SOLAPUR UNIVERSITY, SOLAPUR

Proposed Syllabus

Of

M.Sc. Nano-Technology

Choice Based Credit System-CBCS

With Effect from 2016-2017
1) Title of the Course: M.Sc.-Nanotechnology

2) Introduction: This course provides a broad overview of Nanotechnology and to produces expert hands that would have sufficient knowledge and expertise to solve the urgent problems of the region by using biotechnology. The course structure is technology-centric where students basically learn technology and are taught necessary basic subjects for that purpose.

3) Objectives of the course:
The objectives of M. Sc. Nanotechnology course are
• To provide an intensive and in-depth learning to the students in field of Nanotechnology.
• Beyond simulating, learning, understanding the techniques, the course also addresses the underlying recurring problems of disciplines in today scientific and changing business world.
• To develop awareness & knowledge of different organization requirement and subject knowledge through varied subjects and training methodology in students.
• To train the students to take up wide variety of roles like researchers, scientists, consultants, entrepreneurs, academicians, industry leaders and policy.

4) Advantages of the Course:
Nanotechnology has tremendous job potential including
• Trading,
• industrial job
• Entrepreneurship
• Consultancy organizations in pharmaceuticals, Electronics, Energy, Material Science, Medical, Defense, Agriculture, Environment Protection etc.
• Job in Scientific Research Organizations.
• Universities in India & abroad.
• Hospitals and healthcare
5) Eligibility of Course:

**Eligibility:** A Candidate possessing B.Sc. Degree with Chemistry/ Physics/Electronics/ Biotechnology/ Biochemistry/Chemistry/Microbiology/ Botany/ Zoology/ B. Pharm/ MBBS/ B. E./B.Tech/ B. Sc. Agri./Entrepreneur and who have passed the entrance examination conducted by the Solapur University shall be held eligible for admission to M. Sc. Course in **Nanotechnology.** Students from other University with B.Sc. General Degree and who have passed the entrance examination conducted by the University are also eligible.

- **Admission:** Merit list based on average of Bachelors/ Undergraduates, aggregate and entrance exam conducted by Solapur University for all the candidates from India and abroad.

6) Duration:

- The duration for this program is of 2 years with semester pattern (04 Semesters)

7) Medium of Instruction: English

8) Structure of the Course:

- Structure of M.Sc. course in faculty of Science has total of 4 semesters for 2 years.
- M. Sc. I comprise of total two semesters and M. Sc. II comprises of total two semesters.
- Semester I and II includes four core and two practical course
- Semester III comprising four core theory papers and two practical courses
- Semester IV comprising three core theory papers and one elective paper and two practicals courses in which one practical course comprising research project.
- Each semester will have four theory papers of 70 marks each for University external examination and 30 marks each for internal examination
- Two practical courses of 70 marks each for the University external examination and 30 marks each for internal practical course.
# Syllabus for M.Sc. Nanotechnology Part - I

**COURSE STRUCTURE**

**SEMESTER-I**

<table>
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<th>Semester</th>
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## SEMESTER-II

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M. Sc. SEMESTER –I

HCT1.1 FUNDAMENTALS OF NANOTECHNOLOGY IN PHYSICS

60 Hrs

Total marks: 100

(Credits-4)

Unit-I: Crystal structure, Semiconductors & Their Properties

Atomic structure - Atomic bonding in solids- Crystalline state of solids - Unit cells and Space lattices – Crystal structures - Crystal planes and directions- Miller Indices - Diffraction of X-rays by crystal - Bragg's equation - Correction to Bragg's equation - Reciprocal lattice - Crystal Defects - point, line and surface defects.

Band model of semiconductors - carrier concentrations in intrinsic and extrinsic semiconductors - Fermi level - variation of conductivity and mobility with temperature - law of mass action. Hall Effect - Hall coefficients for intrinsic and extrinsic semiconductors - determination of Hall constant - Hall effect devices.

Unit-II: Quantum Theory of Nanomaterials

Development of Quantum theory of Nanomaterials: Application of Block functions in Nanomaterials. Quantum Dots: (a) Semiconductor Quantum Dots, (b) Introduction to lasers (c) Quantum Dot lasers (d) Quantum Cascade lasers and (e) Quantum Dot optical memory.

