MANONMANIAM SUNDARANAR UNIVERSITY
TIRUNELVELI – 12

M.Sc NANO SCIENCE AND NANOTECHNOLOGY

TAMILNADU STATE COUNCIL FOR HIGHER EDUCATION,

CHENNAI – 600 005

For THE ACADEMIC YEAR 2023 – 2024

The preamble of the syllabus

Nanoscience is the study of systems in nanoscale and nanotechnology is the ability to systematically organize and manipulate properties and behavior of matter in the atomic and molecular levels. Nanotechnology is the application of nanoscience leading to the use of new nanomaterials and nanosize components in useful products. These newborn scientific disciplines are situated at the interface between physics, chemistry, materials science, microelectronics, biochemistry, and biotechnology and engineering. Through nanoscience and nanotechnology it has become possible to study and create very useful functional devices, materials and systems on the 1 to 100 nanometer (one billionth of a meter) length scale. The reasons why nanoscale has become so important are presented. Nanotechnology will eventually provide us with the ability to design custom-made materials and products with new enhanced properties, new nanoelectronics components, new types of "smart" medicines and sensors, and even interfaces between electronics and biological systems, nanodevices, nanorobotics, nanocomputers, nanopowders, nanostructured catalysts and nanoporous materials, molecular manufacturing, nanolayers, molecular nanotechnology, medicine such as Alzheimer's and cancer prediction, prevention and treatment through nanotechnology, nanobiology, organic nanostructures to name a few.

Master of Science (M.Sc.) in Nanoscience and Nanotechnology, the curricula, and course content were designed to meet the standards of UGC-CSIR (NET) and (SLET) examinations. The choice- based credit system of learning develops a strong base in the core subject and specializes in the disciplines of his / her liking and abilities and develops an in-depth understanding of various aspects of Nanotechnology. The students develop experimental skills, design, and implementation of novel synthetic methods, and develop the aptitude for academic and professional skills, by acquiring basic concepts for structural elucidation with hyphenated techniques, and understanding the fundamental biological process and rationale of the computer. The project introduced in the curriculum will motivate the students to pursue research and entrepreneurial skill development**.**

MEDIUM OF INSTRUCTION AND EXAMINATION

The medium of instruction as well as examination will be in English.

ELIGIBLITY

Any undergraduate science degree recognized by UGC.

THEORY EXAMINATION

The external evaluation will be based on the examination to be conducted by the university at the end of each semester.

PRACTICAL EXAMINATION

Practical examinations will be conducted at the end of each semester.

Evaluation

A. Each paper carries an internal component

B. There is a pass minimum of 50% for P.G. external and overall components

Theory External: Internal Assessment = 75:25

Practical External: Internal Assessment = 50:50

C. Internal Assessment

Internal marks for Theory shall be allocated in the following manner.

The average of the best two tests from three compulsory tests	**15 Marks**
Seminar	**05 Marks**
Assignment/ Model Making /Quiz	**05 Marks**
Total	**25 Marks**

Note: Each test will be of one hour duration.

E. External Assessment

External marks distribution

Section A: 10x 1 = 10 marks (Q.No. 1 to 10)

Section B:05 x 5 = 25 marks (Q.No. 11 to 15)

Section C: 05 x 8 = 40 marks (Q.No. 16 to 20)

D. Practical

Core Practical Examination having the following marks:

Internal – 50 marks	**External – 50 marks**
Major Practical = 15 marks	Major Practical = 15 marks
Minor Practical = 10 marks	Minor Practical = 10 marks
Spotters (A, B, C, D & E) 5 x 3 = 20 marks	Spotters (A, B, C, D & E) 5 x 3 = 15 marks
Observation Note book or Record note = 05 marks	Observation Note book or Record note = 05 marks
Viva voce – 05 marks	Viva voce – 05 marks
Total – 50 marks	**Total – 50 marks**

Passing minimum of 50% for external and overall components

E: Project work

Internal – 50 marks	External – 50 marks
Total Marks - 100	

Distribution of Marks in Project Course

Internal	50 marks
External Project mark distribution	
Project report	30 marks
Presentation	10 marks
Viva voce	10 marks
Total	**100 marks**

Note:

i) Student should carry out INDIVIDUAL PROJECTS only

ii) Project shall be allotted at the beginning of the IV semester.

iii) Students may be allowed to carry out the project work in other research institutes.

iv) Faculty members of the respective colleges must serve as guides

v) Project report evaluation will be done and Viva-voce will be conducted by both the external examiner and the internal examiner at the end of the FOURTH SEMESTER itself.

vi) Project report in THREE copies has to be submitted at the time of the exam.

vii) Evaluation of Project report has to be done by the examiner(s) appointed by the University for 50 Marks.

viii) Special weightage may be given for the students who publish their research work in recognised journal including online.

H. INTERNSHIP/Field work/Industrial visit

To strengthen and elevate the professional skills of students, Internship (Part Time/ Full Time) is incorporated with 2 credits (3 Hours / Cycle) in Fourth semester.

Industrial visit or Field visit may adopted and a report has to submitted

Evaluation for internship/Field work/Industrial visit

Student shall submit their report (Minimum of 15 pages focusing internship, excluding front page, declaration, certificate etc.) individually.

Internship work/Field work/Industrial visit

Internal – 50 marks	External – 50 marks
Total Marks - 100	

Distribution of Marks in Internship Course/Field work/Industrial visit

Internal	50 marks
External internship mark distribution	
Internship report	25 marks
Presentation	15 marks
Viva voce	10 marks
Total	**100 marks**

OPEN ONLINE COURSE

The student shall undertake an optional career-based Open online course in this course from an UGC approved MOOC platform (e-PG Pathshala/Swayam etc.) during the fourth semester and submit the Certificate at the end of the fourth semester.

Regarding Online courses are concerned, full liberty is given to the students for the selection of the course. Staff can assist the students in selection of course according to the potential of students.

TANSCHE REGULATIONS ON LEARNING OUTCOMES-BASED CURRICULUM FRAMEWORK FOR POSTGRADUATE EDUCATION	
Programme	**M.Sc., Nano Science & Nanotechnology**
Programme Code	
Duration	**2 years for PG**

Programme Outcomes (Pos)	**PO1** **Demonstrate knowledge on the physics/chemistry/biotechnology and basics of nanoscale science and technology for their multifunctional applications.** **PO2** **Demonstrate ability to synthesis and characterize the materials in general and also nanomaterials.** **PO3** **Project their skill in lithography and nanofabrication.** **PO4 Having expertise in processing of nanomaterials, MEMS and bio MEMS as perneeds and specifications.**

	PO5 **Demonstrate an ability to visualize and work on laboratory and multidisciplinary tasks including material science, physics, chemistry and nanobiotechnology.** **PO6** **Demonstrate skills to use synthesis, processing and imaging equipments to analyze samples.** **PO7** **Able to propagate their knowledge to address problems of social relevance such as energy, environment and medicine through their specific electives.** **PO8** **Understanding the impact of nanomaterials on the society including environment, health and ecosystem.** **PO9** **Able to plan and execute their own innovative ideas in the form of projects, product design and development.** **PO10** **Develop confidence for self-education and ability for life-long learning.**

ProgrammeSpecific Outcomes (PSOs)	**PSO1** **Provide exposure in various specialization of Nanotechnology.** **PSO2** **Provide exposure to advanced experimental/theoretical methods for measurement, observation, and fundamental understanding of phenomenon at nanoscale and nanosystems.**PSO3** **Engage in research and life-long learning to adapt to changing environment.** **PSO4** **Having adaptive thinking and adaptability in relation to environmental context and sustainable development.** **PSO5** **Having a clear understanding of professional and ethical responsibility.**

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Template for P.G., Programmes

Semester–I	Credit	Hours	Semester-II	Credit	Hours	Semester-III	Credit	Hours	Semester–IV	Credit	Hours
1.1. Core-I	5	7	2.1. Core-IV	5	6	3.1. Core-VII	5	6	4.1. Core-XI	5	6
1.2 Core-II	5	7	2.2 Core-V	5	6	3.2 Core-VII	5	6	4.2 Core-XII	5	6
1.3 Core – III	4	6	2.3 Core – VI	4	6	3.3 Core – IX	5	6	4.3 Project with viva voce	7	10
1.4 Discipline Centric Elective –I	3	5	2.4 Discipline Centric Elective – III	3	4	3.4 Core – X	4	6	4.4Elective - VI (Industry / Entrepreneurship) 20% Theory 80% Practical	3	4
1.5 Generic Elective-II:	3	5	2.5 Generic Elective -IV:	3	4	3.5 Discipline Centric Elective – V	3	3	4.5 Skill Enhancement course / Professional Competency Skill	2	4
			2.6 NME I	2	4	3.6 NME II	2	3	4.6 Extension Activity	1	
						3.7 Internship/ Industrial Activity	2	-			
	20	**30**		**22**	**30**		**26**	**30**		**23**	**30**
Total Credit Points -91											

Part	List of Courses	Credits	No. of Hours
	Core – I	5	7
	Core – II	5	7
	Core – III	4	6
	Elective – I	3	5
	Elective – II	3	5
		20	**30**

Semester-II

Part	List of Courses	Credits	No. of Hours
	Core – IV	5	6
	Core – V	5	6
	Core – VI	4	6
	Elective – III	3	4
	Elective – IV	3	4
	Skill Enhancement Course [SEC] – I	2	4
		22	**30**

Second Year – Semester – III

Part	List of Courses	Credits	No. of Hours
	Core – VII	5	6
	Core – VIII	5	6
	Core – IX	5	6
	Core (Industry Module) – X	4	6
	Elective – V	3	3
	Skill Enhancement Course – II	2	3
	Internship / Industrial Activity [Credits]	2	-
		26	**30**

Semester-IV

Part	List of Courses	Credits	No. of Hours
	Core – XI	5	6
	Core – XII	5	6
	Project with VIVA VOCE	7	10
	Elective – VI (Industry Entrepreneurship)	3	4
	Skill Enhancement Course – III / Professional Competency Skill	2	4
	Extension Activity	1	-
		23	**30**

Total 91 Credits for PG Courses

M.Sc., Nano science and Nano Technology

SEMESTER - I

Course status	Course Title	Credits	Hours
Core-1	Introductory Physics	4	7
Core -2	Introductory Chemistry	4	7
Core-3	Introductory Biology	4	6
Elective - I	Introduction to Material Science	3	3
Elective - II	A. Laboratory Safety and Health B. Intellectual Property Rights. C. Innovation and Entrepreneurship	2	3
	Nanoscience Practical-I	4	4
	Total	**21**	**30**

SEMESTER - II

Course status	Course Title	Credits	Hours
Core 4	Introduction to Nanoscience and Nanotechnology	4	6
Core 5	Preparation of Nanomaterials	4	6
Core 6	Characterization Techniques of Nanomaterials –I	4	5
Elective III	Introduction to Nanotoxicology	3	3
Elective IV	Nanobiotechnology	3	3
Practical	Nanoscience Practical – II	4	4
	Skill Enhancement Course [SEC] - I NME	2	2
	Total	**24**	**30**

SEMESTER – III:

COURSE COMPONENTS	NAME OF THE COURSE	Hours	Credits	Exam Hrs	MAX MARKS	
					CIA	EXT
Core-VII	Nanoelectronics and Nano sensors	5	5	3	25	75
Core-VIII	Properties of Nanomaterials	5	5	3	25	75
Core-IX	Characterization Techniques ofNanomaterials-II	5	5	3	25	75
Core X	Nanoscience Practical III	6	4	6	50	50
Discipline Centric Elective- V	Choose any one A. Advanced nanomaterials for Nanotechnology B. Biomaterials and biotechnology for tissue engineering	5	3	3	25	75
SEC II	Green Manufacturing Technology	4	2	3	25	75
	Internship / Industrial Activity / Field Visit	-	2		50	50
		30	26			

SEMESTER - IV

COURSE COMPONENTS	NAME OF THE COURSE	Hours	Credits	Exam Hrs	MAX MARKS	
					CIA	EXT
Core-XI	Biomedical Nanotechnology	6	5	3	25	75
Core-XII	Industrial Nanotechnology	6	5	3	25	75
Elective- VI	Choose any one A. Nanotechnology for Food and Agriculture B. Nanomedicine and drug delivery	4	3	6	50	50
SEC III	Basics of Pharmaceutical sciences and quality audit	4	2	3	25	75
	Project with viva voce	10	7		50	50
	Extension Activity	-	1		50	50
		30	23			

Total Credits: **94 credits**

SEMESTER I
CORE I

Course Code	**Course Name: INTRODUCTORY PHYSICS**		**Credits 4**
Lecture Hours: (L) per week	**Tutorial Hours: (T) per week**	Lab practice Hours: (P) per week	Total: (L+T+P) Hours per week
Course Category: Core I	**Year & Semester:**	Admission Year:	
Pre requisite:	Basic knowledge with concepts of physics.		
Learning Objectives:	The main objectives of this course are to: To understand fundamental concepts of electromagnetic waves, current, magnetism, electronics and quantum mechanics. To gain knowledge on electronic devices such as diodes and transistors also quantum mechanics		

CLO1	To understand fundamental concepts of physics which are necessary for nanoscience and technology subject
CLO2	To apply the gained subject knowledge to understand the nano-enabled devices in second and third semesters
CLO3	To evaluate microscopic scales with macroscopic Impact with the help of Physics.
CLO4	To understanding on real time applications of physics
CLO5	To analyze the acquired knowledge and understanding on real time applications of physics
Recap:	2 Tutorial hours
Contents and Required hours: (Total =90 hours)	

Unit:1	**WAVES AND OPTICS**	**18 hours**
Electromagnetic waves and their characteristics – Theories of light –Wave, Electromagnetic and Quantum – Scattering of light: Rayleigh's and Tyndal scattering – Huygen's principle – Interference – Diffraction – Polarization of light waves		

Unit:2	**ELECTRIC CURRENT**	**18 hours**
Electric Current – Flow of Charges in Metals – Drift Velocity, Mobility and Their Relation – Ohm's Law: Electrical Resistance – I-V Characteristics – Resistivity and Conductivity – Superconductivity – Joule's Heating Effect – Thermoelectric Effects: Seebeck and Peltier Effect.		

