# MANONMANIAM SUNDARANAR UNIVERSITY TIRUNELVELI – 12

## SYLLABUS

# M.Sc NANO SCIENCE AND NANO TECHNOLOGY

## TAMILNADU STATE COUNCIL FOR HIGHER EDUCATION, CHENNAI – 600 005

## For THE ACADEMIC YEAR 2024 – 2025

**The preamble of the syllabus**

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

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

**MEDIUM OF INSTRUCTION AND EXAMINATION**

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

**ELIGIBLITY**

Any undergraduate science degree recognized by UGC.

**THEORY EXAMINATION**

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

**PRACTICAL EXAMINATION**

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

**Evaluation**

A. Each paper carries an internal component

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

Theory External: Internal Assessment = 75:25

Practical External: Internal Assessment = 50:50

C. Internal Assessment

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

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

**Note: Each test will be of one hour duration.**

**E. External Assessment**

External marks distribution

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

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

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

**D. Practical**

Core Practical Examination having the following marks:

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

Passing minimum of 50% for external and overall components

**E: Project work**

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

**Distribution of Marks in Project Course**

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

**Note:**

**i) Student should carry out INDIVIDUAL PROJECTS only**

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

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

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

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

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

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

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

**H. INTERNSHIP/Field work/Industrial visit**

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

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

**Evaluation for internship/Field work/Industrial visit**

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

**Internship work**/Field work/Industrial visit

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

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

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

| **TANSCHE REGULATIONS ON LEARNING OUTCOMES-BASED CURRICULUM FRAMEWORK FOR POSTGRADUATE EDUCATION** | |
|---|---|
| **Programme** | **M.Sc., Nano Science & Nanotechnology** |
| **Programme Code** | |
| **Duration** | **2 years for PG** |
| **Programme Outcomes (Pos)** | **PO1**<br>**Demonstrate knowledge on the physics/chemistry/biotechnology and basics of nanoscale science and technology for their multifunctional applications.**<br><br>**PO2**<br>**Demonstrate ability to synthesis and characterize the materials in general and also nanomaterials.**<br><br>**PO3**<br>**Project their skill in lithography and nanofabrication.**<br><br>**PO4 Having expertise in processing of nanomaterials, MEMS and bio MEMS as perneeds and specifications.**<br><br>**PO5**<br>**Demonstrate an ability to visualize and work on laboratory and multidisciplinary tasks including material science, physics, chemistry and nanobiotechnology.**<br><br>**PO6**<br>**Demonstrate skills to use synthesis, processing and imaging equipments to** |

| | |
|---|---|
| | **analyze samples.**<br><br>**PO7**<br>**Able to propagate their knowledge to address problems of social relevance such as energy, environment and medicine through their specific electives.**<br><br>**PO8**<br>**Understanding the impact of nanomaterials on the society including environment, health and ecosystem.**<br><br>**PO9**<br>**Able to plan and execute their own innovative ideas in the form of projects, product design and development.**<br><br>**PO10**<br>**Develop confidence for self-education and ability for life-long learning.** |

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

## Template for P.G., Programmes

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

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

**Semester-II**

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

**Second Year – Semester – III**

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

**Semester-IV**

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

**Total 91 Credits for PG Courses**

# M.Sc., Nano science and Nano Technology

**SEMESTER – I:**

| COURSE 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-III** | Nanoscience Practical I | 6 | 4 | 6 | 50 | 50 |
| **Discipline Centric Elective- I** | Introduction to Material Science | 6 | 3 | 3 | 25 | 75 |
| **Generic Elective- II** | Choose any one<br>A. Introductory Biology<br>B. Laboratory safety and Health | 6 | 3 | 3 | 25 | 75 |
| | | 30 | **20** | | | |

**SEMESTER - II**

| COURSE COMPONENTS | NAME OF THE COURSE | Hours | Credits | Exam Hrs | MAX MARKS | |
|---|---|---|---|---|---|---|
| | | | | | CIA | EXT |
| **Core-IV** | Introduction to Nanoscience and Nanotechnology | 6 | 5 | 3 | 25 | 75 |
| **Core-V** | Preparation of Nanomaterials | 6 | 5 | 3 | 25 | 75 |
| **Core-VI** | Nanoscience Practical II | 6 | 4 | 6 | 50 | 50 |
| **Discipline Centric Elective- III** | Characterization Techniques of Nanomaterials –I | 4 | 3 | 3 | 25 | 75 |
| **Generic Elective- IV** | Choose any one<br>A.Nanobiotechnology<br>B,Introduction to Nanotoxicology | 4 | 3 | 3 | 25 | 75 |
| **Skill Enhancement [SEC]-I** | Research Methodology | 4 | 2 | 3 | 25 | 75 |
| | | 30 | **22** | | | |

**SEMESTER – III:**

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

**SEMESTER - IV**

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

Total Credits: **91 credits**

**SEMESTER I**
**CORE 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 |

| | |
|---|---|
| Pre requisite: | Basic knowledge in Physics |
| Learning Objectives: | The main objectives of this course are to:<br><br>To understand fundamental concepts of electromagnetic waves,current, magnetism,electronics and quantum mechanics.<br><br>To gain knowledge on electronic devices such as diodes and transistors also to understand the basic concepts of quantum mechanics |
| Course Outcomes | On the successful completion of the course, student will be able to<br><br>CO1: Understand fundamental concepts of physics which are necessary for nanoscience and technology subject<br><br>CO2: Apply the gained subject knowledge to understand the nano-enabled devices<br><br>CO3: Evaluate microscopic scales with macroscopic Impact with the help of Physics.<br><br>CO4: Understanding on real time applications of physics<br><br>CO5: Analyze the acquired knowledge and 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. | | |
| | | |

| Unit: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 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 3 | 3 |
| CO2 | 3 | 2 | 2 | 3 | 3 | 2 | 3 | 3 | 2 | 2 |
| CO3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 2 | 2 | 2 |
| CO4 | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 3 | 2 | 3 |
| CO5 | 3 | 2 | 2 | 3 | 2 | 3 | 2 | 2 | 3 | 3 |