Unit-III: Physical Properties and Ferroelectric & Piezoelectric Material

Static dielectric constant, electronic, ionic and orientation polarizations - Internal or local fields in solid and liquids. Lorentz field in cubic materials - Clausius-Mosotti equation - complex dielectric constant - determination of dipole moment for polar substances - dielectric losses - frequency dependence of electronic, ionic, orientation polarisabilities - optical absorption, luminescence - Thallium activated alkali halides - electro luminescence.
Unit-IV: Size Dependent Properties of Nanomaterials

Elucidation of the structure: chemistry and properties of Nano-structured materials. Variation in properties of micro and Nanomaterials. Length scale involved and effect on properties: mechanical, electronic, optical, magnetic and thermal properties.

References:
1. C. Kittle. Introduction to Solid State Physics
2. S.O. Pillai Solid State Physics
5. Linus Pauling, E. Brignt Wilson Corrier, Introduction to Quantum Mechanics Dover Publication
7. Arthur Baiser -
Unit-I: Atoms, Molecules, Ions, Electrons & Periodic trends (15)

Unit-II: Chemical Bonds, Molecular structure and Bonding Theories (15)
Lewis symbols, Ionic bonding, Covalent bonding, Formal charges & resonance in Lewis structure, Molecules that do not satisfy the octet rule, Bond energies. Valence –orbitals shell Electron-Pair repulsion Model, Polarity of molecules, Valence bond theory, Multiple bonds, Molecular orbitals: Homonuclear Diatomic Molecules, Heteronuclear Diatomic Molecules & Delocalized Molecular orbitals.

Unit-III: Fundamentals of Nanotechnology (15)
Introduction to Nano-science and Nano-technology, Nano-scale material, implications for Physics, Chemistry, Engineering & Biology, and Motivation for Nanotechnology study. History & development of Nano-science and Nano-technology with the emphasis on history of Nano-metals, Chalcogenides& Boron Nitrite and Carbon Nanomaterials

Unit-IV: Structures & Classification of Nanomaterials (15)
REFERENCES:

Unit-I: Physical Methods of Synthesis of Nanomaterials (15)

Synthesis of Nano-structured materials: Principle and relative merits of each techniques for production of Nano-structures including ultra-thin films and multilayer by: (a) Laser Ablation technique, (b) Arc Discharge technique and (c) Mechanical Milling

Unit-II: Physico-Chemical Methods of Synthesis of Nanomaterials (15)

Fundamentals and need of identification of pertinent parameters amenable to synthesis of nanoparticles by Physico chemical methods such as (a) CVD (Chemical Vapor Deposition) / MOCVD technique, (b) Plasma / Sputtering / Hot-Wire Plasma Enhanced CVD method, (c) Molecular Bean Epitaxy (d) Atomic Layer Epitaxy and (f) Self assembly technique

Unit-III: Chemical Methods of Synthesis of Nanomaterials (15)

Chemical methods of synthesis and applicability of the methods

(a) Solution growth techniques of 1D-2D nano structures: Synthesis of metallic, semiconducting and oxide nanoparticles – homo- and hetero-nucleation growth methods, (b) Template-based synthesis (electrochemical, electrophoretic, Melt and solution, CVD, ALD), (c) Gas Phase Synthesis of Nanopowders: – Vapor (or solution) – liquid – solid (VLS or SLS) growth – the Need for Gas/vapor State Processing – Main Stages of Gas Phase Synthesis (d) Evaporation, (e) Self assembly technique (f) Sol-gel method and (g) Spray pyrolysis.

Properties of living organisms such as to combat deleterious effect of heavy metals in high concentrations; resistance against metals by Modulation of their transport, Active efflux, Redox changes and Sequestration and intracellular compartmentation into detoxified complexes; Biogenic synthesis by (i) bacteria, (ii) fungi, (iii) algae and (iv) plants.

