MANONMANIAM SUNDARANAR UNIVERSITY TIRUNELVELI

M.Sc.Nanoscience and Nanotechnology

(Affiliated Colleges)

(OBE–CBCS Framework)

(Applicable from AcademicYear 2026–2027 onwards)

1. VISION AND MISSION OF THE UNIVERSITY

Vision

"To provide qualityeducation to reach the un-reached."

Mission

- To conduct research,teaching and outreach programmes to improve conditions of human living
- To offer a wide variety of off-campus educational and training programmes,including the use of information technology,to individuals and groups.
- To develop partnerships with industries and government so as to improvr the quality of the workplace and to serve as catalyst for economic and cultural development.
- To provide quality/inclusive education, especially for the rural and un-reached segments of economically downtrodden students including women,socially oppressed and differently abled.

2. PREAMBLE

Outcome Based Education (OBE) is adopted to enhance the quality of higher education by focusing on measurable learning outcomes. The curriculum is structured under the Choice Based Credit System (CBCS) to ensure flexibility, interdisciplinary exposure, and lifelong learning.

The programme integrates:

- Programme Educational Outcomes(PEOs)
- Programme Outcomes (POs)
- Programme Specific Outcomes(PSOs)
- Course Outcomes(COs) mapped using Revised Bloom'sTaxonomy(RBT)

The design ensures that attainment of course outcomes collectively leads to achievement of programme outcomes.

3. PROGRAMMEDETAILS

ProgrammeName	:M.Sc. Nanoscience and Nanotechnolgy
Duration	:2Years(4 Semesters)
System	:ChoiceBasedCreditSystem (CBCS)
Total Credits	: 90
MediumofInstruction	: English

4. ELIGIBILITY FOR ADMISSION

Any undergraduate science degree recognized by UGC is eligible for admission to the M.Sc. Nanoscience and Nanotechnology programme.

5. PROGRAMMEEDUCATIONALOUTCOMES(PEOs)

The PEOs for the graduates are

- **PEO1:**Developing a strong positive attitude to learn independently the concepts in the field of dtudy
- **PEO2:**Ensuring confidence among the learners to apply the knowledge and skills gained to solve real life issues.
- **PEO3:** Habituating the ethical values among the learners to succced in personal and professional life.

6. PROGRAMMEOUTCOMES(POs)

After completion of the programme, the learner will be able to:

PO1: Comprehend the knowledge acquired and share the knowledge with others to convince themin a discussion.

PO2:Analyze and comparethefactual data/situation and formulate the problem into a conceptual model to critically evaluate for finding solution.

PO3:Apply the theories and philosophies learned in formulating theoretical research problem with underlying assumptions and solve the problem scientifically.

PO4: Think reflectively on the earlier attempts for applications of the concepts with a sense of inquiring practices and attempt for self directed lifelong learning process.

PO5: Understand the existence of multicultural practices and global viewpoint and utilization of knowledgewith the ability to prolong moral/ethicalvalues in personal and professional life.

PO6: Explore through multiple sourcesand get exposed to the digital literacy and information explosion with latest technology.

PO7: Act as a responsible member in the varied teams with facilitating capability and formulate teams as a leader for defined purposes.

7. PROGRAMMESPECIFICOUTCOMES(PSOs)

Upon the completion of the programme,students will able to

PSO1 : Demonstrate knowledge on the physics/chemistry/biotechnology and basics of nanoscale science and technology for their multifunctional applications.

PSO2: Implement the synthesis and execute the characterization for nanomaterials.

PSO3 : Analyse the Project related to their skill in lithography and nanofabrication.

PSO4: Categorize the expertise needed in processing of nanomaterials for specific applications

PSO5: Develop an ability to visualize and work on laboratory and multidisciplinary tasks including material science, physics, chemistry and nanobiotechnology.

PSO6: Implement their knowledge to address problems of social relevance such as energy, environment and medicine through their specific electives.

PSO7: Construct their own innovative ideas in the form of projects,product design and development.

8. REVISED BLOOM'STAXONOMY (K1–K6LEVELS)

The cognitive levels K1 to K6 represent a hierarchical classification of learning outcomes, rangingfrombasicknowledgeacquisitiontohigher-orderthinkingskillssuchasevaluationand creation.TheselevelsareusedinOutcomeBasedEducation(OBE)todesigncourseoutcomes, assessments, and question papers.

K1–K6 LEVELS–DESCRIPTIONTABLE

Level	Category	Description	ExpectedStudent Ability	TypicalAction Verbs
K1	Remember	Recallbasicfacts,definitions, and concepts	Identify,list,define, recall information	Define,list, name,state
K2	Understand	Comprehendmeaningand interpret concepts	Explain ideas, summarize,classify	Explain, describe, interpret
K3	Apply	Useknowledgeinnewor familiar situations	Solveproblemsusing learned methods	Apply,calculate, solve, use
K4	Analyze	Breakdowninformationinto components and examine relationships	Differentiate,compare, analyze structures	Analyze, compare, categorize
K5	Evaluate	Makejudgmentsbasedon criteria and evidence	Assesssolutions,justify decisions	Evaluate,justify, criticize
K6	Create	Generatenewideas,models, or solutions	Design,formulate, construct new approaches	Design,develop, formulate

OBE SIGNIFICANCE

- **K1–K3→LowerOrderThinkingSkills (LOTS)**
- **K4–K6→HigherOrderThinkingSkills (HOTS)**

For**PGprogrammes**:**40%**questions→K1–K3,**60%**questions→K4–K6

Usageinthe Syllabus

- CO1→ K1 &K2
- CO2 → K3
- CO3 → K4
- CO4→ K5 &K6

This Ensures **progressive learning,**Supports**OBEcompliance and h**elps in **questionpaper setting & evaluation**