**Strong - 3, Medium – 2, Low - 1**

**Mapping with Programme Specific Outcomes**

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

**Strong - 3, Medium – 2, Low - 1**

## SEMESTER I

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

| | |
|---|---|
| Pre requisite: | Basic knowledge with concepts of Chemistry |
| Learning Objectives: | The main objectives of this course are to:<br>Learn the chemical equilibria concepts, symmetry and group theories, thermodynamic law. |
| Course Outcomes | On the successful completion of the course, student will be able to<br><br>CO1: Define and identify differential branches of chemistry and their importance<br><br>CO2: Understand and describe chemical concepts and processes<br><br>CO3: Interpretation and application of the theories to chemical process and derivations<br><br>CO4: Differentiate different properties and mechanisms of organic reactions, inorganic properties and physical concepts<br><br>CO5: Evaluation and assessment of the theories and chemical process fordifferent applications. |

| 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).<br>2. Text Book Of Quantitative Inorganic Analysis – A.I. Vogel, Elbs,IVEd., (1985).<br>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.<br>2. Physical Chemistry, Atkins<br>3. Text Book Of Quantitative Chemical Analysis – A.I. Vogel, VI Ed,Pearson Education Ltd, 2001 |

**Mapping with Programme Outcomes**

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

**Strong - 3, Medium – 2, Low – 1**

**Mapping with Programme Specific Outcomes**

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

**Strong - 3, Medium – 2, Low - 1**

**SEMESTER I**

| **Core Paper III - 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 |

| | |
|---|---|
| Pre requisite: | Basic knowledge in Physics, chemistry and Biology |
| Learning Objectives: | The main objectives of this course are to:<br>Acquire practical skills in basic instruments in the field of biology,chemistry and Physics for nanoscience |
| Course Outcomes | On the successful completion of the course, student will be able to<br><br>CO1: Acquire practical skills in the use of instruments, technologies and methods in biomolecules like glucose, proteins.<br><br>CO2: Gain practical knowledge by applying the experimental methods to correlate with the theory.<br><br>CO3: Provides opportunities to collect and examine samples from bloodand cells.<br><br>CO4: Identify the acidic and bases values of the chemicals<br><br>CO5: Understand the basic characteristics of the electronic devices |

Any five experiments

1.Find out the RF-value of amino acids using Paper chromatography

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 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |
| CO2 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 2 | 2 |
| CO3 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 2 | 2 |
| CO4 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 2 | 3 |
| CO5 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 3 |

**Strong - 3, Medium – 2, Low - 1**

**Mapping with Programme Specific Outcomes**

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

**Strong - 3, Medium – 2, Low - 1**

**SEMESTER I**

**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 |

| | |
|---|---|
| Pre requisite: | Basic knowledge with concepts ofsolid state physics |
| Learning Objectives: | The main objectives of this course are to:<br>To understand fundamental concepts of crystal structure and defects<br>To gain knowledge in electrical, magnetic, thermal,optical and mechanical materials |
| Course Outcomes | On the successful completion of the course, student will be able to<br>CO1: Understand the fundamental concepts of material science<br>CO2: Apply the gained subject knowledge to understand the advanced concepts of nanoscience.<br>CO3: Evaluate the impact of presence of impurity and applied temperature on various properties ofmaterials.<br>CO4: Analyze the acquired knowledge and understanding on real time applications of variousfunctional materials<br>CO5: Evaluate the different in the types of 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 – OpticalPropertiesof 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 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 3 | 3 |
| CO2 | 2 | 2 | 2 | 3 | 3 | 2 | 3 | 3 | 2 | 2 |
| CO3 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 2 | 2 | 2 |
| CO4 | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 3 | 2 | 3 |
| CO5 | 2 | 2 | 2 | 3 | 2 | 3 | 2 | 2 | 3 | 3 |

**Strong - 3, Medium – 2, Low - 1**

**Mapping with Programme Specific Outcomes**

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

**Strong - 3, Medium – 2, Low - 1**

**SEMESTER I**

## Generic elective(Choose AorB)

| Generic Elective II (A) – Introductory Biology | | I YEAR – FIRST SEMESTER | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Subject Code** | **Subject Name** | **Category** | **L** | **T** | **P** | **Credits** | **Inst. Hours** | **Marks** |
| | **Introductory Biology** | Core | | | | 3 | 6 | 75 |

| | |
|---|---|
| Pre requisite: | Basic knowledge with concepts ofBiology |
| Learning Objectives: | The main objectives of this course are to:<br>Learn the morphology process, metabolism and about different enzyme role energy production |
| Course Outcomes | On the successful completion of the course, student will be able to<br><br>CO1: Acquire the knowledge of the cell biology and application.<br><br>CO2: Explain the role of cell organelles, metabolism, and bioenergetics.<br><br>CO3: Understand the about the morphology, structure, of DNA, RNA anddifferent types of nucleic acid.<br><br>CO4: Gain the knowledge about of glucose, and fatty acid metabolism.<br><br>CO5: Evaluate and compare of the different enzyme role energyproduction. |

| Units | |
|---|---|
| **I** | CELL STRUCTURE AND FUNCTIONS<br>Definitions, Types, Eukaryotic and Prokaryotic cells, Principle of membrane organization, Cytoskeletal proteins, Types of cell division, Mitosis and Meiosis. |
| **II** | PROTEINS<br>Structure and functions of proteins, Amino acids and peptides, Proteins-Primary, Secondary, Tertiary, and Quaternary structures, Protein folding, hemoglobin and myoglobin. |
| **III** | ENZYMES<br>Mechanism of actions, Enzyme kinetics, Regulation of activities, Bioenergetics, Role of ATP, Biological oxidation, Respiratory chain and oxidative phosphorylation |
| **IV** | METABOLISOM<br>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<br>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<br>2. L. Stryer, Biochemistry, 4th Edn., 1995<br>3. Haper's Illustrated Biochemistry, R.K, Murray, D.K. Granner and V.W.Rodwell, McGraw Hill, New Delhi, 2003. |