Unit:3	MAGNETISM	18 hours
Fundamental Concepts of Magnetism– Bohr Magneton- Magnetic Dipoles- Field- Electron Spin and Magnetic Moment- Magnetic moment due to Nuclear Spin- Magnetic dipoles- Permeability- Magnetization- Intensity of Magnetization – Magnetic Materials		
Unit:4	**ELECTRONICS**	**18 hours**
Classification of Solids, Energy Levels, Intrinsic and Extrinsic Semiconductor, Conduction In Metals and Semiconductors. Diode Under Forward and Reverse Bias - Transistor Basics, Working Principles – Current-Voltage Characteristics		
Unit:5	**QUANTUM MECHANICS**	**18 hours**
De-Broglie wavelength: in terms of energy and potential – Schrödinger time dependent equation – Time independent equation – Applications of Schrödinger wave equation – One dimensional harmonic oscillator: Eigen values of the total energy – Particle in a one dimensional box.		
	TOTAL LECTURE HOURS	**90 hours**

Text Book(s)	
1	Solid State Physics, S.O. Pillai, 4th Ed, New Age International Publishers (2001).
2	Introduction To Solid-State Physics, C. Kittel, Wiley (1986).
3	Magnetism: Principles and Applications, D. Craik, Wiley (1995).
4	A Textbook of Quantum Mechanics, P. M. Mathews and K. Venkatesan, Tata McGraw-Hill, (1978)
5	Quantum Mechanics: Theory and Applications, Ajoy Ghatak, and S. Lokanathan, Springer (2004)
Reference Book(s)	
1.	Text Book Of Electronics, S. Chattopadhyay, New Central Book Agency pvt. Ltd., (2006).
2.	Magnetic Materials : Fundamentals And Applications by Nicola A. Spaldin, Cambridge University Press, 2nd Edition, (2018)
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	NPTEL: Electromagnetism https://nptel.ac.in/courses/115/106/115106122/
2	NPTEL: Magnetic Properties https://www.youtube.com/watch?v=QQZ6EGf0Ju8
3	NPTEL: Quantum Mechanics https://nptel.ac.in/courses/115/101/115101107/

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	3	2	2	2	2	3	3	3
CO2	3	2	2	3	3	2	3	3	2	2
CO3	3	2	2	3	3	3	3	2	2	2
CO4	3	3	3	2	2	2	3	3	2	3
CO5	3	2	2	3	2	3	2	2	3	3

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	3	3
CO2	3	2	3	3	3
CO3	3	2	3	3	3
CO4	3	2	3	3	3
CO5	3	2	3	3	3
Weightage	15	10	15	15	15
Weighted percentage (rounded of) Course Contribution to Pos	3	2	3	3	3

Strong - 3, Medium – 2, Low - 1

SEMESTER I

CORE-II

Course Code	**Course Name: INTRODUCTORY CHEMISTRY**		**Credits: 4**
Lecture Hours: (L) per week	**Tutorial Hours: (T) per week**	Lab practice Hours: (P) per week	Total: (L+T+P) Hours per week:
Course Category:	**Year & Semester:**	Admission Year:	
Pre requisite:	Basic knowledge with concepts of Chemistry		
Learning Objectives:	The main objectives of this course are to: To understand fundamental concepts of electromagnetic waves, current, magnetism,electronics and quantum mechanics. To gain knowledge on electronic devices such as diodes and transistorsalso quantum mechanics		

CLO1	1. Define and identify differential branches of chemistry and their importance
CLO2	2. Understand and describe chemical concepts and processes
CLO3	3. Interpretation and application of the theories to chemical process and derivations.
CLO4	4. Differentiate different properties and mechanisms of organic reactions, inorganic properties and physical concepts
CLO5	5. Evaluation and assessment of the theories and chemical process fordifferent applications.
Recap:	2 Tutorial hours
Contents and Required hours: (Total =90 hours)	

Units	
I (18 h)	Chemical Equilibria - Activity Concept, Equilibrium Constant and Applications, Ionisation Constants of Acids and Bases. Concept Of pH, Hydrolysis of Salts.
II (18 h)	Buffers – Types, Range and Capacity, Dissociation of Polyprotic Acids, Common Ion Effect, Salt Effect. Electrochemistry – Conductivity o f Electrolytes, Electrochemical Cells, Standard Electrode Potentials
III (18 h)	Symmetry And Group Theory, Bonding Models in Chemistry – Ionic Bond, Covalent Bond, Coordination Chemistry - Theories of Bonding in Coordination Compounds and Electronic Spectra of Coordination Compounds
IV (18 h)	Thermodynamics: First, Second and Third Law of Thermodynamics. Gibbs And Helmholtz Energy and Chemical Equilibrium. Chemical Kinetics, Transition State Theory and Collision Theory, Heterogeneous Catalysis.

V (18 h)	Organic Compounds – Structure and Bonding, Aliphatic and Aromatic Compounds, Functional Groups, Nucleophiles and Electrophiles, Reactions and Mechanisms
Reading List(Printand Online)	1. Fundamentals Of Analytical Chemistry - Skoog, West and Holler, Saunders College, Publishing, VII Ed, (1996). 2. Text Book Of Quantitative Inorganic Analysis – A.I. Vogel, Elbs, IVEd., (1985). 3. Physical Chemistry,.A. Alberty And R.J. Silbey
Recommended Texts	1. Inorganic Chemistry: Principles of Structure and Reactivity – J.E. Huheey, E.A. Keiter and R.L. Keiter, IVEd. 2. Physical Chemistry, Atkins 3. Text Book Of Quantitative Chemical Analysis – A.I. Vogel, VI Ed,Pearson Education Ltd, 2001

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	3	3	2	3	3	3
CO2	3	3	2	3	3	3	2	3	2	2
CO3	3	3	2	3	3	3	2	2	2	2
CO4	3	3	2	3	3	3	2	3	2	3
CO5	3	3	2	3	3	3	2	2	3	3

Strong - 3, Medium – 2, Low – 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	2	3
CO2	3	3	2	2	3
CO3	3	3	2	2	3
CO4	3	3	2	2	3
CO5	3	3	2	2	3
Weightage	15	15	10	10	15
Weighted percentage (rounded of) Course Contribution to Pos	3	3	2	2	3

Strong - 3, Medium – 2, Low - 1

SEMESTER I
CORE-III

Course Code	**Course Name: INTRODUCTORY BIOLOGY**		**Credits: 4**
Lecture Hours: (L) per week	**Tutorial Hours: (T) per week**	Lab practice Hours: (P) per week	Total: (L+T+P) Hours per week
Course Category:	**Year & Semester:**	Admission Year:	
Pre requisite:	Basic knowledge with concepts of Biology		
Links to other Courses			
Learning Objectives:	The main objectives of this course are to: 1. Acquire the knowledge of the cell biology and application. 2. Explaining the role of cell organelles, metabolism, and bioenergetics. 3. Understanding the about the morphology, structure, of DNA, RNAand different types of nucleic acid. 4. Gaining the knowledge about of glucose, and fatty acid metabolism. 5. Evaluation and comparison of the different enzyme role energy production.		
Units			
I	CELL STRUCTURE AND FUNCTIONS Definitions, Types, Eukaryotic and Prokaryotic cells, Principle o membrane organization, Cytoskeletal proteins, Types of cell division Mitosis and Meiosis.		
II	PROTEINS Structure and functions of proteins, Amino acids and peptides, Proteins Primary, Secondary, Tertiary, and Quaternary structures, Protein folding, hemoglobin and myoglobin.		
III	ENZYMES Mechanism of actions, Enzyme kinetics, Regulation of activities, Bioenergetics, Role of ATP, Biological oxidation, Respiratory chain and oxidative phosphorylation		
IV	METABOLISOM Overview of metabolism and catabolism, Carbohydrates, Biological significance, Glycolysis, Lipids of physiological significance, Cholesterol, Synthesis, Transport and Excretion, Glycoproteins and Extracellular matrix, Biooxidation, Fatty acid synthesis, Phospholipids and Membranes		
V	NUCLEIC ACIDS Structure, functions and replications of information macromolecules. Metabolism of purines and pyrimidine nucleotides. Organization, replication and repair of DNA. RNA and protein synthesis.		
Recommended Texts	1. Lehninger, Principles of Biochemistry, Cox and Nelson, VEdn,2008 2. L. Stryer, Biochemistry, 4th Edn., 1995 3. Haper's Illustrated Biochemistry, R.K, Murray, D.K. Granner and V.W.Rodwell, McGraw Hill, New Delhi, 2003.		

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	3	2	2	2	2	3	3	3
CO2	3	2	2	3	3	2	3	3	2	2
CO3	3	2	2	3	3	3	3	2	2	2
CO4	3	3	3	2	2	2	3	3	2	3
CO5	3	2	2	3	2	3	2	2	3	3

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	3	3
CO2	3	2	3	3	3
CO3	3	2	3	3	3
CO4	3	2	3	3	3
CO5	3	2	3	3	3
Weightage	15	10	15	15	15
Weighted percentage (rounded of) Course Contribution to POs	3	2	3	3	3

Strong - 3, Medium – 2, Low - 1

SEMESTER I

Discipline Centric Elective Course-1

Course Code	**Course Name: Introductions To Materials Science**		**Credits 3**
Lecture Hours: (L) per week	**Tutorial Hours: (T) per week**	Lab practice Hours: (P) per week	Total: (L+T+P) Hours per week
Course Category:	**Year & Semester:**	Admission Year:	
Pre requisite:	Basic knowledge with concepts of solid state physics		
Links to other courses			
Learning Objectives:	The main objectives of this course are to: To understand fundamental concepts of crystal structure and defects To gain knowledge on various properties such as electrical, magnetic, thermal, optical andmechanical properties of materials		

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	To understand the fundamental concepts of material science
2	To apply the gained subject knowledge to understand the advanced concepts of nanoscience in second and third semesters
3	To evaluate impact of presence of impurity and applied temperature on various properties of materials.
4	To analyze the acquired knowledge and understanding on real time applications of various functional materials

Unit:1	**CRYSTAL STRUCTURE AND DEFECTS**	**18 hours**

Structure of Matter- Amorphous, Crystalline, Crystals, Polycrystals, Symmetry, Unit Cells, Crystal Structures, Crystallographic Planes, Miller Indices, Chemical Bonding, Atomic Bonding in Solids, Types of Bonds: Metallic, Ionic, Covalent and Vander Waals; Crystal Defects.

Unit:2	**ELECTRICAL PROPERTIES**	**18 hours**

Origin of Band Gap in Solids – Concept of Effective Mass of Electron and Hole – Band Gap Determination – Electrical Conductivity – Activation Energy – Carrier Concentration In Semiconductors – Effect of Temperature and Impurity on Fermi Level – Hall Effect: Determination of Hall Coefficient.

Unit:3	**MAGNETIC PROPERTIES**	**18 hours**

Magnetic Materials – Dia, Para, Ferro, Anti-Ferro and Ferri Magnetism – Magnetic Susceptibility – Curie and Neel Transition Temperature – Hysteresis – Remanence – Coercivity – Saturation Magnetization –Origin of Domain theory- Ferrites – Magnetic Recording and Readout – Storage of Data – Tapes and Floppy - Magnetic Disk Drives.

Unit:4	DIELECTRIC PROPERTIES	18 hours
Dielectric Materials: Electronic, Ionic, Orientational, and Space Charge Polarization – Complex Dielectric Constant RC Equivalent Network – Dielectric Loss – Different Types of Dielectric Breakdown, Classification of Insulating Materials.		
Unit:5	**THERMAL, OPTICAL & MECHANICAL PROPERTIES**	**18 hours**
Thermal: Heat Capacity – Thermal Expansion – Thermal Conductivity and Stresses – OpticalProperties of Metals and Non-Metals. Application of Optical Phenomena – Mechanical Properties: Elastic And Plastic Deformation – Interpretation of Stress-Strain Curves, Compressive Strength – Hardness: Rockwell, Brinell and Vickers.		
	TOTAL LECTURE HOURS	**90 hours**

Text Book(s)

1	Solid State Physics, S.O. Pillai, 4th Ed, New Age International Publishers (2001).
2	Introduction To Solid-State Physics, C. Kittel, Wiley (1986).
3	Magnetism: Principles and Applications, D. Craik, Wiley (1995).
4	Impedance Spectroscopy: Theory, Experiment, and Applications, 3rd Edition, Dr. Evgenij Barsoukov and Dr. J. Ross Macdonald, Wiley (2018).