8. PROGRAMME STRUCTURE

The M.Sc Nanoscience and Nanotechnology programme is organized into:

- Core Courses
- Core Practicals
- Electives (Discipline Centric & Generic)
- Skill Enhancement Courses
- Internship/Field Activity
- Project Work with Viva-Voce
- Extension Activity

Total Credits Distribution/Semester

SEMETER	I	II	III	IV	Total
CREDITS	21	23	26	24	**94**

9. CONDUCT OF THE PROGRAMME

- The programme follows semester pattern
- Each semester includes theory,practical,and skill-based components
- Continuous Internal Assessment(CIA) and End Semester Examination(ESE) are conducted
- Attendance and participation are mandatory

10. EVALUATION MECHANISM AND MARKS WEIGHTAGE

Each non-practical/non-project course shall carry a total of 100 marks, comprising two components:75marks for the End Semester Examination (ESE-3hour duration for theory and 6hour duration for practical) conducted by the University and 25marks for Continuous Internal Assessment (CIA) conducted by the Department/College.

The CIA marks shall be distributed as follows:

- 15marks for Internal Written Examinations
- 05marks for Written Assignment/Quiz
- 05marks for overall performance of the student,including regularity in classroom lectures, Seminar participation and participation in other activities of the Department.

There shall be three internal written examinations of one-hour duration conducted during a semester. For the computation of CIA marks, the average of the best two examinations shall be considered.

Passing Criteria for a Course

Passing Minimum(Overall)	50%combined(Internal + External).
External Assessment	A passing minimum of 50% (38/75)is required in ESE
Internal Assessment	There shall be nominimum pass mark prescribed for CIA alone.It is required for the overall lpassing.

11. ATTAINMENT OF OUTCOMES

Course Outcomes are measured using:

DirectMethods	IndirectMethods	FinalAttainmentFormula
Internal Assessment	Course Exit Survey	DirectAttainment=CIA +ESE
End Semester Examination		FinalAttainment =**0.8 ×Direct +IndirectAssessment**

12. FEEDBACK SYSTEM

The curriculum is periodically reviewed based on the feedback from:

- Teachers
- Students
- Alumni
- Employers

This ensures continuous improvement and industry relevance

13. MINIMUM REQUIREMENTS FOR AWARD OF DEGREE

- Successful completion of all courses
- Minimum required credits(90)
- Passing in ESE (alongwithCIA)
- Completion of project,internship/industrial visit,and extension activity

14. QUESTIONPAPER

a) Theory paper

- Pattern includes both:
  - Quantitative problems
  - Analytical and conceptual questions
- Questions are aligned with Bloom'sTaxonomy(K1–K6)

Part	Question Pattern	Marks
PartA	15 objective questions	15×1 =15
PartB	5short-answer/problem-solvingquestions–oneeither/or question from each unit	5 ×4 =20
PartC	5descriptive/derivation-typequestions–oneeither/or question from each unit	5 ×8 =40
	Total	**75**

b) Practical

Core Practical Examination having the following marks:

Internal – 50 marks	**External – 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) If interested Students may also 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

Template /List of courses

Semester–I	Credit	Hours	Semester-II	Credit	Hours	Semester-III	Credit	Hours	Semester–IV	Credit	Hours
1.1. Core-I	5	6	2.1. Core-III	5	6	3.1. Core-V	5	5	4.1. Core-VIII	5	5
1.2 Core-II	5	6	2.2 Core-IV	5	6	3.2 Core-VI	5	5	4.2 Core-IX	5	5
1.3 Core – Practical I	3	6	2.3 Core – Practical-II	3	6	3.3 Core – VII	5	5	4.3 Core Practical - IV	3	6
1.4 Discipline Centric Elective –I	4	6	2.4 Discipline Centric Elective – III	4	4	3.4 Core – Practical-III	3	6	4.4Elective - VI (Industry / Entrepreneurship)	4	4
1.5 Generic Elective-II:	4	6	2.5 Generic Elective -IV:	4	4	3.5 Discipline Centric Elective – V	4	5	4.5 Skill Enhancement course / Professional Competency Skill SEC III	2	4
			2.6,Skill Enhancement (SEC)-1	2	4	3.6 SEC -II	2	4	4.3 Project with viva voce	3	6
						3.7 Internship/ Industrial Activity/field visit	2	-	4.6 Extension Activity	2	
	21	**30**		**23**	**30**		**26**	**30**		**24**	**30**
Total Credit Points -94											

M.Sc. Nanoscience and NanoTechnology

SEMESTER – I:

COURSE COMPONENTS	NAME OF THE COURSE	Hours	Credits	Exam Hrs	MAX MARKS	
					CIA	EXT
Core-I	Introductory Physics	6	5	3	25	75
Core- II	Introductory Chemistry	6	5	3	25	75
Core Practical I	Nanoscience Practical I	6	3	6	50	50
Discipline Centric Elective- I	Introduction to Material Science	6	4	3	25	75
Generic Elective- II	Choose any one A. Introductory Biology B. Laboratory safety and Health	6	4	3	25	75
		30	**21**			

SEMESTER - II

COURSE COMPONENTS	NAME OF THE COURSE	Hours	Credits	Exam Hrs	MAX MARKS	
					CIA	EXT
Core-III	Introduction to Nanoscience and Nanotechnology	6	5	3	25	75
Core-IV	Preparation of Nanomaterials	6	5	3	25	75
Core Practical II	Nanoscience Practical II	6	3	6	50	50
Discipline Centric Elective- III	Characterization Techniques of Nanomaterials –I	4	4	3	25	75
Generic Elective- IV	Choose any one A.Nanobiotechnology B,Introduction to Nanotoxicology	4	4	3	25	75
Skill Enhancement [SEC]-I	Research Methodology	4	2	3	25	75
		30	**23**			