**Mapping with Programme Outcomes**

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

**Strong - 3, Medium – 2, Low - 1**

**Mapping with Programme Specific Outcomes**

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

**Strong - 3, Medium – 2, Low - 1**

| 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 |

| | |
|---|---|
| Pre requisite: | Basic knowledge about laboratory |
| Learning Objectives: | The main objectives of this course are to:<br>Learn the safety procedures used in the laboratory, safety practices followed in the laborartoty. |
| Course Outcomes | On the successful completion of the course, student will be able to<br><br>CO1: Understand and describe various safety issues and protocols<br>CO2: Interpretation and application of safety protocols and laboratory rules.<br>CO3:Differentiate different types of laboratory accidents and safety protocols and personal protective equipments.<br>CO4: Evaluation and assessment safety regulations, personal protectiveequipments and First aid practices.<br>CO5: Apply the safety practices in real-time and awareness to the societal needs. |

| **Units** | |
|---|---|
| **I** | SAFETY REGULATIONS<br>Standard Laboratory Procedures, Rules and Regulations. Lab Safety Practices. |
| **II** | SAFETY REGULATIONS<br>Employee Information, Safety Plans and Arrangement of Laboratories. |
| **III** | CHEMICAL AND BIOSAFETY<br>Chemicals Handing, MSDS Information, Labelling of The Chemicals, Disposal Of The Chemical And Biological Wastes |
| **IV** | SAFETY EQUIPMENTS<br>Various Safety Equipments, Personal Protective Equipments, User Manuals, Arrangements, Training. |
| **V** | FIRST AID<br>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 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 3 | 3 |
| CO2 | 3 | 2 | 2 | 3 | 3 | 2 | 3 | 3 | 2 | 2 |
| CO3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 2 | 2 | 2 |
| CO4 | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 3 | 2 | 3 |
| CO5 | 3 | 2 | 2 | 3 | 2 | 3 | 2 | 2 | 3 | 3 |

**Strong - 3, Medium – 2, Low - 1**

**Mapping with Programme Specific Outcomes**

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

**Strong - 3, Medium – 2, Low - 1**

**SEMESTER-II**

**CORE-IV**

| **Core IV – 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 |

| | |
|---|---|
| Pre requisite: | Basic knowledge with concepts of materials in the field of nanoscience |
| Learning Objectives: | The main objectives of this course are to:<br>To understand fundamental concepts of nanoscience and technology<br>To gain knowledge on size dependent nanoparticles for various properties |
| Course Outcomes | On the successful completion of the course, student will be able to<br>CO1: Understand the fundamental concepts of nanoscience<br>CO2: Apply the basic concepts of physics, chemistry and biology concepts to understand the advanced concepts of nanoscience<br>CO3: Analyse the influence of size and morphology and other factors on various properties of materials.<br>CO4: Analyze the acquired knowledge and understanding of nanoscience in various field.<br>CO5: Evaluate and assess the theories related to nanoscience for different applications. |

| **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,<br>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 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 3 | 3 |
| CO2 | 3 | 2 | 2 | 3 | 3 | 2 | 3 | 3 | 2 | 2 |
| CO3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 2 | 2 | 2 |
| CO4 | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 3 | 2 | 3 |
| CO5 | 3 | 2 | 2 | 3 | 2 | 3 | 2 | 2 | 3 | 3 |

**Strong - 3, Medium – 2, Low - 1**

**Mapping with Programme Specific Outcomes**

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

**Strong - 3, Medium – 2, Low - 1**

## SEMESTER-II

## CORE-V

| Core 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 |

| | |
|---|---|
| Pre requisite: | Basic knowledge with concepts of materials in the field of nanoscience |
| Learning Objectives: | The main objectives of this course are to:<br>Understand preparation procedures also the various factors that affects the size and morphology of crystallites.<br>Gain knowledge on current status, future trends and scope for research in preparing the nanomaterials |
| Course Outcomes | On the successful completion of the course, student will be able to<br><br>CO1: Understand the fundamental concepts in materials preparation with various Morphologies<br><br>CO2: Apply the gained subject knowledge towards understanding the mechanisms involved in physical, chemical and mechanical routes.<br><br>CO3: Evaluate and understand the role of preparation method towards grain with narrow distribution and desired morphology.<br><br>CO4: Analyze the acquired knowledge and understanding of preparing the nanomaterials for various application<br><br>CO5: Analyze the acquired knowledge and understanding on effect of grain morphology and its needs for technological advancements |

| **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 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 3 | 3 |
| CO2 | 2 | 2 | 2 | 3 | 3 | 2 | 3 | 3 | 2 | 2 |
| CO3 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 2 | 2 | 2 |
| CO4 | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 3 | 2 | 3 |
| CO5 | 2 | 2 | 2 | 3 | 2 | 3 | 2 | 2 | 3 | 3 |