Reference Book(s)

1.	Solid-State Physics: Introduction to the Theory, Patterson, James, Bailey, Bernard C.Springer (2018).
2.	Magnetic Materials : Fundamentals And Applications by Nicola A. Spaldin, Cambridge University Press, 2nd Edition, (2018)

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1	NPTEL: Material Science https://nptel.ac.in/courses/112/108/112108150/
2	NPTEL: Magnetic Properties https://www.youtube.com/watch?v=QQZ6EGf0Ju8

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	3	2	2	2	2	3	3	3
CO2	2	2	2	3	3	2	3	3	2	2
CO3	2	2	2	3	3	3	3	2	2	2
CO4	3	3	3	2	2	2	3	3	2	3
CO5	2	2	2	3	2	3	2	2	3	3

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	2
CO2	3	3	3	3	2
CO3	3	3	3	3	2
CO4	3	3	3	3	2
CO5	3	3	3	3	2
Weightage	15	15	15	15	10
Weighted percentage (rounded of) Course Contribution to Pos	3	3	3	3	2

Strong - 3, Medium – 2, Low - 1

Semester	Course Code	Title of the Course	Core/Elective/ Soft Skill	Credits
		LABORATORY SAFETY AND HEALTH	**Elective II – A**	**2**

Course Outcomes	1. Understanding the basic of Nanoscience and differentiate between nanoand bulk materials 2. Evaluate and critically review the theoretical and practical aspects of nanomerials preparation and application. 3. Understanding the concepts and techniques in nanotechnology 4. Critically assess and outline the nanotechnology for all areas of application 5. Demonstrate the new properties of nanomaterials for next generation needs
Course I	**Generic Elective II- A**
Title of the Course:	**LABORATORY SAFETY AND HEALTH**
Course Objectives	1. Define and identify laboratory safety and health 2. Understand and describe various safety issues and protocols 3. Interpretation and application of safety protocols and laboratory rules. 4. Differentiate different types of laboratory accidents and safety protocolsand personal protective equipments. 5. Evaluation and assessment safety regulations, personal protective equipments and First aid practices. 6. Apply the safety practices in real-time and awareness to the societal needs.
	Units
I	SAFETY REGULATIONS Standard Laboratory Procedures, Rules and Regulations. Lab Safety Practices.
II	SAFETY REGULATIONS Employee Information, Safety Plans and Arrangement of Laboratories.
III	CHEMICAL AND BIOSAFETY Chemicals Handing, MSDS Information, Labelling of The Chemicals, Disposal Of The Chemical And Biological Wastes
IV	SAFETY EQUIPMENTS Various Safety Equipments, Personal Protective Equipments, User Manuals, Arrangements, Training.
V	FIRST AID First Aid Practices - Cardiac, Chemical Injury, Physical Injury. Emergency Calls and Procedures. First Aid Kits.
Reading List(Print and Online)	1. Introduction To Health And Safety At Work, Elsevier (2015)
Recommended Texts	1. Environmental Health & Safety Procedure Manual, Harper College (2001)

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	3	2	2	2	2	3	3	3
CO2	3	2	2	3	3	2	3	3	2	2
CO3	3	2	2	3	3	3	3	2	2	2
CO4	3	3	3	2	2	2	3	3	2	3
CO5	3	2	2	3	2	3	2	2	3	3

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	3	2	3	3	3
CO2	3	2	3	3	3
CO3	3	2	3	3	3
CO4	3	2	3	3	3
rCO5	3	2	3	3	3
Weightage n	15	10	15	15	15
gWeighted percentage (rounded of) Course Contribution to POs	3	2	3	3	3

Strong - 3, Medium – 2, Low - 1

Semester	Course Code	Title of the Course	Core/Elective/ Soft Skill	Credits
		Intellectual Property Rights	**Value Added Course – B**	**2**

Course I	**Generic Elective II – B**
Title of theCourse:	**Intellectual Property Rights**
Course Objectives	1. Define Intellectual Property Rights 2. Understand and describe various types of IP rights 3. To learn different types of IPS 4. Differentiate different types of filing IPS 5. To learn Know How and Trade Secrets 6. Evaluate and assessment of all regulations for the above said IPS.
Units	
I	Introduction: – Invention and Creativity – Intellectual Property (IP) – Importance- Protection of IPR
II	Patents: IP- Patents- Copy rights and related rights- Trademarks and right arising from Trademark registration- definitions- Applications Procedures
III	International Convention relating to Intellectual Property- establishment of WIPO- Mission and Activities- History –General Agreement on Trade and Tariff (GATT)
IV	Indian Position Vs WTO and Strategies – Indian IPR- Word Patents- US patents- regulations
V	Case Studies New Patents – copy right and related rights- Trame Marks- Know How-
Reading List (Print and Online)	ubbaram N.R "Handbook of Indian Patent Law and Practice, S. Viswanathan, (Printer and Publishers) , Pvt. Ltd. 1998
mmendedTexts	Intellectual Property Today: Volume 8 May 2001, [www. Iptoday. Com]

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	3	3	2	3	3	3
CO2	3	3	2	3	3	3	2	3	2	2
CO3	3	3	2	3	3	3	2	2	2	2
CO4	3	3	2	3	3	3	2	3	2	3
CO5	3	3	2	3	3	3	2	2	3	3

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	3	3	2	2	3
CO2	3	3	2	2	3
CO3	3	3	2	2	3
CO4	3	3	2	2	3
CO5	3	3	2	2	3
Weightage	15	15	10	10	15
Weighted percentage (rounded of) Course Contribution to Pos	3	3	2	2	3

Strong - 3, Medium – 2, Low - 1

		Title of the course	Generic Elective II – C			2
CourseCode:		**INNOVATION AND ENTREPRENEURSHIP**	**L**	**T**	**P**	**C**
Core/Elective/Supportive		**Generic Elective – II C**				
Pre-requisite		Basic knowledge with data sets, graphs and scientific images.				

The main objectives of this course are to:

1. To enable the students to learn the various aspects of innovation and methods of fostering Innovation
2. To understand the concept and theories of entrepreneurship
3. To recognize the qualities of entrepreneurs that contributed to their success.

Expected Course Outcomes:

On the successful completion of the course,

1	Crisis management/Risk Management - you must take advance from your clients before hand	
2	Various options to start a business venture. Quality of the product matters much in the marker	
3	Understanding the needs of the customer	
4	Any idea can be innovative if its in accordance to people's need. Marketing strategies	

Unit:1	**Introduction to Innovation**	18 hours

Creativity, Invention and innovation-Types of Innovation-Relevance of Technology for Innovation-The Indian innovations and opportunities

Unit:2	**Promoting and managing innovation**	18 hours

Innovators and Imitators-Patents, Trademarks, Intellectual Property-Exploring, Executing, Leveraging and renewing innovation-Enhancing Innovation Potential & Formulating strategies for Innovation

Unit:3	**Strategy for Commercializing Innovation**	**18 hours**

Innovation Process- Risks and barriers for introducing products and services-Selecting a Strategy, setting up the Investment and establishing organisation-Evaluating the Costs and impact of the Project

Unit:4	**Entrepreneurship**	**18 hours**

Entrepreneurship in global context – social and economic development- Entrepreneurship and social entrepreneurship – Meaning, Entrepreneurial attributes / indicators-Theories of entrepreneurship-Characteristics of an entrepreneurial venture, factors affecting entrepreneurial Growth

Unit:5	ENTREPRENEURSHIP DEVELOPMENT IN INDIA	**18 hours**

Growth and promotion of Entrepreneurship in India - Institutional arrangements - Entrepreneurial motivation - Values and Culture - Entrepreneurship in various sectors - Access to finance, market, R&D and Technology- Policies and programmes related to entrepreneurship development

TOTAL LECTURE HOURS	90 hours

Text Book(s)

1. Robin Lowe and Sue Marriott, Enterprise: Entrepreneurship and Innovation Concepts, Contexts and Commercialization
2. John Bessant and Joe Tidd, Innovation and Entrepreneurship

Reference Book(s)

1. Rabindra N. Kanungo "Entrepreneurship and innovation", Sage Publications, New Delhi, 1998.
2. Peter F. Drucker, Innovation and Entrepreneurship
3. EDII "Faculty and External Experts – A Hand Book for New Entrepreneurs Publishers: Entrepreneurship Development" Institute of India, Ahmadabad, 1986.
4. Philips, Bonefiel and Sharma (2011), Social Entrepreneurship, Global vision publishing house, New Delhi.

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	3	3	2	3	3	3
CO2	3	3	2	3	3	3	2	3	2	2
CO3	3	3	2	3	3	3	2	2	2	2
CO4	3	3	2	3	3	3	2	3	2	3
CO5	3	3	2	3	3	3	2	2	3	3

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	2	3
CO2	3	3	2	2	3
CO3	3	3	2	2	3
CO4	3	3	2	2	3
CO5	3	3	2	2	3
Weightage	15	15	10	10	15
Weighted percentage (rounded of) Course Contribution to POs	3	3	2	2	3

Strong - 3, Medium – 2, Low - 1

SEMESTER I

Nanoscience Practical I

Course Code	**Course Name: Nanoscience Practical- I**		**Credits 4**
Lecture Hours : (L) per week	**Tutorial Hours : (T) per week**	Lab practice Hours : (P) per week	Total: (L+T+P) Hours per week
Course Category:	**Year & Semester :**	Admission Year:	
Pre requisite:	Basic knowledge with concepts of Biology, Chemistry and Physics		
Links to other courses			
Learning Objectives:	The main objectives of this course are to: 1. Acquire practical skills in the use of instruments, technologiesand methods in Biomolecules like glucose, urea, creatinine, DNA, proteins, 2. Apply the practical knowledge in understanding the estimation, separation techniques. 3. Provides opportunities to collect and examine samples fromblood and cells. 4. Master the technical skills in buffer, medium, sterilizing,culturing, and charactering biological samples. 5. To compare the structural diversity of healthy and diseased condition.		

Units	
I	PROTEIN ESTIMATION Lowry and Bradford methods
II	ESTIMATIONS OF BLOOD- Glucose, Blood urea, Uric acid, andCreatinine
III	SEPARATION AND CHARACTERIZATION OF PROTEIN Chromatography, Gel Filtration, Ion exchange, Affinity chromatography,TLC, Polyacrylamide, Agarose gel electrophoresis.
IV	DNA ESTIMATION Isolation of DNA and demonstration of apoptosis of DNA laddering
V	MICROSCOPY – FLUORESCENCE MICROSCOPE EXPERIMENTS Cell Counting, MTT assay for cell viability, and growth.

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	3	3	2	3	3	3
CO2	3	3	2	3	3	3	2	3	2	2
CO3	3	3	2	3	3	3	2	2	2	2
CO4	3	3	2	3	3	3	2	3	2	3
CO5	3	3	2	3	3	3	2	2	3	3

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	2	3
CO2	3	3	2	2	3
CO3	3	3	2	2	3
CO4	3	3	2	2	3
CO5	3	3	2	2	3
Weightage	15	15	10	10	15
Weighted percentage (rounded of) Course Contribution to Pos	3	3	2	2	3

Strong - 3, Medium – 2, Low - 1

SEMESTER-II
CORE-IV

Course Code	**Course Name: Introduction to Nanoscience and Nanotechnology**		**Credits: 4**
Lecture Hours: (L) per week	**Tutorial Hours: (T) per week**	Lab practice Hours: (P) per week	Total: (L+T+P) Hours per week
Course Category:	**Year & Semester:**	Admission Year:	
Pre requisite:	Basic knowledge with concepts of Nanoscience and Nanotechnology		
Learning Objectives:	The main objectives of this course are to: To understand fundamental concepts of nanoscience and technology To gain knowledge on size dependent various physical properties		

Expected Course Outcomes:		
On the successful completion of the course, student will be able to:		
1	To understand the fundamental concepts of nanoscience	
2	To apply the basic concepts of physics, chemistry and biology concepts to understand the advanced concepts of nanoscience	
3	To influence of size and morphology and other factors on various properties of materials.	
4	To analyze the acquired knowledge and understanding on real time applications of various applications	
Unit:1	**FUNDAMENTALS**	**18 hours**
Background to nanoscience – Historical perspectives and Scientific revolutions – Definitions and Classifications based on dimension: Zero, One, Two and Three - Clusters, Quantum dots, Nanowires, Rods and tubes, and thin films; Hard sphere model: Grain and Grain boundary concepts;		
Unit:2	**BASIC CONCEPTS**	**18 hours**
Top-Down and Bottom-Up Approaches: Physical - Chemical and Mechanical Routes; Influence of various parameters on morphology of crystallites - Nanocomposites: Metal and Metal Oxides; Metal		

Oxide - Metal Oxide; Nano in Nature: Gecko Effect, Lotus leaf effect, Superhydrophobicity, Self-Cleaning and Antifogging – Colored Glasses and Dichroism.		
Unit:3	**UNIQUE PROPERTIES**	**18 hours**
Quantum Confinement Effects: Influence of grain size and morphology – Physical properties with Uniqueness compared to bulk and microscopic solids: Optical – Surface Plasmon Resonance, Band Gap Widening, Magnetic – Superparamagnetism, Thermal – Melting point depression.		
Unit:4	**ADVANCED NANOSTRUCTURED MATERIALS**	**18 hours**
Allotropes of carbon: Graphene, CNT, C-dots, Fullerenes – Inorganic: Organic hybrids – Ferrofluids-Zeolites- Core-shells – Nanostructures of Zinc Oxide: tetrapods, rings, springs, belt, rods, wires - Additive Manufacturing of 3D Nanoarchitected Metals – Nanorobots		
Unit:5	**ROAD MAP**	**18 hours**
Miniaturization of electronic materials and devices – Lithography techniques - Scaling issues – batch fabrication and circuit integration – MEMS and NEMS – Current and future challenges		
	TOTAL LECTURE HOURS	**90 hours**

Text Book(s)

1	Solid State Physics, S.O. Pillai, 4th Ed, New Age International Publishers (2001).
2	Introduction To Solid-State Physics, C. Kittel, Wiley (1986).
3	Magnetism: Principles and Applications, D. Craik, Wiley (1995).
4	Springer Handbook of Nanotechnology, Edited by Bharat Bhushan, Springer (2006)

Reference Book(s)

1.	NANO: The Essentials: Understanding Nanoscience and Nanotechnology, T. Pradeep, McGraw Hill (2017)
2.	Magnetic Materials: Fundamentals and Applications by Nicola A. Spaldin, Cambridge University Press, 2nd Edition, (2018)

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1	NPTEL: Introduction to Nanomaterials https://nptel.ac.in/courses/118/104/118104008/
2	NPTEL: Nanostructuresd Materials https://nptel.ac.in/courses/118/102/118102003/

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	3	2	2	2	2	3	3	3
CO2	3	2	2	3	3	2	3	3	2	2
CO3	3	2	2	3	3	3	3	2	2	2
CO4	3	3	3	2	2	2	3	3	2	3
CO5	3	2	2	3	2	3	2	2	3	3

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	3	2	3	3	3
CO2	3	2	3	3	3
CO3	3	2	3	3	3
CO4	3	2	3	3	3
CO5	3	2	3	3	3
Weightage	15	10	15	15	15
Weighted percentage (rounded of) Course Contribution to POs	3	2	3	3	3

Strong - 3, Medium – 2, Low - 1

SEMESTER-II

CORE-V

Course Code:		Preparation of Nanomaterials	L	T	P	C
Core/Elective/Supportive		Core	4	0	0	4
Pre-requisite		Basic knowledge with wet chemistry and materials				

Course Objectives:

The main objectives of this course are to:

1. To understand preparation procedures also the various factors that affects the size and morphology of crystallites.
2. To gain knowledge on current status, future trends and scope for research.