SEMESTER – III

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

SEMESTER – IV

COURSE COMPONENTS	NAME OF THE COURSE	Hours	Credits	Exam Hrs	MAX MARKS	
					CIA	EXT
Core-VIII	Biomedical Nanotechnology	5	5	3	25	75
Core-IX	Industrial Nanotechnology	5	5	3	25	75
Core Practical IV	Nanoscience Practical IV	6	3	6	50	50
Elective- VI	Choose any one A. Nanotechnology for Food and Agriculture B. Nanomedicine and drug delivery	4	4	3	50	50
SEC III	Basics of Pharmaceutical sciences and quality audit	4	2	3	25	75
	Project with viva voce	6	3		50	50

	Extension Activity	-	2		50	50
		30	**24**			

Total Credits: **94 credits**

SEMESTER
ICORE I

Core I – Introductory Physics		I YEAR – FIRST SEMESTER						
Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**Credits**	**Inst. Hours**	**Marks**
	Introductory Physics	Core				5	6	75

Course Outcomes	On the successful completion of the course, student will be able to CO1: Understand fundamental concepts of physics which are necessary for nanoscience and technology subject CO2: Apply the gained subject knowledge to understand the nano-enabled devices CO3: Evaluate microscopic scales with macroscopic Impact with the help of Physics. CO4: Understanding on real time applications of physics

Unit:1	**WAVES AND OPTICS**	

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**	

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.

nit:3	MAGNETISM	
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**	
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**	
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.		

	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
CO1	3	3	2	3	3	3	2
CO2	3	3	2	3	3	3	2
CO3	3	3	2	3	3	3	2
CO4	3	3	2	3	3	3	3
Total Score	12	12	8	15	15	15	9

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	3	3	3	3	2
CO2	3	2	3	3	3	3	2
CO3	3	2	3	3	3	3	2
CO4	3	2	3	3	3	3	2
Weightage	12	8	12	9	12	12	8
Weighted percentage (rounded of) Course Contribution to Pos	3	2	3	3	3	3	2

Strong - 3, Medium – 2, Low - 1

SEMESTER

I

Core II – Introductory chemistry		I YEAR – FIRST SEMESTER						
Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**Credits**	**Inst. Hours**	**Marks**
	Introductory chemistry	Core				5	6	75

Course Outcomes	On the successful completion of the course, student will be able to CO1: Define and identify differential branches of chemistry and their importance CO2: Understand and describe chemical concepts and processes CO3: Interpretation and application of the theories to chemical process and derivations CO4: Differentiate different properties and mechanisms of organic reactions, inorganic properties and physical concept

Units	
I	Chemical Equilibria - Activity Concept, Equilibrium Constant and Applications, Ionisation Constants of Acids and Bases. Concept Of pH, Hydrolysis of Salts.
II	Buffers – Types, Range and Capacity, Dissociation of Polyprotic Acids, Common Ion Effect, Salt Effect. Electrochemistry – Conductivity of Electrolytes, Electrochemical Cells, Standard Electrode Potentials
III	Bonding Models in Chemistry – Ionic Bond, Covalent Bond,Theories of Bonding in Coordination Compounds-valence band theory-crystal field theory Electronic Spectra of CoordinationCompounds
IV	Thermodynamics: First, Second and Third Law of Thermodynamics. Gibbs And Helmholtz Energy - Chemical Equilibrium-Law of mass action-Arrhenius equation –Chemical Kinetics, Transition State Theory and

	Collision Theory,Heterogeneous Catalysis.
V	Structure of Organic Compounds – Electronic theory of Bonding-Tetrahedral model of carbon atoms-substitution reaction and its types- Free radical-Ionic-Electrophillic and nucleophilic reactions of Aromatic compounds-Elimination and addition reaction of Aromatic compounds.
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
CO1	3	3	2	3	3	3	2
CO2	3	3	2	3	3	3	2
CO3	3	3	2	3	3	3	2
CO4	3	3	2	3	3	3	3
Total Score	12	12	8	15	15	15	9

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	3	3	3	3	2
CO2	3	2	3	3	3	3	2
CO3	3	2	3	3	3	3	2
CO4	3	2	3	3	3	3	2
Weightage	12	8	12	9	12	12	8
Weighted percentage (rounded of) Course Contribution to Pos	3	2	3	3	3	3	2

Strong - 3, Medium – 2, Low - 1

SEMESTER I

Core Practical I - Nanoscience Practical I	**I YEAR - FIRST SEMESTER**

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

Course Outcomes	On the successful completion of the course, student will be able to CO1: Acquire practical skills in the use of instruments, technologies and methods in biomolecules like glucose, proteins. CO2: Gain practical knowledge by applying the experimental methods to correlate with the theory. CO3: Provides opportunities to collect and examine samples from bloodand cells. CO4: Identify the acidic and bases values of the chemicals

Any five experiments

1.Determine the average particle size,microstrain and dislocation density of the given XRD pattern.

2.Estimate the protein concentration of the given sample by using Lowry method

3.Estimate of blood glucose level and blood group analysis.

