com/highered
3. https://roadmapresearch.com/entrepreneurship-beyond-curriculum
4. The International Journal of Entrepreneurship and Innovation

References:

1. Reddy, N., Entrepreneurship: Text and Cases, Cengage Learning, 2010.
2. Roy, R., Entrepreneurship, 2nd Edition, Oxford University Press, 2011.
3. R. D. Hisrich, Entrepreneurship, 11th Edition, Tata McGraw Hill, New Delhi, 2020.
4. Bessant, J., and Tidd, J., Innovation and Entrepreneurship, 2nd Edition, John Wiley & Sons, 2011.
5. Desai, V., Small Scale Industries and Entrepreneurship, Himalaya Publishing House, 2018.
6. Entrepreneurship: Successfully Launching New Ventures, Global Edition, 6th Edition Bruce R. Barringer, Texas A & amp; M University, R. Duane Ireland, ©2018 |Pearson.
7. CB Gupta Entrepreneurship – Text and Cases, Sultan Chand & Sons, 2023.