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	To understand fundamental concepts in materials preparation with various Morphologies
2	To apply the gained subject knowledge towards understanding the mechanisms involved physical, chemical and mechanical routes.
3	To evaluate and understand the role of preparation method towards grain with narrow distribution and desired morphology.
4	To analyze acquired knowledge and understanding on effect of grain morphology and its needs for technological advancements

Unit:1	BASICS IN MATERIALS PREPARATION	18 hours

Types of matter – Crystalline and Amorphous solids – Alloys – composites - compounds - Grain – Grain Growth-Grain boundary volume ratio –Temperature effects – Grain boundary segregation and pinning – Aggregation- Dimensional Classifications.

Unit:2	PHYSICAL ROUTES	18 hours

High energy ball mill - Inert gas condensation Role of inert gases - Post oxidation process –Sputtering processes – Laser ablation - Pulsed laser deposition – Rapid solidification – Arc discharge method- photolysis – radiolysis - Fabrication of nanostructures and microfabrication using wet and dry etching-Lithography.

Unit:3	CHEMICAL AND BIOLOGICAL METHODS	18 hours

Polyol route – Colloidal precipitation – Sol-Gel process– Chemical precipitation: Normal and Reverse reactions- Role of surfactant – Hydrolysis: Reaction kinetics – Hydrothermal – Solvothermal – Sonochemical – Template route: DC and Pulsed electrodeposition and Electroless deposition – Combustion route – Biological Methods: synthesis of nanomaterials using bacteria, fungi, yeast and Actinomycetes – magnetotactic bacteria for natural synthesis – role of plants in NPs synthesis and Phytoremediation

Unit:4	SPECIALIZED TECHNIQUES	18 hours

Electrophoretic deposition – Chemical Vapour deposition: Wet and Dry oxidation process –Dip and Spin coating process – Successive ionic layer adsorption and reaction (SILAR) – Spray and Flame spray pyrolysis - Self assembly.

Unit:5	IMPORTANCE OF MORPHOLOGY	18 hours
Crystallites With Various Morphologies – Polymorphs – Surface Aspect Ratio – Grain size distributions – Surface area – Current Status and Forecast for The Future Trends		
	TOTAL LECTURE HOURS	**90 hours**

Text Book(s)	
1	Springer Handbook of Nanotechnology- Ed. by B. Bhushan, Springer-Verlag (2004)
2	Vacuum Technology, A. Roth, North- Holland Pub., 2nd Edition (1982)
3	The Chemistry of Nanomaterials: Synthesis, Properties and Applications, C.N.R. Rao, A.Muller, A. K. Cheetham (Eds), Wiley-VCH Verlag (2004)
4	B.S. Murty and S. Ranganathan, International Materials Reviews (1998) Vol. 43(3), 101
Reference Book(s)	
1.	Nanoparticles And Nanostructured Films Preparation, Characterization And Applications, Janos H. Fendler (Ed) Wiley (1998)
2.	H. Gleiter, Progress In Materials Science, Vol.33, p.223 (1989)
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	NPTEL: Nanotechnology, Science and Applications https://nptel.ac.in/courses/113/106/113106093/
2	YOUTUBE: Introduction to Nanomaterials https://www.youtube.com/watch?v=qUEbxTkPIWI

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	3	2	2	2	2	3	3	3
CO2	2	2	2	3	3	2	3	3	2	2
CO3	2	2	2	3	3	3	3	2	2	2
CO4	3	3	3	2	2	2	3	3	2	3
CO5	2	2	2	3	2	3	2	2	3	3

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	2
CO2	3	3	3	3	2
CO3	3	3	3	3	2
CO4	3	3	3	3	2
CO5	3	3	3	3	2
Weightage	15	15	15	15	10
Weighted percentage (rounded of) Course Contribution to Pos	3	3	3	3	2

Strong - 3, Medium – 2, Low - 1

SEMESTER-II

CORE-VI

Course Code	**Course Name Characterization Techniques of Nanomaterials –I**		**Credits: 4**
Lecture Hours : (L) per week	**Tutorial Hours : (T) per week**	Lab practice Hours: (P) per week	Total: (L+T+P) Hours per week
Course Category:	**Year & Semester :**	Admission Year:	
Pre requisite:	Basic knowledge with concepts of physics.		
Learning Objectives:	1. Understand the properties of the light and interaction with matter 2. Distinguish the nanomaterials and bulk materials using X-ray. 3. Explore the chemistry of the materials 4. Understanding the mechanical properties of the nanomaterials 5. Study the magnetic and electrical properties.		

Course Outcomes	1. Understanding the purpose of characterization for the given materials 2. Explore the properties of nanomaterials for the particular applications 3. Understanding the principles of characterization techniques 4. Studythe properties of nanomaterials 5. Understanding the instrumentation involved in the characterization technique. 6. Understanding the suitability of the characterization for the particular material. 7. Learn the interpretation of the results obtained from thecharacterization
Units	
I	**Unit I Introduction to spectroscopy** Basic principles and applications of UV-Vis-NIR, FTIR, FT-Raman, Photoluminescence, NMR, ESR and Light Scattering methods.
II	**Unit II X – ray techniques** X-ray powder diffraction –Quantitative determination of phases; Structure analysis, single crystal diffraction techniques - Determination of accurate lattice parameters - structure analysis-profile analysis - particlesize analysis using Scherer formula- Particle Size Analyzer- Ellipsometry- thickness measurements
III	**Unit III Electron Spectroscopy** X-Ray Photoelectron Spectroscopy, Auger Electron Spectroscopy, X-Ray Characterization of Nanomaterials - EELS– EDAX and WDA analysis - Applications to nanomaterials characterization

IV	**Unit IV Mechanical properties measurement** 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- MD simulation of nanoindentation.
V	**Unit IV Magnetic and electrical properties measurement** Vibration Sample Magnetometer, Impedance Spectroscopy- PPMS, - Measurement of Magnetic and electrical properties of nanomaterials.
Reading List(Print and Online)	1. Introduction to Spectroscopy *dl.iranchembook.ir* › ebook › organic-chemistry-2753 2. An Introduction to Surface Analysis by XPS and AES | Wiley ... *onlinelibrary.wiley.com* › doi › book 3. EPMA - electron probe microanalysis *www.ems.psu.edu* › harbin › EPMA.ppt.pdf 4. Physical Property Measurement System www.mrl.ucsb.edu › instruments › hcapPPMS
mmendedTexts	**References:** 1. Elements of X-ray Diffraction B. D. Cullity, Addison Wesley, 1977 **2. Transmission Electron Microscopy: A Textbook for Materials Science** David B Williams, C Barry Carter, (1996) Plenum Press, New York 3. Impedance Spectroscopy: Theory, Experiment, and Applications, E. Barsoukov and J. Ross Macdonald (Editors) (2000) John Wiley & Sons (P)Ltd. **4. Fundamentals of Fourier Transform Infrared Spectroscopy,** Brian C Smith, (1995) CRC Press **5.** Nanoindentation, By Anthony C Fischercripps, Anthony C. , Springerscience and Bussiness media publications, 2011 **6.** Nanomaterials, Nanotechnologies and Design: An Introduction for Engineers, Daniel L. Schodek, Paulo Ferreira, Michael F. Ashby, Elsevier, 2009.

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	3	2	2	2	2	3	3	3
CO2	3	2	2	3	3	2	3	3	2	2
CO3	3	2	2	3	3	3	3	2	2	2
CO4	3	3	3	2	2	2	3	3	2	3
CO5	3	2	2	3	2	3	2	2	3	3

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	3	3
CO2	3	2	3	3	3
CO3	3	2	3	3	3
CO4	3	2	3	3	3
CO5	3	2	3	3	3
Weightage	15	10	15	15	15
Weighted percentage (rounded of) Course Contribution to Pos	3	2	3	3	3

Strong - 3, Medium – 2, Low - 1

SEMESTER-II

Discipline Centric Elective Course - III

Course Code	**Course Name: INTRODUCTION TO NANOTOXICOLOGY**		**Credits: 3**
Lecture Hours: (L) per week	**Tutorial Hours: (T) per week**	Lab practice Hours: (P) per week	Total: (L+T+P) Hours per week
Course Category:	**Year & Semester:**	Admission Year:	
Pre requisite:	The students who are taking this course should know about the fundamentals of biological cell and tissues and also the basic knowledge in materials.		
Links to other courses			
Learning Objectives:	The main objectives of this course are to: 1. Understanding the basic of Toxoicology and Nano science and differentiate between nanomaterials and bulk materials 2. Evaluate and critically review the theoretical and practical aspects of Nano materials application 3. Comprehending the novel function resulted from the nanoscale structures using scientific and technological principles in Nano toxicology 4. Critically assess and outline the nanoscience for nanotoxicology 5. Demonstrate the new properties of Nano materials and its significance in toxicology		

Course Outcomes	On the successful completion of the course, student will be able to 1. Understanding the basic of Toxoicology and Nano science and differentiate between nanomaterials and bulk materials 2. Evaluate and critically review the theoretical and practicalaspects of Nano materials application 3. Comprehending the novel function resulted from the nanoscale structures using scientific and technological principles in Nano toxicology 4. Critically assess and outline the nanoscience for nanotoxicology 5. Demonstrate the new properties of Nano materials and its significance in toxicology

Course Objectives	**1.** Learn the types of hazard and its application- **2.** Understand the importance of nanotoxicant and its effect inhealth - **3.** Studythe basics of biomolecules and its application in nanotoxicology - **4.** Comprehend the effect of Nanotoxicology – **5.** Understand the response of nanomaterials in Nano engineering devices and evaluate its significance -
Units	**Total -48hrs**
I **10h**	**AREAS OF TOXICOLOGY** Introduction- definition of terms- areas of Toxicology- Toxicant- Types of Toxic hazardous materials- Physical Hazard, Chemical hazard, Biological Hazard, Toxic metabolites, Assessment of Risk- Risk assessment of Nanoparticles and Human Health.
II **10h**	**NANOMATERIALS** Nanoparticles in the Environment- Nanomaterials in the atmosphere, Particle Characterization, Types of Transport, Routes of Exposure, Deposition mechanism, Potential mechanism of Nanosize particle toxicity, Passage through biological Membranes, toxic kinetics.
III **8h**	**NANOPOLLUTION** Nanomaterials in environment, Source of pollution, Transport through environment.
IV **10h**	**NANOMATERIAL EXPOSURE MEASUREMENT** Nano sized materials exposure to human, Measurement methods, Threshold values-permissible limits.
V **10h**	**PORTALS OF NANOMATERIALS ENTRY** Types of portals entry, Target tissue, Routes of entry of nano pollutants, Absorption, Distribution mechanism on target tissue.
Reading List(Print and Online)	https://www.intechopen.com/books/toxicology-new-aspects
Recommended Texts	*1.* Nanotechnology: Health and Environmental Risks, Jo Anne Shatkin, *CRC Press, 2008* ***2.*** Nanotechnology: Environmental Health and Safety, Risks Regulation and Management, **Matthew Hull** and **Diana Bowman, Elsevier, 2010** Principles and Methods of Toxicology. Edited by A.W. Hayes. Taylor and Francis, 2008.

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	3	2	2	2	2	3	3	3
CO2	3	2	2	3	3	2	3	3	2	2
CO3	3	2	2	3	3	3	3	2	2	2
CO4	3	3	3	2	2	2	3	3	2	3
CO5	3	2	2	3	2	3	2	2	3	3

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	3	2	3	3	3
CO2	3	2	3	3	3
CO3	3	2	3	3	3
CO4	3	2	3	3	3
CO5	3	2	3	3	3
Weightage	15	10	15	15	15
Weighted percentage (rounded of) Course Contribution to Pos	3	2	3	3	3

Strong - 3, Medium – 2, Low - 1

SEMESTER-II

Generic Elective course-IV

Course Code	**Course Name: Nanobiotechnology**		**Credits 3**
Lecture Hours : (L) per week	**Tutorial Hours : (T) per week**	Lab practice Hours : (P) per week	Total: (L+T+P) Hours per week
Course Category:	**Year & Semester :**	Admission Year:	
Pre requisite:	The Student should have the fundamental knowledge in biomaterials, Biological Cell, functions of cell, biochemistry of biomolecules and its relation to cell function		
Links to other courses			
Learning Objectives:	The main objectives of this course are to: 1. Acquire the knowledge of the cell biology and application. 2. Explaining the role of cell organelles, metabolism, and bioenergetics. 3. Understanding the about the morphology, structure, of DNA, RNAand different types of nucleic acid. 4. Gaining the knowledge about of glucose, and fatty acid metabolism. 5. Evaluation and comparison of the different enzyme role energy production2		
Course Outcomes	On the successful completion of the course, student will be able to 1. Understanding the basic of Biology and Nano science and differentiate between Nano materials and bulk materials 2. Evaluate and critically review the theoretical and practical aspectsof Nano materials application. 3. Explain the concepts in Nano biotechnology 4. Critically assess and outline the nanotechnology for all areas ofapplication 5. Demonstrate the new properties of Nano materials for next generation needs		
Course Objectives	**1.** Understand the basics of bioinspired strategies for the fabrication of Implants in Nanobiotechnology- **2.** Learn the importance of bioactive nanomaterials in bone grafting and tissue engineering **3.** Recognize the significance of Biomolecules in the fabrication of Nanostructures – **4.** Studythe applications of Polymer nanofibers in Tissue engineering and its merits and demerits- **5.** Know the importance of vesicles and lipids in sensor and also its application in drug delivery – **6.** Understand the overall basics of biomolecules and its application in Nano biotechnology		