4.Curve fitting analysis for given set of data

5. Study the forward and reverse characterize of P-N junction diode and Zenor diode

6. Study the characteristics of transistor in CE,CC, CB mode.

7. DC conductivity measurement using Two probe setup.

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	2	3	3	3	2
CO2	3	3	2	3	3	3	2
CO3	3	3	2	3	3	3	2
CO4	3	3	2	3	3	3	3
Total Score	12	12	8	15	15	15	9

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	3	3	3	3	2
CO2	3	2	3	3	3	3	2
CO3	3	2	3	3	3	3	2
CO4	3	2	3	3	3	3	2
Weightage	12	8	12	9	12	12	8
Weighted percentage (rounded of) Course Contribution to Pos	3	2	3	3	3	3	2

Strong - 3, Medium – 2, Low - 1

SEMESTER I

Discipline Centric Elective Course-1

Dicipline centric Elective I – Introduction to Material Science		**I YEAR – FIRST SEMESTER**						
Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**Credits**	**Inst. Hours**	**Marks**
	Introduction to Material Science	Core				3	6	75

Course Outcomes	On the successful completion of the course, student will be able to CO1: Understand the fundamental concepts of material science CO2: Apply the gained subject knowledge to understand the advanced concepts of nanoscience. CO3: Evaluate the impact of presence of impurity and applied temperature on various properties ofmaterials. CO4: Analyze the acquired knowledge and understanding on real time applications of variousfunctional materials

Unit:1	**CRYSTAL STRUCTURE AND DEFECTS**	
Structure of Matter- Amorphous, Crystalline, Crystals, Polycrystals, Symmetry, Unit Cells, CrystalStructures, Crystallographic Planes, Miller Indices, Chemical Bonding, Atomic Bonding in Solids,Types of Bonds: Metallic, Ionic, Covalent and Vander Waals; Crystal Defects.		
Unit:2	**ELECTRICAL MATERIALS**	

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 MATERIALS**	

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 MATERIALS	
Dielectric Materials: Electronic, Ionic, Orientational, and Space Charge Polarization – ComplexDielectric Constant RC Equivalent Network – Dielectric Loss – Different Types of Dielectric Breakdown, Classification of Insulating Materials.		
Unit:5	**THERMAL, OPTICAL & MECHANICAL MATERIALS**	
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.		

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
CO1	3	3	2	3	3	3	2
CO2	3	3	2	3	3	3	2
CO3	3	3	2	3	3	3	2
CO4	3	3	2	3	3	3	3
Total Score	12	12	8	15	15	15	9

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	3	3	3	3	2
CO2	3	2	3	3	3	3	2
CO3	3	2	3	3	3	3	2
CO4	3	2	3	3	3	3	2
Weightage	12	8	12	9	12	12	8
Weighted percentage (rounded of) Course Contribution to Pos	3	2	3	3	3	3	2

Strong - 3, Medium – 2, Low - 1

SEMESTER I

Generic elective(Choose AorB)

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
	Introductory Biology	Core				3	6	75

Course Outcomes	On the successful completion of the course, student will be able to CO1: Acquire the knowledge of the cell biology and application. CO2: Explain the role of cell organelles, metabolism, and bioenergetics. CO3: Understand the about the morphology, structure, of DNA, RNA anddifferent types of nucleic acid. CO4: Gain the knowledge about of glucose, and fatty acid metabolism.

Units	
I	CELL STRUCTURE AND FUNCTIONS Definitions, Types, Eukaryotic and Prokaryotic cells, Principle of 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, Glycolysis, Lipids of physiological significance, Cholesterol, Synthesis, Transport and Excretion, Glycoproteins, Biooxidation, Fatty acid synthesis, Phospholipids.
V	NUCLEIC ACIDS Structure, functions and replications of information macromolecules.Metabolis of purines and pyrimidine nucleotides.Organization, replication and repair of DNA. RNA andprotein 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
CO1	3	3	2	3	3	3	2
CO2	3	3	2	3	3	3	2
CO3	3	3	2	3	3	3	2
CO4	3	3	2	3	3	3	3
Total Score	12	12	8	15	15	15	9

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	3	3	3	3	2
CO2	3	2	3	3	3	3	2
CO3	3	2	3	3	3	3	2
CO4	3	2	3	3	3	3	2
Weightage	12	8	12	9	12	12	8
Weighted percentage (rounded of) Course Contribution to Pos	3	2	3	3	3	3	2

Strong - 3, Medium – 2, Low - 1

Generic Elective II (B) – LABORATORY SAFETY AND HEALTH		I YEAR – FIRST SEMESTER						
Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**Credits**	**Inst. Hours**	**Marks**
	LABORATORY SAFETY AND HEALTH	Core				3	6	75

Course Outcomes	On the successful completion of the course, student will be able to CO1: Understand and describe various safety issues and protocols CO2: Interpretation and application of safety protocols and laboratory rules. CO3:Differentiate different types of laboratory accidents and safety protocols and personal protective equipments. CO4: Evaluation and assessment safety regulations, personal protectiveequipments and First aid practices.

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. EmergencyCalls 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
CO1	3	3	2	3	3	3	2
CO2	3	3	2	3	3	3	2
CO3	3	3	2	3	3	3	2
CO4	3	3	2	3	3	3	3
Total Score	12	12	8	15	15	15	9

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	3	3	3	3	2
CO2	3	2	3	3	3	3	2
CO3	3	2	3	3	3	3	2
CO4	3	2	3	3	3	3	2
Weightage	12	8	12	9	12	12	8
Weighted percentage (rounded of) Course Contribution to Pos	3	2	3	3	3	3	2

Strong - 3, Medium – 2, Low - 1

SEMESTER-II

CORE-IV

Core III – Introduction to Nanoscience and Nanotechnology		**I YEAR – Second SEMESTER**						
Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**Credits**	**Inst. Hours**	**Marks**
	Introduction to Nanoscience and Nanotechnology	Core				5	6	75