**Strong - 3, Medium – 2, Low - 1**

**Mapping with Programme Specific Outcomes**

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

**Strong - 3, Medium – 2, Low - 1**

**SEMESTER-II**

**CORE-VI**

| **Core Paper VI - 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 |

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

| | |
|---|---|
| **Practical-II** | **Synthesis and band gap determination of Biomolecules and Biomaterials**<br>**(Any five experiments)** |
| | 1. Synthesis of Silver Nanoparticles by Chemical Reduction Method and their UV-VIS Absorption Studies.<br>2. Synthesis of Gold Nanoparticles by Chemical Reduction Method and their UV-VIS Absorption Studies.<br>3. Synthesis of Silver Nanoparticles by Polyol Method and their UV-VIS Absorption Studies.<br>4. Synthesis of zinc oxide Nanoparticles by sol-gel method and characterize using UV-VIS Absorption Studies.<br>5. Synthesis of silver nanoparticles by using plant extract and UV vis absorption studies<br>6. Synthesis of silver nanoparticles using bacteria and their UV visabsorption studies<br>7. Study of chemical kinetics using UV- vis absorbtion spectroscopy and extrapolate it using Tauc plot. |
| **Reading List(Print and Online)** | 1. Fundamentals Of Analytical Chemistry - Skoog, West and Holler, Saunders College, Publishing, VII Ed, (1996).<br>2. Text Book Of Quantitative Inorganic Analysis – A.I. Vogel, Elbs, IVEd., (1985).<br>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.<br>2. Physical Chemistry, Atkins<br>3. Text Book Of Quantitative Chemical Analysis – A.I. Vogel, VI Ed,Pearson Education Ltd, 2001 |

**Mapping with Programme Outcomes**

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

**Strong - 3, Medium – 2, Low - 1**

## Mapping with Programme Specific Outcomes

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

**Strong - 3, Medium – 2, Low – 1**

**SEMESTER 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 |

| | |
|---|---|
| Pre requisite: | Basic knowledge with concepts of nanostructured materials |
| Learning Objectives: | The main objectives of this course are to:<br>Understand the purpose of characterization techniques adopted to study the properties of the given nanomaterials |
| Course Outcomes | On the successful completion of the course, student will be able to<br><br>CO1: Explore the properties of nanomaterials for the particular applications<br><br>CO2: Understand the principles of characterization techniques And study the properties of nanomaterials<br><br>CO3: Explain the instrumentation involved in the characterization technique<br><br>CO4: Identify the suitability of the characterization for the particularmaterial.<br><br>CO5: Analyse the interpretation of the results obtained from the characterization techniques.<br>. |

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

**Mapping with Programme Outcomes**

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

**Strong - 3, Medium – 2, Low - 1**

**Mapping with Programme Specific Outcomes**

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

**Strong - 3, Medium – 2, Low - 1**

**SEMESTER-II**

## 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 |

| | |
|---|---|
| Pre requisite: | Basic knowledge with concepts of biomaterials |
| Learning Objectives: | The main objectives of this course are to:<br>1. Acquire the knowledge of the cell biology and application.<br>2. Explain the role of cell organelles, metabolism, andbioenergetics.<br>3. Understand about the morphology, structure, of DNA,RNAand different types of nucleic acid.<br>4. Gain the knowledge about of glucose, and fatty acidmetabolism. |
| Course Outcomes | On the successful completion of the course, student will be able to<br><br>CO1: Understand the basics of bioinspired strategies for the fabricationof Implants<br>CO2: Analyse the importance of bioactive nanomaterials in bone grafting and tissue engineering<br>CO3: Recognize the significance of Biomolecules in the fabrication of Nanostructures<br><br>CO4 : Study the applications of Polymer nanofibers in Tissue engineeringand its merits and demerits .<br><br>CO5: Understand the overall basics of biomolecules and its applicationin Nano biotechnology<br>. |

| 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<br>http :// www.routledgehandbooks.co |
| **Recommended Texts** | 1. Challa S.S.R. Kumar (Ed) Biological and pharmaceutical nanomaterials : Wiley – VCH Verlag GmbH& Co, KgaA.<br>2. Ninmeyer C.M, Mirkin C.A (Eds) 2005. Nanobiotechnology<br>3. H.S. Nalwa (Ed) Handbook of Nanostructured Bioaterials and their applications in Nanobiotechnology, American Scientific Publishers.2005 |

**Mapping with Programme Outcomes**

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

**Strong - 3, Medium – 2, Low - 1**

**Mapping with Programme Specific Outcomes**

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

**Strong - 3, Medium – 2, Low - 1**

**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 |

| | |
|---|---|
| Pre requisite: | Fundamentals knowledge in biological cell and tissues and also the basic knowledge in materials. |
| Learning Objectives: | The main objectives of this course are to:<br>Learn the basics of nanotoxiology and relate it to various application. |
| Course Outcomes | On the successful completion of the course, student will be able to<br><br>CO1: Understand the basic of Toxoicology and Nano science anddifferentiate between nanomaterials and bulk materials<br><br>CO2 Evaluate and critically review the theoretical and practical aspects of Nanomaterials application<br>CO3: Critically assess and outline the nanoscience related to nanotoxicology.<br>CO4 Demonstrate the new properties of Nano materials and its significance in toxicology<br>CO5: Analyse the overall basics of nanotoxilogy and its application in various field. |

| Units | |
|---|---|
| I | **AREAS OF TOXICOLOGY**<br>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<br>Human Health. |
| II | **NANOMATERIALS**<br>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**<br>Nanomaterials in environment, Source of pollution, Transport throughenvironment. |
| IV | **NANOMATERIAL EXPOSURE MEASUREMENT**<br>Nano sized materials exposure to human, Measurement methods, Thresholdvalues-permissible limits. |
| V | **PORTALS OF NANOMATERIALS ENTRY**<br>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*<br>***2.*** Nanotechnology: Environmental Health and Safety, Risks, Regulation and Management, **Matthew Hull** and **Diana Bowman, Elsevier, 2010**<br>Principles and Methods of Toxicology. Edited by A.W. Hayes. Taylor and Francis, 2008. |