References:

1. Edelestein A.S and Cammarata RC, Nano materials synthesis, properties and applications:
Unit-I: Living System


Unit-II: Suitability of living organisms as nano-factories


Unit-III: DNA, Amino acids and Proteins

Introduction to DNA & DNA nanotechnology. Components of DNA –[ purine bases -pyrimidine bases deoxyribose sugar - physical and chemical properties of DNA- Protein introduction , biochemistry of proteins - cellular functions of proteins - introduction to protein based nanotechnology. Structure and reactions of amino acids - hydrophilic and hydrophobic amino acids - table of standard amino acid abbreviations and side chain properties - nonstandard amino acids-
Nature in the construction of Nano-scale biosensor devices and motors: ATP synthesis is a nanomotor with 100% thermodynamic efficiency., bacterial flagella & its energetic momentum. DNA and protein’s use as actuators, chips, sensors and electronic circuits.

REFERENCES:

1. H. Baltimore, WH Freeman, Cell & Molecular Biology
2. Kimball T.W. , Cell Biology, Wesley Pub
Unit 1: Background to Nanotechnology
Scientific revolution - Atomic structures - Molecular and atomic size - Bohr radius – Emergence of Nanotechnology – Challenges in Nanotechnology - Carbon age – New form of carbon (from Graphene sheet to CNT).

Unit 2: Nucleation
Influence of nucleation rate on the size of the crystals - macroscopic to microscopic crystals and nanocrystals - large surface to volume ratio, top-down and bottom-up approaches - self assembly process - grain boundary volume in nanocrystals - defects in nanocrystals - surface effects on the properties.

Unit 3: Types of Nanostructures
Definition of a Nano system - Types of Nanocrystals - One Dimensional (1D) - Two Dimensional (2D) - Three Dimensional (3D) nanostructured materials - Quantum dots - Quantum wire Core/Shell structures.

Unit 4: Nanomaterials and properties
Carbon Nanotubes (CNT) - Metals (Au, Ag) - Metal oxides (TiO2, CeO2, ZnO) - Semiconductors (Si, Ge, CdS, ZnSe) - Ceramics and Composites - Dilute magnetic semiconductor - Biological system - DNA and RNA - Lipids - Size dependent properties - Mechanical, Physical and Chemical properties.

Unit 5: Applications of Nanomaterials
Molecular electronics and nanoelectronics – Quantum electronic devices - CNT based transistor and Field Emission Display - Biological applications - Biochemical sensor - Membrane based water purification.

References:
Physics Experiments (Any six practicals)

1. Determination of Young’s modulus of a given material – Uniform / Non-uniform bending methods.
2. Determination of Rigidity modulus of a sample – Torsion pendulum
3. Determination of dispersive power of a prism – Spectrometer
4. Study of attenuation and propagation characteristics of optical fiber cable
5. Calibration of voltmeter / ammeter using galvanometer
6. Construction & study of IC regulation properties of a given power supply
7. Study of electrical characteristics of a solar cell
Chemistry Experiments (Any six practicals)

1. Preparation of standard solutions
2. Estimation of total, permanent and temporary hardness by EDTA method
3. Conductometric titration - determination of strength of an acid
4. Estimation of iron by potentiometry.
5. Determination of molecular weight of polymer by viscosity average method
6. Determination of dissolved oxygen in a water sample by Winkler’s method
7. Determination of Na / K in water sample by Flame photometry (Demonstration)
8. Estimation of Copper in ore
9. Estimation of nickel in steel
10. Determination of total alkalinity and acidity of a water sample
11. Determination of rate of corrosion by weight loss method.
HCP 1.3 NANOTECHNOLOGY

Nanotech Experiments (Any six practicals)

2. Synthesis of dendrimers.
3. Preparation of thiolated silver nanoparticles
4. Synthesis of Gold Nanoparticles by chemical and biogenic methods
6. Synthesis of Iron Oxide Nanoparticle
8. Synthesis of Nickel metal nanoparticle by urea decomposition method
9. Synthesis of Zinc Oxide nanoparticle
10. Preparation of nanoparticles by using Ball milling
SCP 1.1 BIO-NANOTECHNOLOGY

Bio-nanotechnology Experiments (Any six practicals)