Course Outcomes	On the successful completion of the course, student will be able to
	CO1: Understand the fundamental concepts of nanoscience
	CO2: Apply the basic concepts of physics, chemistry and biology concepts to understand the advanced concepts of nanoscience
	CO3: Analyse the influence of size and morphology and other factors on various properties of materials.
	CO4: Analyze the acquired knowledge and understanding of nanoscience in various field

Unit:1	**FUNDAMENTALS**	
Background to nanoscience – Historical perspectives and Scientific revolutions – Definitions andClassifications 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**	
Top-Down and Bottom-Up Approaches: Physical - Chemical and Mechanical Routes; Influence ofvarious 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**	
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**	
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**	
Miniaturization of electronic materials and devices – Lithography techniques - Scaling issues – batch fabrication and circuit integration – MEMS and NEMS – Current and future challenges		
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
CO1	3	3	2	3	3	3	2
CO2	3	3	2	3	3	3	2
CO3	3	3	2	3	3	3	2
CO4	3	3	2	3	3	3	3
Total Score	12	12	8	15	15	15	9

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	3	3	3	3	2
CO2	3	2	3	3	3	3	2
CO3	3	2	3	3	3	3	2
CO4	3	2	3	3	3	3	2
Weightage	12	8	12	9	12	12	8
Weighted percentage (rounded of) Course Contribution to Pos	3	2	3	3	3	3	2

Strong - 3, Medium – 2, Low - 1

SEMESTER-

IICORE-V

Core I V – Preparation of Nanomaterials		I YEAR – Second SEMESTER						
Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**Credits**	**Inst. Hours**	**Marks**
	Preparation of Nanomaterials	Core				5	6	75

Course Outcomes	On the successful completion of the course, student will be able to CO1: Understand the fundamental concepts in materials preparation with various Morphologies CO2: Apply the gained subject knowledge towards understanding the mechanisms involved in physical, chemical and mechanical routes. CO3: Evaluate and understand the role of preparation method towards grain with narrow distribution and desired morphology. CO4: Analyze the acquired knowledge and understanding of preparing the nanomaterials for various application

Unit:1	**BASICS IN MATERIALS PREPARATION**	
Types of matter – Crystalline and Amorphous solids – Alloys – composites - compounds - Grain –Grain Growth-Grain boundary volume ratio –Temperature effects – Grain boundary segregation andpinning – Aggregation- Dimensional Classifications.		
Unit:2	**PHYSICAL ROUTES**	
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**	
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	
Electrophoretic deposition – Chemical Vapour deposition: Wet and Dry oxidation process – Dip andSpin coating process – Successive ionic layer adsorption and reaction (SILAR) – Spray and Flame spray pyrolysis - Self assembly.		

Unit:5	IMPORTANCE OF MORPHOLOGY	
Crystallites With Various Morphologies – Polymorphs – Surface Aspect Ratio – Grain size distributions – Surface area – Current Status and Forecast for The Future Trends		

	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
CO1	3	3	2	3	3	3	2
CO2	3	3	2	3	3	3	2
CO3	3	3	2	3	3	3	2
CO4	3	3	2	3	3	3	3
Total Score	12	12	8	15	15	15	9

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	3	3	3	3	2
CO2	3	2	3	3	3	3	2
CO3	3	2	3	3	3	3	2
CO4	3	2	3	3	3	3	2
Weightage	12	8	12	9	12	12	8
Weighted percentage (rounded of) Course Contribution to Pos	3	2	3	3	3	3	2

Strong - 3, Medium – 2, Low - 1

SEMESTER-

IICORE-VI

Core Practical II - Nanoscience Practical II	I YEAR - SECOND SEMESTER

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

Course Outcome	On the successful completion of the course, student will be able to: CO1: Synthesis nanomaterials by different methods. CO2: Synthesis thin films using different techniques CO3: Synthesis various nanocomposites CO4: Characterize structurally the nanoparticles prepared and analysis their size and lattice parameters CO5: Characterize the nanomaterials prepared electrically and optically.

Practical-II	**Synthesis and band gap determination of Biomolecules and Biomaterials (Any five experiments)**
	1. Synthesis of Silver Nanoparticles by Chemical Reduction Method . 2. Synthesis manganese oxide nonoparticles by using NaOH as a capping agent. 3. Synthesis of Silver Nanoparticles by Polyol Method.. 4. Synthesis of zinc oxide Nanoparticles by sol-gel method. 5. Synthesis of silver nanoparticles by using plant extract. 6. Synthesis Cadmium oxide Nanoparticles by hydrothermal method
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
CO1	3	3	2	3	3	3	2
CO2	3	3	2	3	3	3	2
CO3	3	3	2	3	3	3	2
CO4	3	3	2	3	3	3	3
Total Score	12	12	8	15	15	15	9

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	3	3	3	3	2
CO2	3	2	3	3	3	3	2
CO3	3	2	3	3	3	3	2
CO4	3	2	3	3	3	3	2
Weightage	12	8	12	9	12	12	8
Weighted percentage (rounded of) Course Contribution to Pos	3	2	3	3	3	3	2

Strong - 3, Medium – 2, Low - 1

SEMESTER II

Discipline Centric Elective Course-1II

Discipline centric Elective III – Characterization Techniques of Nanomaterials –I		I YEAR – SECOND SEMESTER						
Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**Credits**	**Inst. Hours**	**Marks**
	Characterization Techniques of Nanomaterials –I	Core				3	4	75

Course Outcomes	On the successful completion of the course, student will be able to CO1: Explore the properties of nanomaterials for the particular applications CO2: Understand the principles of characterization techniques And study the properties of nanomaterials CO3: Explain the instrumentation involved in the characterization technique CO4: Identify the suitability of the characterization for the particularmaterial..