Units	**Total -48hrs**
I **9h**	Bio-mineralised Inorganic Nanomaterials – Nanostructures and Dynamicsof Biocompatible surfactant monolayers and bilayers – Bio-interface, Bio-conjugation, Bio-matrix based on bioinspired phospholipids polymers.
II **10h**	Self-assembly of ionic-complementary peptides and their applications in nano-biotechnology –from nanocluster assays to optical biochips for nano-biotechnology –bioactive nanomaterials in bone grafting and tissue engineering- inorganic /polymer nano composites for dental restoration and bone replacement applications.
III **9h**	DNA based artificial nanostructures: fabrication, properties and applications – Nucleic acid engineered nanomaterials and their applications- RNA, DNA
IV **10h**	Protein patterning for applications in biomaterials and biodevices. Polymers nanofibers and their applications in bioengineering – functional polymers for bone tissue engineering applications – applications of nanotechnology in tissue engineering
V **10h**	Vesicles and liposomes in sensor technology –Self-assembling nanostructured injectable polymeric gels for drug delivery - Engineering surface erodable polyanhydrides with tailored microstructure for controlled drug and protein delivery
Reading List(Print and Online)	https://onlinelibrary.wiley.com http :// www.routledgehandbooks.co
Recommended Texts	1. Challa S.S.R. Kumar (Ed) Biological and pharmaceutical nanomaterials : Wiley – VCH Verlag GmbH& Co, KgaA. 2. Ninmeyer C.M, Mirkin C.A (Eds) 2005. Nanobiotechnology 3. H.S. Nalwa (Ed) Handbook of Nanostructured Bioaterials and their applications in Nanobiotechnology, American Scientific Publishers.2005

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	3	3	2	3	3	3
CO2	3	3	2	3	3	3	2	3	2	2
CO3	3	3	2	3	3	3	2	2	2	2
CO4	3	3	2	3	3	3	2	3	2	3
CO5	3	3	2	3	3	3	2	2	3	3

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	2	3
CO2	3	3	2	2	3
CO3	3	3	2	2	3
CO4	3	3	2	2	3
CO5	3	3	2	2	3
Weightage	15	15	10	10	15
Weighted percentage (rounded of) Course Contribution to Pos	3	3	2	2	3

Strong - 3, Medium – 2, Low - 1

Course Code	**Course Name Nanoscience Practical II**		**Credits: 3**
Lecture Hours: (L) per week	**Tutorial Hours: (T) per week**	Lab practice Hours: (P) per week	Total: (L+T+P) Hours per week
Course Category:	**Year & Semester:**	Admission Year:	
Pre requisite:	Fundamental and theoretical knowledge on preparation and characterization techniques		
Learning Objectives:	The main objectives of this course are to: 1. Acquire practical skills in the use of instruments, technologies and methods to fabricate nanomaterials and their characterization 2. Apply the practical knowledge in understanding the structural of the materials 3. Provides opportunities to synthesize the materials using different approaches 4. Master the technical skills in handling lab equipments,characterizing the acquired data and analyze using appropriate tool 5. Understand the role of environmental conditions on the preparation of nanomaterials		

Practical-II	**Synthesis and Characterization of Biomolecules and Biomaterials**
	1. Synthesis of Silver Nanoparticles by Chemical Reduction Method and Their UV-VIS Absorption Studies. 2. Synthesis of Gold Nanoparticles by Chemical Reduction Method and Their UV-VIS Absorption Studies. 3. Synthesis of Silver Nanoparticles by Polyol Method and Their UV-VIS Absorption Studies. 4. Synthesis of zinc oxide Nanoparticles by sol-gel method and characterize using UV-VIS Absorption Studies. 5. Synthesis of silver nanoparticles by using plant extract and UV vis absorption studies 6. Synthesis of silver nanoparticles using bacteria and 7. Study of chemical kinetics using UV- vis spectroscopy.
Reading List(Print and Online)	1. Fundamentals Of Analytical Chemistry - Skoog, West and Holler, Saunders College, Publishing, VII Ed, (1996). 2. Text Book Of Quantitative Inorganic Analysis – A.I. Vogel, Elbs, IVEd., (1985). 3. Physical Chemistry, A. Alberty And R.J. Silbey
mmendedTexts	1. Inorganic Chemistry: Principles of Structure and Reactivity – J.E. Huheey, E.A. Keiter and R.L. Keiter, IVEd. 2. Physical Chemistry, Atkins 3. Text Book Of Quantitative Chemical Analysis – A.I. Vogel, VI Ed,Pearson Education Ltd, 2001

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	3	3	2	3	3	3
CO2	3	3	2	3	3	3	2	3	2	2
CO3	3	3	2	3	3	3	2	2	2	2
CO4	3	3	2	3	3	3	2	3	2	3
CO5	3	3	2	3	3	3	2	2	3	3

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	2	3
CO2	3	3	2	2	3
CO3	3	3	2	2	3
CO4	3	3	2	2	3
CO5	3	3	2	2	3
Weightage	15	15	10	10	15
Weighted percentage (rounded of) Course Contribution to Pos	3	3	2	2	3

Strong - 3, Medium – 2, Low – 1

Skill enhancement Course – I

RESEARCH METHODOLOGY

Semester	Course Code	Title of the Course	Core/Elective/ Soft Skill	Credits
		RESEARCH METHODOLOGY	**Soft skill**	**2**

Learning objectives	On completion of this course the students will be able to: 1. Understand the aims and objectives research and formulate a research work plan in a scientific manner. 2. Generate good research hypothesis, design appropriate experiments, collect and interpret the data to validate their experiments. 3. Process the data using computer software, analyze the data and critically examine the hypothesis and the conclusions. 4. Obtain and evaluate information from a variety of databases. 5. Communicate effectively in a variety of forms like research publications, patents, etc.
Title of the Course:	**RESEARCH METHODOLOGY**
Credits:	2
Course Objectives	1. To help students in formulation of research aims and objectives in an appropriate manner. 2. To help the students in framing good research hypothesis. 3. To inculcate knowledge of scientific methodology in analysing research data. 4. To impart the knowledge of sampling techniques and record scientific data in a proper way 5. To acquaint the students with chemistry related software and online scientific databases like Scifinder, Cambridge Structural Database (CSD) etc.
	Units

I	**Foundations of Research: (9 h)** Meaning, Objectives, Motivation, Utility. Concept of theory, empiricism,

	deductive and inductive theory. Characteristics of scientific method – Understanding the language of research – Concept, Construct, Definition, Variable. Research Process Problem Identification & Formulation – Research Question – Investigation Question – Measurement Issues – Hypothesis – Qualities of a good Hypothesis – Null Hypothesis & Alternative Hypothesis. Hypothesis Testing – Logic & Importance.
II	**Research Design: (9 h)** Concept and Importance in Research – Features of a good research design – Exploratory Research Design – concept, types and uses, Descriptive Research Designs – concept, types and uses. Experimental Design: Concept of Independent & Dependent variables. Qualitative and Quantitative Research: Qualitative research – Quantitative research – Concept of measurement, causality, generalization, replication. Merging the two approaches. Measurement: Concept of measurement– what is measured? Problems in measurement in research – Validity and Reliability. Levels of measurement – Nominal, Ordinal, Interval, Ratio.
III	**Sampling and data analysis: (9 h)** Concepts of Statistical Population, Sample, Sampling Frame, Sampling Error, Sample Size, Non Response. Characteristics of a good sample. Probability Sample – Simple Random Sample, Systematic Sample, Stratified Random Sample & Multi-stage sampling. Determining size of the sample – Practical considerations in sampling and sample size. Data Analysis: Data Preparation – Univariate analysis (frequency tables, bar charts, pie charts, percentages), Bivariate analysis – Cross tabulations and Chi-square test including testing hypothesis of association.
IV	**Interpretation of Data and Paper Writing : (9 h)** – Layout of a Research Paper, Impact factor of Journals, When and where to publish? Ethical issues related to publishing, Plagiarism and Self-Plagiarism. Forms and types of scientific reports. Steps involved in scientific article writing. Publication process, selection of journals. Writing research proposals and steps involved. Dissertation/Thesis writing: format, content and chapterization. Bibliography and references, referencing styles. Appendices.
V	**Use of tools / techniques for Research: : (9 h)** methods to search required information effectively, Reference Management Software like Zotero/Mendeley, Software for paper formatting like LaTeX/MS Office, Software for detection of Plagiarism.
Recommended Texts	1. Business Research Methods – Donald Cooper & Pamela Schindler, TMGH, 9th edition 2. Business Research Methods – Alan Bryman & Emma Bell, Oxford University Press. 3. Research Methodology – C.R.Kothari, New Age International, New Delhi, 2014. 4. Kumar, R. Research Methodology–A Step-By-Step Guide for Beginners; 2nd Ed., Pearson Education: New Delhi, 2005. 5. Montgomery, D. C. Design & Analysis of Experiments; 8th Ed., Wiley India: Noida, 2013.

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	3	3	2	3	3	3
CO2	3	3	2	3	3	3	2	3	2	2
CO3	3	3	2	3	3	3	2	2	2	2
CO4	3	3	2	3	3	3	2	3	2	3
CO5	3	3	2	3	3	3	2	2	3	3

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	2	3
CO2	3	3	2	2	3
CO3	3	3	2	2	3
CO4	3	3	2	2	3
CO5	3	3	2	2	3
Weightage	15	15	10	10	15
Weighted percentage (rounded of) Course Contribution to Pos	3	3	2	2	3

Strong - 3, Medium – 2, Low - 1

SEMESTER-III

Core Paper VII - Nanoelectronics and Nano sensors		II YEAR - THIRD SEMESTER						
Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**Credits**	**Inst. Hours**	**Marks**
	Nanoelectronics and Nano sensors	Core				5	5	75

Pre Requisites

Basics of electronics, electronic devices and basic ideas on sensors.

Learning Objectives

The main objectives of this course are to:

1. Learning New Perspective in Nanoelectronics
2. Explaining the size and shape enabled properties of nanomaterials
3. Understanding the functioning of various electronic devices.
4. Understanding and assessment of electronic properties for sensordevelopment and application.
5. Compare and evaluate the nano enabled electronic properties fordevelopment of smart devices.
6. Conceptualization of nanoscale electronic phenomena for societalapplications

Course outcome

On the successful completion of the course the students will be able to:

CO1: Describe the principles of nanosensors.
CO2: Analyze the different types of nanodevices for applications.
CO3: Discuss about electronic and photonic materials.
CO4: Describe about the basics of nanosensors
CO5: Relate the application of nanosensors.

	Units
I	BASIC CONCEPT OF NANOELECTRONICS New Perspectives- New Ohm's Law- Densityof states- Fermic Function- Types of Conductance- Ballastic Conductance- Resistance: Ballistic to Diffusive- Nanotransistors
II	SEMICONDUCTOR NANODEVICES Nano Scale MOSFET – Single-Electron Transistors; Nanorobotics and Nanomanipulation; Molecular Nanowires-Organic LED, Organic FETs-CNT And Graphene FET, Si NW FET.
III	ELECTRONIC AND PHOTONIC MATERIALS Single Electron Tunnelling Phenomena- Coulomb Blockad - RSD and Resonant Tunnelling Transistor- Quantum Structures Based LEDs - OLED and Photo Detectors- Magnetic Quantum Dots andTheir Applications.
IV	NANOSENSORS BASICS Micro and Nano - Sensors, Fundamentals of Sensors, Biosensor, MEMS And NEMS, Packaging and Characterization of Sensors, Method of Packaging At Zero Level, Dye Level And First Level,Temperature Sensors, Heat Sensors.

V	NANOSENSORS Electromagnetic Sensors, Electrical Current Sensors, Electrical Voltage Sensors, Electrical Power Sensors, Magnetism Sensors - Mechanical Sensors -Pressure Sensors, Gas and Liquid Flow Sensors, Position Sensors - Chemical Sensors - Gas Sensor, Bio Sensors - DNA Based Biosensors
Recommended Texts	1. Introduction To Molecular Electronics, M.C. Pettey 2. The Physics And Chemistry Of Nanosolids, Frank J. Owens AndCharles P. Poole Jr., Wiley Interscience (2006) 3. Nanotechnology Enabled Sensors, Kouroush Kalantar – Zadeh,Benjamin Fry, Springer (2007)

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	3	3	2	3	3	3
CO2	3	3	2	3	3	3	2	3	2	2
CO3	3	3	2	3	3	3	2	2	2	2
CO4	3	3	2	3	3	3	2	3	2	3
CO5	3	3	2	3	3	3	2	2	3	3

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	2	3
CO2	3	3	2	2	3
CO3	3	3	2	2	3
CO4	3	3	2	2	3
CO5	3	3	2	2	3
Weightage	15	15	10	10	15
Weighted percentage (rounded of) Course Contribution to Pos	3	3	2	2	3

Strong - 3, Medium – 2, Low - 1

SEMESTER III

Core Paper VIII - Properties Of Nanomaterials	**II YEAR - THIRD SEMESTER**

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**Credits**	**Inst. Hours**	**Marks**
	Properties of Nanomaterials	Core				5	5	75

Pre requisite:

Basics of atom model,basics of electrical and magnetic materials

Learning objectives:

1.To Understand the various properties of nanomaterials such as electrical, magnetical,optical ,mechanical and thermal properties.

2. To understand the characterized property related to the nanomaterials,

Course Outcomes:

On the successful completion of the course, student will be able to:

CO1	Analyse the electrical and magnetic properties of nanostructured materials
CO2	Relate the physical properties of nanostructred materials.
CO3	Describe various magnetic properties of materials.
CO4	Distinguish various characterization techniques involved in nanomaerials.
CO5	Demonstrate the skills required for the characterizing the nanomaterial.

Unit:1	**Electrical and Dielectric properties**	

Electrical: Temperature Coefficient of Resistance–Resistivity–Arrhenius Relation–Activation Energy; Dielectrics: Types of Polarization–Dielectric Constant–Dielectric Loss–Dielectric Breakdown–Double Schottky potential Barrier Height Model.

Unit:2	**Magnetic Properties**	

Origin of Magnetism in material – Classification – Magnetic Moment – Magnetic Hysteresis – Magnetostriction – Curie Transition – Neel Temperature –Giant and Colossal Magnetoresistance– Superparamagnetism–Magnetic phenomena at Nanoscale.

Unit:3	**Optical Properties**	

Optical phenomena in Materials–Surface Plasmon Resonance–Bandgap tailoring–Burstein – Moss Effect – Direct and Indirect Transitions – Effective Mass Approximation Theory – Kubelka – Munk function – isobestic effect – Hyper, Hypso, Batho and Hypochromic effects –Fluorescence: Stoke shift.		
Unit:4	**Mechanical Properties**	
Mechanical: Modes of deformation – Elastic and plastic deformation – Compressive strength-Mechanical stiffness–Fracture–Toughness–Superplasticity–Hardness–Micro-hardness–Fracture–Toughness –Indentation –Hall-petch Relation.		
Unit:5	**Thermal Properties**	
Thermal: Thermal conductivity–Expansion–Stress–Specific Heat Capacity–Glass Transition Temperatures–Melting-point Depression.		