**Mapping with Programme Outcomes**

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

**Strong - 3, Medium – 2, Low - 1**

**Mapping with Programme Specific Outcomes**

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

**Strong - 3, Medium – 2, Low - 1**

# SEMESTER II
## 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 |

| | |
|---|---|
| Pre requisite: | Basic knowledge in doing project and research |
| Learning Objectives: | The main objectives of this course are to:<br>1. Learn the formulation of research aims and objectives in anappropriate manner and to framing good research hypothesis.<br>2. Inculcate knowledge of scientific methodology in analysing researchdata.<br>3. Impart the knowledge of sampling techniques and record scientific datain a proper way. |
| Course Outcomes | On the successful completion of the course, student will be able to<br>CO1: Understand the aims and objectives research and formulate a research workplan in a scientific manner<br>CO2 Evaluate and critically review the theoretical and practical aspects of Research<br>CO3: Generate good research hypothesis, design appropriate experiments, collect and interpret the data to validate their experiments.<br>CO4 Generate good research hypothesis, design appropriate experiments, collect and interpret the data to validate their experiments.<br>CO5: Obtain and evaluate information from a variety of databases and Communicate effectively in a variety of forms like research publications,patents. |

| | |
|---|---|
| I | **Foundations of Research:**<br>Meaning, Objectives, Motivation, Utility. Concept of theory, Characteristics of scientific method – Understanding the language of research – Concept, Construct, Definition, Variable. Research Process<br>Research Question – Measurement Issues – Hypothesis – Qualities of a good Hypothesis –Null Hypothesis & Alternative Hypothesis. Hypothesis Testing – Logic & Importance. |
| **II** | **Research Design:**<br>Concept and Importance in Research – Features of a good research design concept, types and uses, Descriptive Research Designs – concept, types and uses.<br>Experimental Design: Concept of Independent & Dependent variables.<br>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:**<br>Characteristics of a good sample. Probability Sample – Simple Random Sample, Systematic Sample- Determining size of the sample – Practical considerations in sampling and sample size.<br>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 :**<br>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: :**<br>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<br>2. Business Research Methods – Alan Bryman & Emma Bell, Oxford University Press.<br>3. Research Methodology – C.R.Kothari, New Age International, New Delhi, 2014.<br>4. Kumar, R. Research Methodology–A Step-By-Step Guide for Beginners; 2nd Ed., Pearson Education: New Delhi, 2005.<br>5. Montgomery, D. C. Design & Analysis of Experiments; 8th Ed., Wiley India: Noida, 2013. |

## Mapping with Programme Outcomes

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

**Strong - 3, Medium – 2, Low - 1**

## Mapping with Programme Specific Outcomes

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

**Strong - 3, Medium – 2, Low - 1**

**SEMESTER-III**

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

**Pre Requisites**

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

**Learning Objectives**

The main objectives of this course are to:

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

**Course outcome**

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

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

| | Units |
|---|---|
| **I** | BASIC CONCEPT OF NANOELECTRONICS<br>New Perspectives- New Ohm's Law- Densityof states- Fermic Function- Types of Conductance- Ballastic<br>Conductance- Resistance: Ballistic to Diffusive- Nanotransistors |
| **II** | SEMICONDUCTOR NANODEVICES<br>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<br>Single Electron Tunnelling Phenomena- Coulomb Blockad - RSD and Resonant Tunnelling Transistor- Quantum Structures Based LEDs - OLED and Photo Detectors-<br>Magnetic Quantum Dots andTheir Applications. |
| **IV** | NANOSENSORS BASICS<br>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<br>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,<br>Bio Sensors - DNA Based Biosensors |
| **Recommended Texts** | 1.Introduction To Molecular Electronics, M.C. Pettey<br>2.The Physics And Chemistry Of Nanosolids, Frank J. Owens AndCharles P. Poole Jr., Wiley Interscience (2006)<br>3.Nanotechnology Enabled Sensors, Kouroush Kalantar – Zadeh,Benjamin Fry, Springer (2007) |

**Mapping with Programme Outcomes**

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

**Strong - 3, Medium – 2, Low - 1**

**Mapping with Programme Specific Outcomes**

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

**Strong - 3, Medium – 2, Low - 1**

**SEMESTER III**

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

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

**Pre requisite:**

Basics of atom model,basics of electrical and magnetic materials

**Learning objectives:**

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

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

**Course Outcomes:**

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

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

| **Unit:1** | **Electrical and Dielectric properties** | |
|---|---|---|

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

| **Unit:2** | **Magnetic Properties** | |
|---|---|---|

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

| **Unit:3** | **Optical Properties** | |
|---|---|---|

| |
|---|
| Optical phenomena in Materials–Surface Plasmon Resonance–Bandgap tailoring–Burstein – Moss Effect – Direct and Indirect Transitions – Effective Mass Approximation Theory – Kubelka – Munk function – isobestic effect – Hyper, Hypso, Batho and Hypochromic effects –Fluorescence: Stoke shift. |

| **Unit:4** | **Mechanical Properties** | |
|---|---|---|
| Mechanical: Modes of deformation – Elastic and plastic deformation – Compressive strength-Mechanical stiffness–Fracture–Toughness–Superplasticity–Hardness–Micro-hardness–Fracture–Toughness –Indentation –Hall-petch Relation. | | |

| **Unit:5** | **Thermal Properties** | |
|---|---|---|
| Thermal: Thermal conductivity–Expansion–Stress–Specific Heat Capacity–Glass Transition Temperatures–Melting-point Depression. | | |

| **Text Book(s)** | |
|---|---|
| 1 | Springer Handbook of Nanotechnology- Ed. by B. Bhushan, Springer-Verlag (2004) |
| 2 | Magnetic Materials: Fundamentals and Applications by Nicola A. Spaldin, Cambridge University Press, 2nd Edition, (2018) |
| 3 | The Chemistry of Nanomaterials: Synthesis, Properties and Applications, C.N.R. Rao, A.Muller,<br>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<br>https://www.youtube.com/watch?v=bwZW96c743A |
| 2 | YOUTUBE: Introduction to Nanomaterials<br>https://www.youtube.com/watch?v=qUEbxTkPIWI |