Units	
I	**Unit I Introduction to spectroscopy** Basic principles and applications of UV-Vis-NIR, Fourier transform infrared spectroscopy ,Photoluminescence, Nuclear magnetic resonance spectroscopy.
II	**Unit II X – ray techniques** X-ray powder diffraction –Quantitative determination of phases- single crystal diffraction techniques - Determination of accurate lattice parameters - structure analysis-profile analysis – particle size analysis using Scherer formula- Particle Size Analyzer.

III	**Unit III Electron Spectroscopy** X-Ray Photoelectron Spectroscopy, Auger Electron Spectroscopy, X-Ray Characterization of Nanomaterials – Electron energy loss spectroscopy(EELS)– Energy dispersive X-ray analysis(EDAX) and Swear debris analysis(WDA).
IV	**Unit IV Mechanical properties measurement** Nanoindentation principles- elastic and plastic deformation -mechanical properties of materials in small dimensions- Nanoindentation load-displacement curves - MD simulation of nanoindentation- Hardness testing of thin films and coatings
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
Recommended Texts	**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
CO1	3	3	2	3	3	3	2
CO2	3	3	2	3	3	3	2
CO3	3	3	2	3	3	3	2
CO4	3	3	2	3	3	3	3
Total Score	12	12	8	15	15	15	9

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	3	3	3	3	2
CO2	3	2	3	3	3	3	2
CO3	3	2	3	3	3	3	2
CO4	3	2	3	3	3	3	2
Weightage	12	8	12	9	12	12	8
Weighted percentage (rounded of) Course Contribution to Pos	3	2	3	3	3	3	2

Strong - 3, Medium – 2, Low - 1

SEMESTER-II

Generic Elective course-IV

Generic Elective IV (A) – Nanobiotechnology		I YEAR – SECOND SEMESTER						
Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**Credits**	**Inst. Hours**	**Marks**
	Nanobiotechnology	Core				3	4	75

Course Outcomes	On the successful completion of the course, student will be able to CO1: Understand the basics of bioinspired strategies for the fabricationof Implants CO2: Analyse the importance of bioactive nanomaterials in bone grafting and tissue engineering CO3: Recognize the significance of Biomolecules in the fabrication of Nanostructures CO4 : Study the applications of Polymer nanofibers in Tissue engineeringand its merits and demerits .

Units	
I	Bio-mineralised Inorganic Nanomaterials – Nanostructures and Dynamicsof Biocompatible surfactant monolayers and bilayers – Bio-interface, Bio-conjugation, Bio-matrix based on bioinspired phospholipids polymers.
II	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	DNA based artificial nanostructures: fabrication, properties and applications – Nucleic acid engineered nanomaterials and theirapplications- RNA, DNA
IV	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	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(Printand 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
CO1	3	3	2	3	3	3	2
CO2	3	3	2	3	3	3	2
CO3	3	3	2	3	3	3	2
CO4	3	3	2	3	3	3	3
Total Score	12	12	8	15	15	15	9

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	3	3	3	3	2
CO2	3	2	3	3	3	3	2
CO3	3	2	3	3	3	3	2
CO4	3	2	3	3	3	3	2
Weightage	12	8	12	9	12	12	8
Weighted percentage (rounded of) Course Contribution to Pos	3	2	3	3	3	3	2

Strong - 3, Medium – 2, Low - 1

SEMESTER-II

Generic Elective course-IV

Generic Elective IV (B) – INTRODUCTION TO NANOTOXICOLOGY		I YEAR – SECOND SEMESTER						
Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**Credits**	**Inst. Hours**	**Marks**
	INTRODUCTION TO NANOTOXICOLOGY	Core				3	4	75

Course Outcomes	On the successful completion of the course, student will be able to CO1: Understand the basic of Toxoicology and Nano science anddifferentiate between nanomaterials and bulk materials CO2 Evaluate and critically review the theoretical and practical aspects of Nanomaterials application CO3: Critically assess and outline the nanoscience related to nanotoxicology. CO4 Demonstrate the new properties of Nano materials and its significance in toxicology

Units	
I	**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	**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	**NANOPOLLUTION** Nanomaterials in environment, Source of pollution, Transport throughenvironment.
IV	**NANOMATERIAL EXPOSURE MEASUREMENT** Nano sized materials exposure to human, Measurement methods, Thresholdvalues-permissible limits.
V	**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
CO1	3	3	2	3	3	3	2
CO2	3	3	2	3	3	3	2
CO3	3	3	2	3	3	3	2
CO4	3	3	2	3	3	3	3
Total Score	12	12	8	15	15	15	9

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	3	3	3	3	2
CO2	3	2	3	3	3	3	2
CO3	3	2	3	3	3	3	2
CO4	3	2	3	3	3	3	2
Weightage	12	8	12	9	12	12	8
Weighted percentage (rounded of) Course Contribution to Pos	3	2	3	3	3	3	2

Strong - 3, Medium – 2, Low - 1

SEMESTER II
Skill enhancement Course – I

Skill enhancement course I – RESEARCH METHODOLOGY	**I YEAR – SECOND SEMESTER**

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
	RESEARCH METHODOLOGY	Core				2	4	75

Course Outcomes	On the successful completion of the course, student will be able to CO1: Understand the aims and objectives research and formulate a research workplan in a scientific manner CO2 Evaluate and critically review the theoretical and practical aspects of Research CO3: Generate good research hypothesis, design appropriate experiments, collect and interpret the data to validate their experiments. CO4 Generate good research hypothesis, design appropriate experiments, collect and interpret the data to validate their experiments.