Text Book(s)	
1	Springer Handbook of Nanotechnology- Ed. by B. Bhushan, Springer-Verlag (2004)
2	Magnetic Materials: Fundamentals and Applications by Nicola A. Spaldin, Cambridge University Press, 2nd Edition, (2018)
3	The Chemistry of Nanomaterials: Synthesis, Properties and Applications, C.N.R. Rao, A.Muller, A. K. Cheetham (Eds), Wiley-VCH Verlag (2004)
4	Dan Guo *et al*, Journal of Physics D: Applied Physics (2018) Vol. 47, 013001
Reference Book(s)	
1.	Impedance Spectroscopy: Theory, Experiment, and Applications, E Barsoukov and JRoss MacdonaldWiley (2018)
2.	H. Gleiter, Progress In Materials Science, Vol.33, p.223 (1989)
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	NPTEL: Defect Structure & Mechanical Behaviour of Nanomaterials https://www.youtube.com/watch?v=bwZW96c743A
2	YOUTUBE: Introduction to Nanomaterials https://www.youtube.com/watch?v=qUEbxTkPIWI

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	3	2	2	2	2	3	3	3
CO2	3	2	2	3	3	2	3	3	2	2
CO3	3	2	2	3	3	3	3	2	2	2
CO4	3	3	3	2	2	2	3	3	2	3
CO5	3	2	2	3	2	3	2	2	3	3

Strong - 3, Medium – 2, Low – 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	3	3
CO2	3	2	3	3	3
CO3	3	2	3	3	3
CO4	3	2	3	3	3
CO5	3	2	3	3	3
Weightage	15	10	15	15	15
Weighted percentage (rounded of) Course Contribution to Pos	3	2	3	3	3

Strong - 3, Medium – 2, Low - 1

SEMESTER-III

Core Paper IX - CHARACTERIZATION TECHNIQUES OFNANOMATERIALS-II	II YEAR - THIRD SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
	CHARACTERIZATION TECHNIQUES OF NANOMATERIALS-II	Core				5	5	75

Pre requisite:
The student should have the fundamental knowledge in lattice parmeters and microscopic techniques and basic understanding in properties of materials.

Learning Objectives:

The main objectives of this course are to:

1. Visualize the nanomaterials to understand the morphology
2. Understand nanostructure of materials
3. Understand the microstructure of materials
4. Reveal the thermal behavior of the nanomaterials
5. Studying bio-materials using proper tools

Course Outcome
On the successful completion of the course, student will be able to:

CO1: Describe the purpose of characterization for the given materials
CO2:Explore the properties of nanomaterials for the particular applications

CO3:Understand the instrumentation involved in the characterizationtechnique.
CO4: Understand the suitability of the characterization for the particularmaterial.
CO5:Relate the interpretation of the results obtained from the characterization

Units	
I	**Unit I Morphological studies** Principles, Overview of Instrumentation and Sample preparation, Experimental techniques adopted in: Scanning Electron Microscopy: SEM -Transmission Electron Microscopy (TEM) – HRTEM- Nanomanipulator- Nanotweezers
II	**Unit II Materials defects studies** Scanning Tunnelling Microscopy (STM), Atomic Force MicroscopyAFM)-Non-contact-contact-Tapping- conducting mode-. Near Field Scanning Optical Microscopy; Scanning capacitance Microscopy- Magnetic Force Microscopes MFM)- Chemical Force Microscope (CFM).

III	**Unit III Microscopic characterization** Optical microscopes- Use of polarized light microscopy – Phase contrast microscopy – Interference Microscopy – hot stage microscopy - surface morphology – Etch pit density and hardness measurements- Confocal Microsocopes.
IV	**Unit IV Thermal analysis** Principle and Instrumentation of Thermogravimetry; Differential Thermal Analysis and Differentia scanning calorimetry-Importance of thermal analysis for nanostructures.
V	**Unit V Bio-materials characterization** New Advances and challenges in biological and biomedical materials characterizations- Dynamic light scattering spectroscopy. Confocal Microscopes - Confocal Raman – Application in Nanobiotechnology. Fluorescence Microscope

Related Online Contents

www.technologynetworks.com › sem-vs-tem-331262 *onlinelibrary.wiley.com* › abs › 9780470022184.hmm319www.umassmed.edu › maps › confocal-explanation

Text book and References:

1. Nanotechnology: basic science and emerging technologies-Mick Ailson, Kamali Kannangara, Geoff Smith, Michelle Simmons, Burkhard Raguse, Overseas Press (2005)
2. Nanocomposite science and technology, Pulickel M.Ajayan, Linda S.Schadler, Paul V.Braun, Wiley-VCH Verlag, Weiheim (2003).
3. 'Advanced X-ray Techniques in Research and Industries' by A.K.Singh (ed.)
4. 'Transmission Electron Microscopy of Materials' by G.Thomas
5. Physical Principles of Microscopy: An introduction to TEM, SEM and AFM by R.F.Egerton
6. 'Instrumental Methods of Analysis (7^{th}edn.)' by Willard, Merritt, dean and Settle
7. Scanning Electron Microscopy and X-ray Microanalysis' by J.Goldstein
8. S.L. Flegler, J.W. Heckman and K.L. Klomparens, "Scanning andTransmission Electron Microscopy: An Introduction",WH Freeman & Co, 1993.
9. P.J.Goodhew, J.Humphreys, R.Beanland, "Electron Microscopy andAnalysis",
10. R.Haynes, D.P.Woodruff and T.A.Talchar, "Optical Microscopy ofMaterials", Cambridge University press, 1986.
11. R.M.Rose, L.A.Shepard and J.Wulff, "The Structure and Properties ofMaterials", Wiley Eastern Ltd,

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	3	2	2	2	2	3	3	3
CO2	3	2	2	3	3	2	3	3	2	2
CO3	3	2	2	3	3	3	3	2	2	2
CO4	3	3	3	2	2	2	3	3	2	3
CO5	3	2	2	3	2	3	2	2	3	3

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	3	2	3	3	3
CO2	3	2	3	3	3
CO3	3	2	3	3	3
CO4	3	2	3	3	3
CO5	3	2	3	3	3
Weightage	15	10	15	15	15
Weighted percentage (rounded of) Course Contribution to Pos	3	2	3	3	3

Strong - 3, Medium – 2, Low – 1

Core Paper X - Nanoscience Practical III	II YEAR - THIRD SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
	Nanoscience Practical III	Core				4	6	50 +50

Pre requisite:	Fundamental and theoretical knowledge on preparation and characterization techniques
Learning Objectives:	The main objectives of this course are to: 1. Acquire practical skills in the use of instruments, technologies andmethods to fabricate nanomaterials and their characterization 2. Apply the practical knowledge in understanding the structural ofthe materials 3. Provides opportunities to synthesize the materials using differentapproaches 4. Master the technical skills in handling lab equipments,characterizing the acquired data and analyze using appropriate tool 5. Understand the role of environmental conditionson thepreparation of nanomaterials
Course Outcome	On the successful completion of the course, student will be able to: CO1: To synthesis nanomaterials by different methods. CO2: To synthesis thin films using different techniques CO3: To synthesis various nanocomposites CO4: To characterize structurally the nanoparticles prepared and analysis their size and lattice parameters CO5: To characterize the nanomaterials prepared electrically and optically.

Part:1	**Synthesis of Nanostructured materials**	
	1. Preparation of Nanoparticles by Sol-Gel Method. 2. Synthesis of Nanoparticles by co-precipitation method 3. Nanostructured thin film preparation by dip coating technique. 4. Synthesis of nanoparticles using domestic microwave oven. 5. Preparation of Nanocomposites by solvothermal method.	

Part:2	**Characterization of Nanomaterials**	
	1. X-Ray powder diffraction pattern analysis and lattice parameters determination of nanoparticles. 2. Impedance measurement and analysis using Cole-Cole plot method 3. Dielectric constant measurement at various temperatures with various frequencies. 4. Band gap studies of Metal oxide semiconductors using UV-Vis Spectroscopy 5. DC conductivity measurements of nanoparticles at various temperatures	
Reading List(Printand Online)	1. Fundamentals Of Analytical Chemistry - Skoog, West and Holler,Saunders College, Publishing, VII Ed, (1996). 2. Text Book Of Quantitative Inorganic Analysis – A.I. Vogel, Elbs, IVEd., (1985). 3. Physical Chemistry, .A. Alberty And R.J. Silbey	

RecommendedTexts	1. Inorganic Chemistry : Principles Of Structure And Reactivity – J.E.Huheey, E.A. Keiter and R.L. Keiter, IVEd. 2. Physical Chemistry, Atkin 3. Text Book Of Quantitative Chemical Analysis – A.I. Vogel, VI Ed,Pearson Education Ltd, 2001

Lab Manuals	
1	Das, S. and Saha, R. 2020. Microbiology Practical Manual. CBS Publishers and Distributors (P) Ltd., New Delhi, India.
2	Arora, B. and Arora, D.R. 2009. Practical Microbiology. 2nd ed. CBSPublishers and Distributors (P) Ltd., New Delhi, India.
3	Jha, D. K. Laboratory Manual on Plant Pathology. 2nd ed. Pointer Publishers,Jaipur, India.
4	Chmielewski, J. G. and Krayesky, D. 2013. General Botanylaboratory Manual. AuthorHouse, Bloomington, USA.
5	Jha, D. K. 2018. Laboratory Manual on Plant Pathology (English). Pointer Publishers, Jaipur.
6	McMahon, K., Levetin, E. and Reinsvold, R. 2001. Laboratory Manual forApplied Botany. McGraw-Hill Education, New York, USA.
7	Bendre, A. M. 2010. A Text Book Of Practical Botany – 1. Rastogi Publications, Meerut, India.
8	Sivakumar, K. 2016. Algae- A Practical Approach. MJP Publishers, Chennai,India.
9	Gupta, V.K., Tuohy, M.G., Ayyachamy, M., Turner, K.M. and O'Donovan, A. 2013.Laboratory Protocols in Fungal Biology: Current Methods in Fungal Biology. Springer, London, UK.
10	Garg, N., Garg, K. L. and Mukerji, K. G. 2010. Laboratory Manual of Food Microbiology. IK International Publishing House Pvt. Ltd., New Delhi, India.

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	3	3	2	3	3	3
CO2	3	3	2	3	3	3	2	3	2	2
CO3	3	3	2	3	3	3	2	2	2	2
CO4	3	3	2	3	3	3	2	3	2	3
CO5	3	3	2	3	3	3	2	2	3	3

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	2	3
CO2	3	3	2	2	3
CO3	3	3	2	2	3
CO4	3	3	2	2	3
CO5	3	3	2	2	3
Weightage	15	15	10	10	15
Weighted percentage (rounded of) Course Contribution to Pos	3	3	2	2	3

Strong - 3, Medium – 2, Low - 1

Elective course – V (Choose Anyone)

Elective V (A): Advanced Nanomaterials for Nanotechnology	**II YEAR - THIRD SEMESTER**

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**Credits**	**Inst. Hours**	**Marks**
	Advanced Nanomaterials for Nanotechnology	Elective				3	5	75

Pre requisite:	The student should have the fundamental knowledge in nanomaterials used in the field of nanotechnology like magnetic, electric nanomaterials sensors and medical devices
Learning Objectives:	The main objectives of this course are to: 1. Know about magnetism and its properties 2. Gain knowledge in thermoelectric materials 3. Understand the properties of polymeric nanoparticles 4. Create knowledge in application of nanomaterials 5. Gain theoretical knowledge in the development of biosensors and their uses in medical field.
Course Outcome	CO1: Understand the properties of nanostructured magnetism CO2:Development of knowledge about magnetosomes. CO3: Learn about working and types of biosensors CO4: Applications of various nanomaterials in medical field CO5:Demonstrate the pharmaceutically important nanomaterials as therapeutic agents

Units	
I	**Nanostructured Magnetism**: Nanostructure magnetism, Effect Bulk nanostructuring of magnetic property, Giant and colossal magnetic resistance,Nanomagnetic materials, Paramagnetism in metallic nanoparticles.
II	**Thermoelectric Materials:** Concept of phonon, Thermal conductivity specificheat, exothermic and endothermic processes, Different types of thermoelectric materials, One dimensional and composite thermoelectric materials and Applications.
III	**Structure Properties of Polymeric Nanomaterials** stress-strain behavior of polymer nanomaterials, glass transition temperature and relationship between Tm and Tg. Effect of molecular weight, property requirements and its utilization. Synthetic procedure for commercial polymers, Fire retarding and biomedical polymers.
IV	**Nanocomposites** Definition of nanocomposites - Types of nanocomposites – Synthesis of nanocomposites: Direct mixing, solution mixing, In-situ polymerization - Polymer/ Metal oxide nanocomposites, diblock copolymer based nanocomposites, Polymer/CNTs and Polymer/Nanoclay basedcomposites.
V	**Nanotechnology for biophotonics** The interface of bioscience, nanotechnology and photonics - Semiconductor quantum dots for bioimaging – Metallic nanoparticles and nanorods for Biosensing - Inorganic nanoparticles – Pebble nanosensors for Invitro Bioanalysis - Nanoclinics for optical diagnostics and Targeted therapy
Reading List (Print and online)	. Solid state electronic device, Ben G Streetman, Prentice Hall of IndiaPvt Ltd., New Delhi 1995. Organic Photovoltaics Biophotonics, Optical Science and Engineering for the 21st Century, (Ed.) Xun Shen and Roeland Van Wijk, NANO BIOPHOTONICS: Science and Technology, (Eds) Hiroshi Masuhara, Satoshi Kawata and Fumio Tokunaga, Elsevier (2007). Polymer-Clay Nanocomposites, T.J. Pinnayain, G.W.Beall, Wiley, New York, 2001. Composite Materials, Deborah D.L.Chung, Springer, 2002.