**Mapping with Programme Outcomes**

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

**Strong - 3, Medium – 2, Low – 1**

**Mapping with Programme Specific Outcomes**

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

**Strong - 3, Medium – 2, Low - 1**

**SEMESTER-III**

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

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

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

**Learning Objectives:**

The main objectives of this course are to:

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

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

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

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

| **Units** | |
|---|---|
| **I** | **Unit I Morphological studies**<br>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**<br>Scanning Tunnelling Microscopy (STM), Atomic Force MicroscopyAFM)-Non-contact-contact-Tapping- conducting mode-. Near Field Scanning Optical Microscopy; Scanning capacitance Microscopy- Magnetic Force Microscopes MFM)- Chemical Force Microscope (CFM). |

| | |
|---|---|
| **III** | **Unit III Microscopic characterization**<br>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**<br>Principle and Instrumentation of Thermogravimetry; Differential Thermal Analysis and Differential scanning calorimetry-Importance of thermal analysis for nanostructures. |
| **V** | **Unit V Bio-materials characterization**<br>New Advances and challenges in biological and biomedical materials characterizations- Dynamic light scattering spectroscopy. Confocal Microscopes - Confocal Raman – Application in Nanobiotechnology. Fluorescence Microscope |

**Related Online Contents**

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

**Text book and References:**


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

**Mapping with Programme Outcomes**

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

**Strong - 3, Medium – 2, Low - 1**

**Mapping with Programme Specific Outcomes**

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

**Strong - 3, Medium – 2, Low – 1**

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

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

| | |
|---|---|
| **Pre requisite:** | Fundamental and theoretical knowledge on preparation and characterization techniques |
| **Learning Objectives:** | The main objectives of this course are to:<br>6. Acquire practical skills in the use of instruments, technologies andmethods to fabricate nanomaterials and their characterization<br>7. Apply the practical knowledge in understanding the structural ofthe materials<br>8. Provides opportunities to synthesize the materials using differentapproaches<br>9. Master the technical skills in handling lab equipments,characterizing the acquired data and analyze using appropriate tool<br>10. Understand the role of environmental conditionson thepreparation of nanomaterials |
| **Course Outcome** | On the successful completion of the course, student will be able to:<br><br>CO1: To synthesis nanomaterials by different methods.<br>CO2: To synthesis thin films using different techniques<br>CO3: To synthesis various nanocomposites<br>CO4: To characterize structurally the nanoparticles prepared and analysis their size and lattice parameters<br>CO5: To characterize the nanomaterials prepared electrically and optically. |

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

| | | |
|---|---|---|
| **Part:2** | **Characterization of Nanomaterials** | |
| | 1. X-Ray powder diffraction pattern analysis and lattice parameters determination of nanoparticles.<br>2. Impedance measurement and analysis using Cole-Cole plot method<br>3. Dielectric constant measurement at various temperatures with various frequencies.<br>4. Band gap studies of Metal oxide semiconductors using UV-Vis Spectroscopy<br>5. DC conductivity measurements of nanoparticles at various temperatures | |
| **Reading List(Printand Online)** | 1. Fundamentals Of Analytical Chemistry - Skoog, West and Holler,Saunders College, Publishing, VII Ed, (1996).<br>2. Text Book Of Quantitative Inorganic Analysis – A.I. Vogel, Elbs, IVEd., (1985).<br>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.<br>2.Physical Chemistry, Atkin<br>3.Text Book Of Quantitative Chemical Analysis – A.I. Vogel, VI Ed,Pearson Education Ltd, 2001 |

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

**Mapping with Programme Outcomes**

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

**Strong - 3, Medium – 2, Low - 1**

**Mapping with Programme Specific Outcomes**

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

**Strong - 3, Medium – 2, Low - 1**

**Elective course – V (Choose Anyone)**

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

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

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

| Units | |
|---|---|
| **I** | **Nanostructured Magnetism**: Nanostructure magnetism, Effect Bulk nanostructuring of magnetic property, Giant and colossal magnetic resistance,Nanomagnetic materials, Paramagnetism in metallic nanoparticles. |
| **II** | **Thermoelectric Materials:** Concept of phonon, Thermal conductivity specificheat, exothermic and endothermic processes, Different types of thermoelectric materials, One dimensional and composite thermoelectric materials and Applications. |
| **III** | **Structure Properties of Polymeric Nanomaterials** stress-strain behavior of polymer nanomaterials, glass transition temperature and relationship between Tm and Tg. Effect of molecular weight, property requirements and its utilization. Synthetic procedure for commercial polymers, Fire retarding and biomedical polymers. |
| **IV** | **Nanocomposites**<br>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**<br>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.<br>Organic Photovoltaics Biophotonics, Optical Science and Engineering for the 21st Century, (Ed.) Xun Shen and Roeland Van Wijk,<br>NANO BIOPHOTONICS: Science and Technology, (Eds) Hiroshi Masuhara, Satoshi Kawata and Fumio Tokunaga, Elsevier (2007).<br>Polymer-Clay Nanocomposites, T.J. Pinnayain, G.W.Beall, Wiley, New York, 2001.<br>Composite Materials, Deborah D.L.Chung, Springer, 2002. |