I	**Foundations of Research:** Meaning, Objectives, Motivation, Utility. Concept of theory, Characteristics of scientific method – Understanding the language of research – Concept, Construct, Definition, Variable. Research Process Research Question – Measurement Issues – Hypothesis – Qualities of a good Hypothesis –Null Hypothesis & Alternative Hypothesis. Hypothesis Testing – Logic & Importance.
II	**Research Design:** Concept and Importance in Research – Features of a good 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 – Merging the two approaches. Measurement: Concept of measurement– what ismeasuredProblems in measurement in research – Validity and Reliability- Levels of measurement
III	**Sampling and data analysis:** Characteristics of a good sample. Probability Sample – Simple Random Sample, Systematic Sample- 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 :** 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- Dissertation/Thesis writing: format, content and chapterization.Bibliography and references, referencing styles. Appendices.
V	**Use of tools / techniques for Research: :** Reference Management -Software like Zotero/Mendeley, Software for paper formatting like LaTeX/MSOffice, 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
CO1	3	3	2	3	3	3	2
CO2	3	3	2	3	3	3	2
CO3	3	3	2	3	3	3	2
CO4	3	3	2	3	3	3	3
Total Score	12	12	8	15	15	15	9

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	3	3	3	3	2
CO2	3	2	3	3	3	3	2
CO3	3	2	3	3	3	3	2
CO4	3	2	3	3	3	3	2
Weightage	12	8	12	9	12	12	8
Weighted percentage (rounded of) Course Contribution to Pos	3	2	3	3	3	3	2

Strong - 3, Medium – 2, Low - 1

SEMESTER-III

Core Paper V - 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

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

	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
CO1	3	3	2	3	3	3	2
CO2	3	3	2	3	3	3	2
CO3	3	3	2	3	3	3	2
CO4	3	3	2	3	3	3	3
Total Score	12	12	8	15	15	15	9

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	3	3	3	3	2
CO2	3	2	3	3	3	3	2

CO3	3	2	3	3	3	3	2
CO4	3	2	3	3	3	3	2
Weightage	12	8	12	9	12	12	8
Weighted percentage (rounded of) Course Contribution to Pos	3	2	3	3	3	3	2

Strong - 3, Medium – 2, Low - 1

SEMESTER III

Core Paper VI - 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

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.

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
CO1	3	3	2	3	3	3	2
CO2	3	3	2	3	3	3	2
CO3	3	3	2	3	3	3	2
CO4	3	3	2	3	3	3	3
Total Score	12	12	8	15	15	15	9

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	3	3	3	3	2
CO2	3	2	3	3	3	3	2
CO3	3	2	3	3	3	3	2
CO4	3	2	3	3	3	3	2
Weightage	12	8	12	9	12	12	8
Weighted percentage (rounded of) Course Contribution to Pos	3	2	3	3	3	3	2

Strong - 3, Medium – 2, Low - 1

SEMESTER-III

Core Paper VII - 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

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 particularmaterials

	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 Microscopy AFM)-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 Differential 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
CO1	3	3	2	3	3	3	2
CO2	3	3	2	3	3	3	2
CO3	3	3	2	3	3	3	2
CO4	3	3	2	3	3	3	3
Total Score	12	12	8	15	15	15	9

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	3	3	3	3	2
CO2	3	2	3	3	3	3	2
CO3	3	2	3	3	3	3	2
CO4	3	2	3	3	3	3	2
Weightage	12	8	12	9	12	12	8
Weighted percentage (rounded of) Course Contribution to Pos	3	2	3	3	3	3	2

Strong - 3, Medium – 2, Low - 1

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
	Nanoscience Practical III	Core				3	6	50 +50

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 analyze various preparation techniques

Part:1	**Synthesis of Nanostructured materials**	
	1. Preparation of Nanoparticles by Hydrothermal 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.	
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
CO1	3	3	2	3	3	3	2
CO2	3	3	2	3	3	3	2
CO3	3	3	2	3	3	3	2
CO4	3	3	2	3	3	3	3
Total Score	12	12	8	15	15	15	9

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	3	3	3	3	2
CO2	3	2	3	3	3	3	2
CO3	3	2	3	3	3	3	2
CO4	3	2	3	3	3	3	2
Weightage	12	8	12	9	12	12	8
Weighted percentage (rounded of) Course Contribution to Pos	3	2	3	3	3	3	2

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				4	5	75

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

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) HiroshiMasuhara, Satoshi Kawata and Fumio Tokunaga, Elsevier (2007). Polymer-Clay Nanocomposites, T.J. Pinnayain, G.W.Beall, Wiley, NewYork, 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
CO1	3	3	2	3	3	3	2
CO2	3	3	2	3	3	3	2
CO3	3	3	2	3	3	3	2
CO4	3	3	2	3	3	3	3
Total Score	12	12	8	15	15	15	9

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	3	3	3	3	2
CO2	3	2	3	3	3	3	2
CO3	3	2	3	3	3	3	2
CO4	3	2	3	3	3	3	2
Weightage	12	8	12	9	12	12	8
Weighted percentage (rounded of) Course Contribution to Pos	3	2	3	3	3	3	2

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				4	5	75

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

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
CO1	3	3	2	3	3	3	2
CO2	3	3	2	3	3	3	2
CO3	3	3	2	3	3	3	2
CO4	3	3	2	3	3	3	3
Total Score	12	12	8	15	15	15	9

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	3	3	3	3	2
CO2	3	2	3	3	3	3	2
CO3	3	2	3	3	3	3	2
CO4	3	2	3	3	3	3	2
Weightage	12	8	12	9	12	12	8
Weighted percentage (rounded of) Course Contribution to Pos	3	2	3	3	3	3	2