Recommended Texts	References 1. Semiconductor for solar cells, H J Moller, Artech House Inc, MA, USA, 1993. 2 Materials, Device Physics and Manufacturing Technologies, (eds. C. Brabec, V. Dyakonov, U. Scherf), 2nd Ed., Wiley-VCH, Germany, 2014. 3. Text Book of Polymer Science, F.W. Billmeyer Jr, Wiley. 4. Polymer Science, V.R. Gowariker, N.V. Viswanathan and J. Sreedhar, Wiley-Eastern. 5. Introduction to Biophotonics, Paras N. Prasad, John Wiley and Sons, New Jersey, (2003 6. Nanocomposites - Science and Technology - P. M. Ajayan, L.S. Schadler, P. V. Braun, Wiley-VCH, 2004.

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	3	3	2	3	3	3
CO2	3	3	2	3	3	3	2	3	2	2
CO3	3	3	2	3	3	3	2	2	2	2
CO4	3	3	2	3	3	3	2	3	2	3
CO5	3	3	2	3	3	3	2	2	3	3

Strong - 3, Medium – 2, Low – 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	2	3
CO2	3	3	2	2	3
CO3	3	3	2	2	3
CO4	3	3	2	2	3
CO5	3	3	2	2	3
Weightage	15	15	10	10	15
Weighted percentage (rounded of) Course Contribution to Pos	3	3	2	2	3

Strong - 3, Medium – 2, Low – 1

Elective V (B): Biomaterials and Nanobiotechnology for Tissue Engineering	II YEAR - THIRD SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
	Biomaterials and Nanobiotechnology for Tissue Engineering	Elective				3	5	75

Pre requisite:	Fundaments of biomaterials, basics in biological cell, tissues and the metabolism of carbohydrates and Proteins and also able to understandthe mechanism of cellular function
Learning Objectives:	The main objectives of this course are to: Learn the types of biomaterials, biomaterial used in implantandits application in orthopedics and dental- Understand the importance of biomaterials used for cartilage and Vascular implant and its mode of failure-
Course Outcomes	On the successful completion of the course, student will be able to CO1:Understand the basic of Biology and Nano science anddifferentiate between nanomaterials and bulk materials CO2: Evaluate and critically review the theoretical and practicalaspectsof Nano materials application CO3: Comprehending the novel function resulted from the nanoscalestructures using scientific and technological principles in Nano biotechnology CO4:Critically assess and outline the nanotechnology for all areas of application CO5: Understand the basics of tissue engineering and its application invitalorgans and mode of bladder implant failure

Unit	
I	**MATERIALS FOR IMPLANT** Orthopedic implants – material s used – modes of failure – wear debris, stress and strain imbalances at the tissue implant interface. Dental: Dental materials used – modes of dental implant failure – debris, stress and strain imbalances at the tissue implant interface
II	**CARTILAGE IMPLANT** Cartilage materials used – modes of cartilage implant failure –wear debris, stress and strain imbalances at the tissue implant interface; Vascular materials used – modes of vascular implant failure – wear debris; stress and strain imbalances at the tissue implant interface
III	**BLADDER IMPLANT** Bladder overall view, Bladder implant materials used – modes of bladder implant failure – stress and strain imbalances at the tissue implant interface
IV	**BIOLOGICAL EFFECT OF NANOMATERIALS** Biological response of Nanomaterials used as implants – biological response of implanted materials – desirable and undesirable reactions of the body with implanted materials: Protein interactions with implanted Materials
V	**ADVANTAGE OF NANOMATERIALS**
	Advantages of Nanomaterials used as implants - cellular recognition of Proteins Adsorbed on material surfaces – adhesion – migration differentiation – Cellular Extra cellular Matrix deposition leading to tissue regeneration – foreign-body response – inflammatory response

Reading List(Print and Online)	https://www.verywellhealth.com/tissue-engineering-4580368 https://www.liebertpub.com/doi/10.1089/ten.tec.2019.0344
Recommended Texts	1. William A. Goddard, Sergey Edward Lyshevski, Donald W Brenner (Ed) Handbook of Nanoscience, Engineering and Technology CRC press 2003 2. Joachim Schummer, Davis Baird (Ed) Nanotechnology Challenges: implications for philosophy, Ethics and society ; World scientific ; 2006 3. William Sims Bainbridge, Mihail C. Roco (Ed) Societal implication of Nanosciences and Nanotechnology;Springer;2001 4. Jon J. Kellar (Ed) Functional fillers and nanoscale minerals; new markets/ new horizonsSME science; 2006 5. Davis Baird, Alfred Nordmann, Joachim Schummer (Eds) Discovering the nanoscale; IOP press; 2004

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	3	3	2	3	3	3
CO2	3	3	2	3	3	3	2	3	2	2
CO3	3	3	2	3	3	3	2	2	2	2
CO4	3	3	2	3	3	3	2	3	2	3
CO5	3	3	2	3	3	3	2	2	3	3

Strong - 3, Medium – 2, Low – 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	2	3
CO2	3	3	2	2	3
CO3	3	3	2	2	3
CO4	3	3	2	2	3
CO5	3	3	2	2	3
Weightage	15	15	10	10	15
Weighted percentage (rounded of) Course Contribution to Pos	3	3	2	2	3

Strong - 3, Medium – 2, Low - 1

Semester III

Skill Enhanced course – II

SEC II: Green Manufacturing Technology	**II YEAR - THIRD SEMESTER**

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**Credits**	**Inst. Hours**	**Marks**
	Green Manufacturing Technology	SEC				2	4	75

Pre requisite:	Basics of environmental sciences,social work ,waste issues.
Learning Objectives	1. To create awareness in current green practices in manufacturing industry 2. To acquire knowledge in International green manufacturing standard and Process 3. To enlighten the students with knowledge about water pollution and its effects on the environment 4. To introduce the concept of environmental design and industrial ecology. 5. To impart knowledge about green plastics and nanocomposites manufacturing from plants and microbes.
Course Outcomes	On completion of this course the students will be able to: CO1: Identify waste and pollutants CO2:Recognize the opportunities to improve efficiency. CO3: Understand life cycle impacts and Conserve resources. CO4: Prevent pollution and improve the quality level. CO5: Keep a direct control on the quality of the formulation and assuring thecompliance of standards
	Units
I	GREEN MANUFACTURING TRENDS Green Manufacturing: Fundamentals and Applications - basic definitions and issues surrounding green manufacturing at the process, machine and system - government motivations for green manufacturing – traditional manufacturing to green manufacturing -economic issues.
II	SUSTAINABLE GREEN MANUFACTURING Green Manufacturing processes, requirements and risk, International green manufacturing standards and compliance, Green rapid prototyping and rapid manufacturing, Green flexible automation, Green Collaboration Processes. Sustainable Green Manufacturing System.

III	WASTE MANAGEMENT Sustainability and global conditions, Materials and Solid waste Management, Energy Management, Chemical Waste Management, and green chemistry, Water pollutants and their effects. Measurement of DO, BOD, COD and Pesticides as water Pollutants. Water supply and Waste-water Management
IV	INDUSTRIAL ECOLOGY Material flow in Chemical Manufacturing, Industrial Parks, Assessing opportunities for waste exchanges and by-product synergies, Regulatory, social and business environment for green manufacturing. Green Supply chains. Present state of green Manufacturing.
V	GREEN PLASTICS AND NANOCOMPOSITES Introduction to commercial plastics and elastomers, Natural Rubber, Modified Naturalrubber and bends.Plastics from Vegetable oils, cellulose and starch-based materials. Nanocomposites: Natural fillers, Fibres and clay nanocomposites, biodegradability, life cycle assessment of using natural materials
Recommended Texts	1. T. David Allen and David R. Shonnard, Green engineering, Prentice Hall NJ, (2002). 2. David Dornfeld, Green manufacturing fundamental and applications, Prentice hall (2002). 3. G. Sammy Shinga, Green electronics design and manufacturing, Prince publications (2008). 4. James clark, Green chemistry, Blackwell publishing (2008). 5. Paulo Davim, Sustainable Manufacturing, Wiley publications (2010). 6. Frank Kreith, George Tchobanoglous, Solid waste management, McGraw Hill (2002). 7. E. S. Stevens, Green plastics, Princeton university press (2002). 8. U. Robert Ayres, A Handbook of Industrial Ecology, Edward elgar publishing (2002).

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	3	1	3	3	2	3	3	3
CO2	2	2	2	2	3	3	3	3	3	2
CO3	2	2	2	3	3	3	2	2	2	2
CO4	2	3	2	3	3	3	2	3	2	3
CO5	2	2	2	3	3	3	2	2	3	3

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	2	3
CO2	2	3	2	2	2
CO3	3	2	3	3	2
CO4	3	3	2	2	3
CO5	3	3	3	2	3
Weightage	14	14	13	11	13
Weighted percentage (rounded of) Course Contribution to Pos	3	3	2	2	3

Strong – 3, Medium – 2, Low - 1

SEMESTER-IV

Core Paper XI - Biomedical Nanotechnology	II YEAR – FOURTH SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
	Biomedical Nanotechnology	Core				4	6	75

Pre requisite:	Fundamental knowledge in biomaterials, Biological Cell, functions of cell.
Learning Objectives:	**1.** To study the basic of Bioceramics for implant coating. **2.** To understand about drug delivery and usage. **3.** To understand about the pharmacy related biomaterials. **4.** To outline the nanotechnology in the area of Drug delivery

Course Outcomes	On the successful completion of the course, student will be able to CO 1: Discuss the basic of Biomedical sciences and their usage in different fields. CO2: Evaluate and critically review the theoretical and practicalaspects of Nano materials in biomedical application application. CO3: Summarize the concepts in Biomedical nanomaterials in pharmacy. CO4: Critically assess and outline the nanotechnology for allareas of biomedical application CO5: Demonstrate the new properties of Nano materials for next generation medical needs
Units	
I	BIO CERAMICS FOR IMPLANT COATING Calcium phosphate, hydroxy epilates Ti_6Al_4V biomedical alloys - implant tissue interfacing – metal organic CVD – osteoporosis – osteoplastic – regeneration of bones by using bio compactable ceramics

II	TISSUE ENGINEERING Scaffolds for tissue fabrications – materials for scaffolds – materials for hydrogel scaffolds – scaffolds fabrications technologies – nano-featured and bioactive scaffolds – nano-fiber scaffolds – nanocomposite scaffolds – scaffolds for stem cells – micro and nanopatterned scaffolds - scaffolds and stem cells – fibrous proteins and tissue engineering
III	DRUG DELIVERY Diagnosis of diseases, treating and preventing of diseases – targeted for drug delivery – ligand coupled nanoparticle features – methods for coupling targeting ligands to nanoparticles – targeting modalities – barriers totumor targeting *in vivo* – MRI contrast enhancement – Gene delivery
IV	NANOPHARMACY Bio interactive hydro gels – PEG coating and surface modifications –PEG hyrogels patterned on surfaces- Nanopharmacy- multi-targeted drugs – delivery of nucleic acids – interaction of organic molecules of the drug with pathological tissue
V	NANOMEDICINE Formation of nucleic acid core particle – protective steric coating – surface exposed ligands targeting specific tissues –biocompatible core-shell nanoparticles for medicine – configuration of core – shell structure with different cores, shells and biomolecules-least toxicity- nanocapsules.

Reading List(Printand Online)

https://link.springer.com/content/pdf/10.10090Fs11834-013-6063- 0.pdf
http://nopr.niscair.res.in/bitstream/123456789/5224/1/IJEB2045(2)20160-165.pdf

RecommendedTexts

1. Robert.W.Kelsall, Ian.W.Hamley, Mark Geoghegan (Ed),
2. NanoScaleScience And Technology, John Wiley and son, ltd., 2005
3. H.Fujita (Ed), Micromachines As Tools For Nanotechnology,Springer, 2003
4. Mick Wilson Kamali Kannangara Geooff Smith Michelle, SimmonsUrkhard Raguse, Nano Technology, Overseas India private Ltd.,2005.
5. Gunter Schmid , Nano Particles, Jhon wiley and sons limited, 2004
6. K.K.Jain, Nano Biotechnology, Horizions Biosciences, 2006
7. Malsch, N.H., "Biomedical Nanotechnology", CRC Press. (2005).
8. Mirkin, C.A. and Niemeyer, C.M., "Nanobiotechnology II: MoreConcepts and Applications", Wiley-VCH. (2007)
9. Kumar, C. S. S. R., Hormes, J. and Leuschner C., "Nanofabrication Towards Biomedica Applications: Techniques, Tools, Applications, and Impact", WILEY -VCH Verlag GmbH & Co (2005).

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	3	3	2	3	3	3
CO2	3	3	2	3	3	3	2	3	2	2
CO3	3	3	2	3	3	3	2	2	2	2
CO4	3	3	2	3	3	3	2	3	2	3
CO5	3	3	2	3	3	3	2	2	3	3

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	3	3	2	2	3
CO2	3	3	2	2	3
CO3	3	3	2	2	3
CO4	3	3	2	2	3
CO5	3	3	2	2	3
Weightage	15	15	10	10	15
Weighted percentage (rounded of) Course Contribution to POs	3	3	2	2	3

Strong - 3, Medium – 2, Low – 1

SEMESTER-IV

Core Paper XII - Industrial Nanotechnology	II YEAR – FOURTH SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
	Industrial Nanotechnology	Core				4	6	75

Pre requisites:	Basics in semiconductor materials, magnetic materials
Learning Objectives:	The main objectives of this course are to: 1. Identification of industrially relevant materials 2. Summarize suitability of nanomaterials for industries. 3. Interpretation and employment of nanomaterials for industrialneeds 4. Understanding the role of different nanomaterials for industrial applications
Course Outcome	On the successful completion of the course, student will be able to CO1:Development of new combination of nanomaterial based ontheir properties for future needs. CO2: Evaluation and critical assessment of nanomaterials for various industrial application. CO3:Assess the role of nanomaterial for enhancing the applicationeffect. CO4: Review the industrial development and relevant nanomaterials supplywith required functionalities. CO5:Demonstrate the new properties of nanomaterials for next generationneeds.
Units	
I	SEMICONDUCTOR NANOSTRUCTURES AND DEVICES Fabrication and Applications of different types of semiconductor Nanostructures- Silicon horizontal and vertical core shell Nanowires- Integrated circuits- Sensors- Electro optica devices. Semiconductor Quantum dots (QDs) – QD LASER- Quantum cascade LASER devices.