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

**Mapping with Programme Outcomes**

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

**Strong - 3, Medium – 2, Low – 1**

**Mapping with Programme Specific Outcomes**

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

**Strong - 3, Medium – 2, Low – 1**

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

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

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

| Unit | |
|---|---|
| I | **MATERIALS FOR IMPLANT**<br>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**<br>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**<br>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**<br>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<br><br>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<br>2. Joachim Schummer, Davis Baird (Ed) Nanotechnology Challenges: implications for philosophy, Ethics and society ; World scientific ; 2006<br>3. William Sims Bainbridge, Mihail C. Roco (Ed) Societal implication of Nanosciences and Nanotechnology;Springer;2001<br>4. Jon J. Kellar (Ed) Functional fillers and nanoscale minerals; new markets/ new horizonsSME science; 2006<br>5. Davis Baird, Alfred Nordmann, Joachim Schummer (Eds) Discovering the nanoscale; IOP press; 2004 |

**Mapping with Programme Outcomes**

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

**Strong - 3, Medium – 2, Low – 1**

**Mapping with Programme Specific Outcomes**

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

**Strong - 3, Medium – 2, Low - 1**

**Semester III**

## Skill Enhanced course – II

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

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

| | |
|---|---|
| **Pre requisite:** | Basics of environmental sciences,social work ,waste issues. |
| **Learning Objectives** | 1. To create awareness in current green practices in manufacturing industry<br>2. To acquire knowledge in International green manufacturing standard and Process<br>3. To enlighten the students with knowledge about water pollution and its effects on the environment<br>4. To introduce the concept of environmental design and industrial ecology.<br>5. To impart knowledge about green plastics and nanocomposites manufacturing from plants and microbes. |
| **Course Outcomes** | On completion of this course the students will be able to:<br>CO1: Identify waste and pollutants<br>CO2:Recognize the opportunities to improve efficiency.<br>CO3: Understand life cycle impacts and Conserve resources.<br>CO4: Prevent pollution and improve the quality level.<br>CO5: Keep a direct control on the quality of the formulation and assuring thecompliance of standards |
| | **Units** |
| **I** | GREEN MANUFACTURING TRENDS<br>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<br>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<br>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<br>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<br>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).<br>2. David Dornfeld, Green manufacturing fundamental and applications, Prentice hall (2002).<br>3. G. Sammy Shinga, Green electronics design and manufacturing, Prince publications (2008).<br>4. James clark, Green chemistry, Blackwell publishing (2008).<br>5. Paulo Davim, Sustainable Manufacturing, Wiley publications (2010).<br>6. Frank Kreith, George Tchobanoglous, Solid waste management, McGraw Hill (2002).<br>7. E. S. Stevens, Green plastics, Princeton university press (2002).<br>8. U. Robert Ayres, A Handbook of Industrial Ecology, Edward elgar publishing (2002). |

## Mapping with Programme Outcomes

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

**Strong - 3, Medium – 2, Low - 1**

## Mapping with Programme Specific Outcomes

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

**Strong – 3, Medium – 2, Low - 1**

## SEMESTER-IV

| Core Paper XI - Biomedical Nanotechnology | II YEAR – FOURTH SEMESTER |
|---|---|

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

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

| | |
|---|---|
| **Course Outcomes** | On the successful completion of the course, student will be able to<br><br>CO 1: Discuss the basic of Biomedical sciences and their usage in different fields.<br><br>CO2: Evaluate and critically review the theoretical and practicalaspects of Nano materials in biomedical application application.<br><br>CO3: Summarize the concepts in Biomedical nanomaterials in pharmacy.<br><br>CO4: Critically assess and outline the nanotechnology for allareas of biomedical application<br><br>CO5: Demonstrate the new properties of Nano materials for next generation medical needs |
| **Units** | |
| **I** | BIO CERAMICS FOR IMPLANT COATING<br>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<br>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<br>Diagnosis of diseases, treating and preventing of diseases – targeted for drug delivery – ligand coupled nanoparticle features – methods for coupling targeting ligands to nanoparticles – targeting modalities – barriers totumor targeting *in vivo* – MRI contrast enhancement – Gene delivery |
| **IV** | NANOPHARMACY<br>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<br>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 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |
| CO2 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 2 | 2 |
| CO3 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 2 | 2 |
| CO4 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 2 | 3 |
| CO5 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 3 |

**Strong - 3, Medium – 2, Low - 1**

**Mapping with Programme Specific Outcomes**

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

**Strong - 3, Medium – 2, Low – 1**

## SEMESTER-IV

| Core Paper XII - Industrial Nanotechnology | II YEAR – FOURTH SEMESTER |
|---|---|

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

| | |
|---|---|
| **Pre requisites:** | Basics in semiconductor materials, magnetic materials |
| **Learning Objectives:** | The main objectives of this course are to:<br>1. Identification of industrially relevant materials<br>2. Summarize suitability of nanomaterials for industries.<br>3. Interpretation and employment of nanomaterials for industrialneeds<br>4. Understanding the role of different nanomaterials for industrial applications |
| **Course Outcome** | On the successful completion of the course, student will be able to<br><br>CO1:Development of new combination of nanomaterial based ontheir properties for future needs.<br><br>CO2: Evaluation and critical assessment of nanomaterials for various industrial application.<br><br>CO3:Assess the role of nanomaterial for enhancing the applicationeffect.<br><br>CO4: Review the industrial development and relevant nanomaterials supplywith required functionalities.<br><br>CO5:Demonstrate the new properties of nanomaterials for next generationneeds. |