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

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.
	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
CO1	3	3	2	3	3	3	2
CO2	3	3	2	3	3	3	2
CO3	3	3	2	3	3	3	2
CO4	3	3	2	3	3	3	3
Total Score	12	12	8	15	15	15	9

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	3	3	3	3	2
CO2	3	2	3	3	3	3	2
CO3	3	2	3	3	3	3	2
CO4	3	2	3	3	3	3	2
Weightage	12	8	12	9	12	12	8
Weighted percentage (rounded of) Course Contribution to Pos	3	2	3	3	3	3	2

Strong - 3, Medium – 2, Low - 1

SEMESTER-IV

Core Paper VIII - Biomedical Nanotechnology	II YEAR – FOURTH SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
	Biomedical Nanotechnology	Core				5	5	75

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 applicatios
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 to tumor 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 Biomedical Applications: Techniques, Tools, Applications, and Impact", WILEY -VCH Verlag GmbH & Co. (2005).

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	2	3	3	3	2
CO2	3	3	2	3	3	3	2
CO3	3	3	2	3	3	3	2
CO4	3	3	2	3	3	3	3
Total Score	12	12	8	15	15	15	9

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	3	3	3	3	2
CO2	3	2	3	3	3	3	2
CO3	3	2	3	3	3	3	2
CO4	3	2	3	3	3	3	2
Weightage	12	8	12	9	12	12	8
Weighted percentage (rounded of) Course Contribution to Pos	3	2	3	3	3	3	2

Strong - 3, Medium – 2, Low - 1

SEMESTER-

IV

Core Paper IX - Industrial Nanotechnology	II YEAR – FOURTH SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
	Industrial Nanotechnology	Core				5	5	75

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.
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 optical 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
CO1	3	3	2	3	3	3	2
CO2	3	3	2	3	3	3	2
CO3	3	3	2	3	3	3	2
CO4	3	3	2	3	3	3	3
Total Score	12	12	8	15	15	15	9

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	3	3	3	3	2
CO2	3	2	3	3	3	3	2
CO3	3	2	3	3	3	3	2
CO4	3	2	3	3	3	3	2
Weightage	12	8	12	9	12	12	8
Weighted percentage (rounded of) Course Contribution to Pos	3	2	3	3	3	3	2

Strong - 3, Medium – 2, Low - 1

SEMESTER-IV

Core Practical IV- Nanoscience Practical IV	**II YEAR - Fourth SEMESTER**

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**Credits**	**Inst. Hours**	**Marks**
	Nanoscience Practical IV	Core				3	6	50 +50

Course Outcome	On the successful completion of the course, student will be able to: CO1: To analyze the morphology of the nanomaterials CO2: To characterize the nanomaterials using different techniques CO3: To characterize structurally the nanoparticles prepared and analysis their size and lattice parameters CO4: To characterize the nanomaterials prepared electrically and optically.

Nanoscience practical IV	**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 usingUV-Vis Spectroscopy 5. DC conductivity measurements of nanoparticles at various temperatures
Reading List(Printand Online)	4. Fundamentals Of Analytical Chemistry - Skoog, West and Holler,Saunders College, Publishing, VII Ed, (1996). 5. Text Book Of Quantitative Inorganic Analysis – A.I. Vogel, Elbs, IVEd., (1985). 6. 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
CO1	3	3	2	3	3	3	2
CO2	3	3	2	3	3	3	2
CO3	3	3	2	3	3	3	2
CO4	3	3	2	3	3	3	3
Total Score	12	12	8	15	15	15	9

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	3	3	3	3	2
CO2	3	2	3	3	3	3	2
CO3	3	2	3	3	3	3	2
CO4	3	2	3	3	3	3	2
Weightage	12	8	12	9	12	12	8
Weighted percentage (rounded of) Course Contribution to Pos	3	2	3	3	3	3	2

Strong - 3, Medium – 2, Low - 1

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				4	4	75

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.
	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
CO1	3	3	2	3	3	3	2
CO2	3	3	2	3	3	3	2
CO3	3	3	2	3	3	3	2
CO4	3	3	2	3	3	3	3
Total Score	12	12	8	15	15	15	9

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	3	3	3	3	2
CO2	3	2	3	3	3	3	2
CO3	3	2	3	3	3	3	2
CO4	3	2	3	3	3	3	2
Weightage	12	8	12	9	12	12	8
Weighted percentage (rounded of) Course Contribution to Pos	3	2	3	3	3	3	2

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				4	4	75

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 applications
	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
CO1	3	3	2	3	3	3	2
CO2	3	3	2	3	3	3	2
CO3	3	3	2	3	3	3	2
CO4	3	3	2	3	3	3	3
Total Score	12	12	8	15	15	15	9

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	3	3	3	3	2
CO2	3	2	3	3	3	3	2
CO3	3	2	3	3	3	3	2
CO4	3	2	3	3	3	3	2
Weightage	12	8	12	9	12	12	8
Weighted percentage (rounded of) Course Contribution to Pos	3	2	3	3	3	3	2

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

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
	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

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	2	3	3	3	2
CO2	3	3	2	3	3	3	2
CO3	3	3	2	3	3	3	2
CO4	3	3	2	3	3	3	3
Total Score	12	12	8	15	15	15	9

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	3	3	3	3	2
CO2	3	2	3	3	3	3	2
CO3	3	2	3	3	3	3	2
CO4	3	2	3	3	3	3	2
Weightage	12	8	12	9	12	12	8
Weighted percentage (rounded of) Course Contribution to Pos	3	2	3	3	3	3	2

Strong - 3, Medium – 2, Low - 1

PROJECT (3credit/6 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 : 2)

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