II	NANOSCALE MAGNETIC MATERIALS Application In Magnetic Storage Devices - Storing and Reading Device – Current Trends of Spin Based Electronic Devices. Optical Storage Devices: Near Field Optical Recording- Holographic Data Storage- AFM Based Recording Technology.
III	NANO ELECTRO MECHANICAL SYSTEMS Overview- Nano-Electromechanical Systems - Fabrication Process- Choice of Materials, Performance of Different Structures - Advantages and Disadvantages of Different Approaches. Applications In Sensors, Micro Actuators - Extension to The Nanoscale.
IV	NANOSTRUCTURING BY PHYSCIAL TECHNIQUES Lithography-photo lithography-Phase shifing Photo Lithography- Electron beam Lithography— X-Ray Lithography- Focussed Ion Beam Lithography(FIB)- Neutron Atomic beam Lithography- Nanomanipulation-Micro fabrication
V	INDUSTRIAL APPLICATIONS OF NANOMATERIALS Nanoparticles And Micro Organism for industrial application, Nano-Materials in Bone Substitutes and Dentistry, Food and Cosmetic Applications. Textiles, Paints, Catalysis, Drug Delivery and Its Applications, Biochips -Analytical Devices, Biosensors.

Reading List(Printand Online)

1.Nano Electronics, Parag Diwan and Ashish Bharadwaj, Pentagen Press(2006)
2.Principles of Superconductive Devices Aad Circuits, C.W. Turner and T. Van Duzer (1981)
3. Principles of Optical Electronics, A. Yariv, Wiley (1984)

RecommendedTexts

1. Introduction To Molecular Electronics, M C Petty, M R Bryce, D Bloor(Eds.), Edward Arnold (1995)
2. Current Opinion In Solid State & Materials Science, D.D.C. Bradley,Vol. 1, 789 (1996)
Nano Electronics And Information Technology, Rainer Waser, Wiely(2003)

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	3	2	2	2	2	3	3	3
CO2	3	2	2	3	3	2	3	3	2	2
CO3	3	2	2	3	3	3	3	2	2	2
CO4	3	3	3	2	2	2	3	3	2	3
CO5	3	2	2	3	2	3	2	2	3	3

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	3	3
CO2	3	2	3	3	3
CO3	3	2	3	3	3
CO4	3	2	3	3	3
CO5	3	2	3	3	3
Weightage	15	10	15	15	15
Weighted percentage (rounded of) Course Contribution to Pos	3	2	3	3	3

Strong - 3, Medium – 2, Low - 1

SEMESTER-IV (ELECTIVE)

Elective VI A : Nanotechnology for Food and Agriculture	II YEAR - FOURTH SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
	Nanotechnology for Food and Agriculture	Elective				3	4	75

Pre requisites:	Basics in sensors ,nanomaterials,food and agriculture needs
Learning Objectives	1.To understand the usage of sensors in food and agriculture. 2. To explain about the functional materials for food and agriculture. 3.To understand the required nano composities for application purposes.
Course outcomes:	On the successful completion of the course, student will be able to CO1:Define and identify functional materials for food industry. CO2: Understand and describe food and agricultural processes. CO3: Interpretation and application of the theories and protocols for soil andfoodnutrient management. CO4:Differentiate different types of nanomaterials food sensing, nutrientmanagement and packaging application. CO5:Evaluation and assessment of various functional materials for sensing,nutrient management and packaging processes.
	Units
I	SENSORS FOR SOIL, SEED AND FOOD MONITORING Introduction and Importance, Various Sensing Methods, Chemical and Biosensors, Sensors for Monitoring Soil, Seed and Food, Nanomaterials For Intelligent Sensors.
II	FUNCTIONAL MATERIALS Functional Materials for Food and Agriculture Use - Super Absorbent Polymers, Coatings, Aerosols. Zeolites, Nano-Clays, Nano Emulsion,

III	NANOFERTILIZERS Nanofertilizer, Synthesis and Characterization. Fungicides, Herbicides – Pesticides. Types Of Nano-Formulations – Encapsulation of Pesticides. Release Studies, Smart Delivery, Bio- Efficacy and Bio-Safety.

IV	MICRO-NANO ENCAPSULATION Encapsulation – Principles – Micro and Nano-Encapsulation – Release Mechanism –Encapsulation Versus Traditional Delivery Method - Sorption And Release Of Nutrients. Encapsulation Technologies – Extrusion –Spray Chilling – Spray Coating – Spray Drying – Emulsion – Gel Particles.
V	NANOCOMPOSITES AND FOOD PACKAGING Introduction And Scope. Polymer Films and Nano Composites – Bio-Nano Composites - Fabrication Process – Equipments Used - Testing Standards - Nano Material in Food Packaging - Solid And Liquid Food - Safety IssuesOf Nano Food Systems

Reading List (Print andonline)	1.Nano and Microencapsulation For Foods, Hae-Soo Kwak, Wiley (2018)
RecommendedTexts	1. Nanotechnologies In Food and Agriculture, Mahendra Rai, Caue Ribeiro, Luiz Mattoso, Nelson Duran, Springer (2015) 2. Nanotechnology Applications In Food, Alexandru Grumezescu, Alexandra Oprea, Academic Press (2017)

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	3	3	2	3	3	3
CO2	3	3	2	3	3	3	2	3	2	2
CO3	3	3	2	3	3	3	2	2	2	2
CO4	3	3	2	3	3	3	2	3	2	3
CO5	3	3	2	3	3	3	2	2	3	3

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	2	3
CO2	3	3	2	2	3
CO3	3	3	2	2	3
CO4	3	3	2	2	3
CO5	3	3	2	2	3
Weightage	15	15	10	10	15
Weighted percentage (rounded of) Course Contribution to POs	3	3	2	2	3

Strong - 3, Medium – 2, Low - 1

SEMESTER-IV

Elective VI B – **Nanomedicine and Drug Delivery**	**II YEAR – FOURTH SEMESTER**

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**Credits**	**Inst. Hours**	**Marks**
	Nanomedicine and Drug Delivery	Core				3	4	75

Pre requisite:	Basics concepts of nanomaterials and its limitations
Learning Objectives:	1. To learn the nanomaterials for bio–pharmaceuticals and drug delivery. 2. To learn about the nanocarriers for drug delivery 3. To learn the process of drug delivery to brain.lungs and the pharmaceutical nanocarriers in the treatment and imaging of inflection.

Course Outcomes	On the successful completion of the course, student will be able to **CO-1**: Explain the basics of nanomedicine ,surgical needs and imaging tools in medicine field. **CO-2:** Understand the biopharmaceutical nanomaterials requiredfor drug delivery **CO-3:** Explain the various types of sensors for medical analysis **CO-4:** Evaluate the properties of nanocarriers for diagonis and therapeutic application **CO5:** Summarise and analyse the application of nanocarriers in drug delivery
UNITS	
I	**Prospect of Nanomedicine**: History of the idea – The Biological and MechanicalTraditions–Nanomedicine-Taxonomy–Bio-Pharmaceuticals-Implantable Materials-Implantable Devices-Surgical Aids-Diagnostic Tools-Genetic Testing-Imaging

II	**Types of Sensors**: Chemical and Molecular Sensors- Displacement and Motion sensors-Force Nanosensors-Pressure sensing-Thermal nanosensors- Electric and Magnetic Sensing.
III	**Nanocarriers:** Needs and Requirements-Nanoparticle Flow: Implications for Drug Delivery-Genetic vaccines: A Role for Liposomes-Polymer Micelles as Drug Carriers-Recent advances in Microemulsions as Drug Delivery Vehicles.
IV	**Nanocapsules**: Preparation, Characterization and Therapeutic Applications-Aerosols as Drug Carriers-Magnetic Nanoparticles as Drug Carriers – Nanomedicine for eye (Ophthalmology).
V	**Applications Drug Delivery**: Delivery of Nanoparticles to the Cardiovascular System-Nanocarriers for the vascular Delivery of Drugs to the Lungs-Nanoparticulate Carriers for Drug Delivery to the Brain-Pharmaceutical Nanocarriers in Treatment and Imaging of Inflection.

Reading List(Printand Online)

https://link.springer.com/content/pdf/10.10090Fs11834-013-6063-0.pdf

http://nopr.niscair.res.in/bitstream/123456789/5224/1/IJEB2045(2)20160-165.pdf

RecommendedTexts

1. Nano Medicines Edited by Dr.Parag Diwan and Ashish Bharadwaj, Pentagon Press (2006) ISBN 81-8274-139-4
2. Nanoparticulates as Drug Carriers, Edited by Vladimir P.Torchilin, Imperical College Press, North Eastern University, USA (2006) ISBN 1-86094-630-5

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	3	3	2	3	3	3
CO2	3	3	2	3	3	3	2	3	2	2
CO3	3	3	2	3	3	3	2	2	2	2
CO4	3	3	2	3	3	3	2	3	2	3
CO5	3	3	2	3	3	3	2	2	3	3

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	3	3	2	2	3
CO2	3	3	2	2	3
CO3	3	3	2	2	3
CO4	3	3	2	2	3
CO5	3	3	2	2	3
Weightage	15	15	10	10	15
Weighted percentage (rounded of) Course Contribution to POs	3	3	2	2	3

Strong - 3, Medium – 2, Low – 1

Semester IV

SKILL ENHANCEMENT COURSE III

SEC III: **Basics of Pharmaceutical Sciences and Quality Audit**	**II YEAR - FOURTH SEMESTER**

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
	Basics of Pharmaceutical Sciences and Quality Audit	SEC				2	4	75

Pre requisite:	Basics concepts of materials compositions.
Learning Objectives	1. To Understand the principles and types of pharmaceutics 2. To know the concept of pharmacology 3. To understand the fundamental aspects of pharmaceutical product development
Course Outcomes	On completion of this course the students will be able to: CO1: Analyse the quality of the finished product and finally its validation to facilitate its market launch. CO2: Discuss about ICH guidelines, i.e., the organization that sets andgoverns the laws and rules for all the quality tests CO3:Describe direct control on the quality of the formulation and assuring the compliance of standards CO4: Evaluate the quality of various process and factors influencing the stability of products CO5:Design to give a quality assurance and control process involving documentation, regulatory and other aspects in a pharmaceutical industry
	Units
I	**Introduction to pharmaceutical sciences**: Introduction about Pharameceutical -Principles and types of pharmaceutical dosageforms-solid, liquid, semi-solids, aerosols. Routes of drug administration

II	**Basics of pharmacology** Overview, sources of drugs, routes of drug administration, Pharmacokinetics-absorption, distribution, metabolism and excretion, Pharmacodynamics, Adverse drugreactions, Drug interactions.
III	**Pharmaceutical product development:** Fundamental aspects, pharmaceutical excipients, biopharmaceutical considerations,Principles of solubilization, dissolution, partition coefficient, ionization and bioavailability.
IV	**Kinetics and Drug stability:** General concept of physical and chemical stability of pharmaceutical product, factorsaffecting drug stability, Degradation rate constant, Half-life determination and expiration dating, Introduction to ICH guidelines, Accelerated stability studies
V	**Quality Audit** Quality audit, Standard Operating Procedure (SOP), International Conference Harmonization (ICH), ISO-9000, ISO14000, WHO specifications, USFDA guidelinesand ICMR.
Recommended Texts	1. Sed mtiazhaider. (2011).Pharmaceutical Master Validation Plan: The Ultimate Guide to FDA 2. Ira R. Berry, Robert A Nash (2013), Pharmaceutical process validation, 3rd Rev Edition.Marcel Dekker 3. Quality Assurance of Aseptic Preparation Services: Standards Part A | Fifth edition, Alison M Beaney, Royal Pharmaceutical Society and the NHS Pharmaceutical Quality Assurance Committee,2016. 4. Manging for quality and performance excellence ninth edition James R.Every, William M.Lindsay South-western Cengage learning 2014.

Mapping with Programme Outcomes

s	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	2	2	2	3	3	3	2	3	3	3
CO2	2	3	2	3	3	3	2	3	2	2
CO3	2	2	2	3	3	3	2	2	2	2
CO4	2	3	2	3	3	3	2	3	2	3
CO5	2	2	2	3	3	3	2	2	3	3

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3	2	2	3
CO2	2	3	2	2	3
CO3	3	2	2	2	3
CO4	2	3	2	2	3
CO5	3	3	2	2	3
Weightage	12	14	10	10	15
Weighted percentage (rounded of) Course Contribution to Pos	3	3	2	2	3

Strong - 3, Medium – 2, Low – 1

PROJECT (7 credit/10 hours)

The purpose of final year projects is to provide students an opportunity to apply the knowledge they have learnt, their intellectual abilities and practical skills to synthesize new nanomaterials.

Throughout the project, students are expected, with guidance from their supervisors, to do things and obtain information for themselves.

i) Student should carry out INDIVIDUAL PROJECTS only

ii) Project shall be allotted at the beginning of the IV semester.

iii) Students may be allowed to carry out the project work in other research institutes.

iv) Faculty members of the respective colleges must serve as guides

v) Project report evaluation will be done and Viva-voce will be conducted by both the external examiner and the internal examiner at the end of the FOURTH SEMESTERitself.

vi) Project report in THREE copies has to be submitted at the time of the exam.

vii) Evaluation of Project report has to be done by the examiner(s) appointed by the University for 50 Marks.

EXTENSION ACTIVITY (Credit : 1)

Choose any one activity from the list given below and submit the report.
Indiviual report must be submitted

1, Entrepreneurship and Innovation Workshop Series
Empowering students to develop entrepreneurial skills and explore opportunities for commercializing Nanoscience -related technologies or starting their ventures.

2,Science Education Outreach Program
Involving students in educational outreach activities, such as designing and delivering workshops for schools or mentoring undergraduate students in projects.

3.Social relevant and Environmental related activities/approach