**Units**

| | |
|---|---|
| **I** | SEMICONDUCTOR NANOSTRUCTURES AND DEVICES<br><br>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<br>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<br>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<br>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<br>Nanoparticles And Micro Organism for industrial application, Nano-Materials in Bone Substitutes and Dentistry, Food and Cosmetic Applications. Textiles, Paints, Catalysis, Drug Delivery and Its Applications, Biochips -Analytical Devices, Biosensors. |

**Reading List(Printand Online)**

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

**RecommendedTexts**

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

**Mapping with Programme Outcomes**

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

**Strong - 3, Medium – 2, Low - 1**

**Mapping with Programme Specific Outcomes**

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

**Strong - 3, Medium – 2, Low - 1**

## SEMESTER-IV (ELECTIVE)

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

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

| | |
|---|---|
| **Pre requisites:** | Basics in sensors ,nanomaterials,food and agriculture needs |
| **Learning Objectives** | 1.To understand the usage of sensors in food and agriculture.<br>2. To explain about the functional materials for food and agriculture.<br>3.To understand the required nano composities for application purposes. |
| **Course outcomes:** | On the successful completion of the course, student will be able to<br>CO1:Define and identify functional materials for food industry.<br>CO2: Understand and describe food and agricultural processes.<br>CO3: Interpretation and application of the theories and protocols for soil andfoodnutrient management.<br>CO4:Differentiate different types of nanomaterials food sensing, nutrientmanagement and packaging application.<br>CO5:Evaluation and assessment of various functional materials for sensing,nutrient management and packaging processes. |
| | **Units** |
| **I** | SENSORS FOR SOIL, SEED AND FOOD MONITORING<br>Introduction and Importance, Various Sensing Methods, Chemical and Biosensors, Sensors for Monitoring Soil, Seed and Food, Nanomaterials For Intelligent Sensors. |
| **II** | FUNCTIONAL MATERIALS<br>Functional Materials for Food and Agriculture Use - Super Absorbent Polymers, Coatings, Aerosols. Zeolites, Nano-Clays, Nano Emulsion, |
| **III** | NANOFERTILIZERS<br>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<br>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<br>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)<br>2. Nanotechnology Applications In Food, Alexandru Grumezescu, Alexandra Oprea, Academic Press (2017) |

**Mapping with Programme Outcomes**

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

**Strong - 3, Medium – 2, Low - 1**

**Mapping with Programme Specific Outcomes**

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

**Strong - 3, Medium – 2, Low - 1**

**SEMESTER-IV**

| **Elective VI B –**<br>**Nanomedicine and Drug Delivery** | **II YEAR – FOURTH SEMESTER** |
|---|---|

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

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

| | |
|---|---|
| **Course Outcomes** | On the successful completion of the course, student will be able to<br>**CO-1**: Explain the basics of nanomedicine ,surgical needs and imaging tools in medicine field.<br>**CO-2:** Understand the biopharmaceutical nanomaterials requiredfor drug delivery<br>**CO-3:** Explain the various types of sensors for medical analysis<br>**CO-4:** Evaluate the properties of nanocarriers for diagonis and therapeutic application<br>**CO5:** Summarise and analyse the application of nanocarriers in drug delivery |
| **UNITS** | |
| **I** | **Prospect of Nanomedicine**:<br>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**:<br>Chemical and Molecular Sensors- Displacement and Motion sensors-Force Nanosensors-Pressure sensing-Thermal nanosensors- Electric and Magnetic Sensing. |
| **III** | **Nanocarriers:**<br>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**:<br>Preparation, Characterization and Therapeutic Applications-Aerosols as Drug Carriers-Magnetic Nanoparticles as Drug Carriers – Nanomedicine for eye (Ophthalmology). |
| **V** | **Applications Drug Delivery**:<br>Delivery of Nanoparticles to the Cardiovascular System-Nanocarriers for the vascular Delivery of Drugs to the Lungs-Nanoparticulate Carriers for Drug Delivery to the Brain-Pharmaceutical Nanocarriers in Treatment and Imaging of Inflection. |

**Reading List(Printand Online)**

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

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

**RecommendedTexts**

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

**Mapping with Programme Outcomes**

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

**Strong - 3, Medium – 2, Low - 1**

**Mapping with Programme Specific Outcomes**

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

**Strong - 3, Medium – 2, Low – 1**

# Semester IV

## SKILL ENHANCEMENT COURSE III

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

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

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

| | |
|---|---|
| II | **Basics of pharmacology**<br>Overview, sources of drugs, routes of drug administration, Pharmacokinetics-absorption, distribution, metabolism and excretion, Pharmacodynamics, Adverse drugreactions, Drug interactions. |
| **III** | **Pharmaceutical product development:**<br>Fundamental aspects, pharmaceutical excipients, biopharmaceutical considerations,Principles of solubilization, dissolution, partition coefficient, ionization and bioavailability. |
| **IV** | **Kinetics and Drug stability:**<br>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**<br>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<br>2. Ira R. Berry, Robert A Nash (2013), Pharmaceutical process validation, 3rd Rev Edition.Marcel Dekker<br>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.<br>4. Manging for quality and performance excellence ninth edition James R.Every, William M.Lindsay South-western Cengage learning 2014. |

## Mapping with Programme Outcomes

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

**Strong - 3, Medium – 2, Low - 1**

## Mapping with Programme Specific Outcomes

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

**Strong - 3, Medium – 2, Low – 1**

## PROJECT (7 credit/10 hours)

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

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

**i) Student should carry out INDIVIDUAL PROJECTS only**

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

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

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

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

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

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

## EXTENSION ACTIVITY (Credit : 1)

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

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

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

**3.Social relevant and Environmental related activities/approach**

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