1. Isolation of DNA from various sources
2. Determination of Electrical conduction of DNA
3. Isolation and separation of cell organelles
4. 2D- Electrophoresis technique for separation of proteins
5. Synthesis of Gold Nanoparticles by biogenic methods
6. Synthesis of Silver Nanoparticles by biogenic methods
7. Isolation of enzymes involved in biosynthesis of nanomaterials
SCP 1.2 GENERAL LAB

General Lab Experiments (Any six practicals)
1. Origin Plot
2. Curve fitting - straight line fit, exponential and power – law fit
3. Non-linear curve fitting: Polynomial, Gaussian and Lorentzian
4. Image processing of AFM and SEM micrograph
5. Determination of dielectric constant - LCR bridge
6. Determination of Band gap of semiconductors
7. Hall effect
8. Resistivity measurement of a thin film
9. Determination of Molecular weight by viscometry method
10. pH determination of solution
M.Sc. SEMESTER – II

HCP 2.1 CHARACTERIZATION TOOLS OF NANOMATERIALS

60 Hrs
Total marks: 100
(Credits-4)

Unit-I: Electron Microscopic characterization of nanomaterials


Unit-II: Spectroscopic characterization of nanomaterials


Spectroscopic equipments: UV-VIS Spectroscope, XRD, RAMAN Spectroscope, EELS, XPS (X-ray Photoelectron Spectroscope), SIMS, NMR, DLS (Dynamic Light Scattering or photon correlation spectroscope), DPI (Dual Polarisation Interferometry), FTIR, Nano-lithographic technique and Surface area measurement & analysis technique. Analysis for evaluating Optical absorption and Nonlinear Kerr effect, Photoluminescence and Optical band gap Analysis for evaluating Optical absorption & Nonlinear Kerr effect, Photoluminescence & Optical band gap

Unit-III: Mechanical, Thermal & Optical Property Characterization of Nanomaterials

Unit – IV: Characterization of Quantum structures

Quantum structures Particle diameter by HRTEM Photoluminescent properties, Excitation wavelength, Photoluminescence by Micro plate Reader Photostability, Quantum yield

REFERENCES:

1. Zhong Lin Wang, Handbook of Nanophase and Nanomaterials (Vol 1 and II) Springer
3. J.C. Vickerman, Surface Analysis: The Principal Techniques, John Wiley and Sons
4. Roland Wiesendanger, Scanning Probe Microscopy and Spectroscopy: Methods and Applications, Cambridge Univ press
Unit – I: Fundamental Properties of Nanomaterials

Size dependent properties: Surface to volume ratio (SVR), Size Effects on Structure and Morphology of Free or Supported Nanoparticles - Size and Confinement Effects - Fraction of Surface Atoms - Specific Surface Energy and Surface Stress - Effect on the Lattice Parameter - Effect on the Phonon Density of States - Nanoparticles Morphology - Equilibrium Shape of a Macroscopic Crystal - Equilibrium Shape of Nanometric Crystals - Morphology of Supported Particles. Some Physical forces do not apply at the nano-scale: Gravitational force and friction.

Unit - II: Optical properties of nanomaterials


Unit-III: Magnetic Properties of Nanomaterials


REFERENCES:

2. Hari Singh Nalwa Handbook of Nanostructured Materials and Nanotechnology Optical Properties Vol.4
3. Paras N Prasad, Nano-photonics, Wiley IEEE
5. M. Gentili et al. (edits), Nanolithography, Springer
SCT 2.1 CARBON AND NANOFORMS OF CARBON

60 Hrs
Total marks: 100
(Credits-4)

Unit –I: Introduction to Carbon


Unit –II: Nanoforms of Carbon


Unit –III: Synthesis of Nano-Carbon

Methods of CNM synthesis: Arc-discharge, Chemical Vapor Deposition (CVD), Pulsed Laser deposition (PLD), Thermal Vapor Deposition of CNM thin films. Synthesis of Nano-catalysts for CNT synthesis preparation & purification of CNM. Synthesis of Nano-diamonds (amorphous Carbon) and DLC.

REFERENCES:

1. Laurie Kelly, MeyyappanMeyyappen, Carbon Nano tubes: Science and Applications, CRC Press
Unit – I Basics of Nano-Electronics  

Introduction, Fundamentals of Nano-Electronics & Nano-fabrication; Molecular electronics and basic properties of molecular materials; Optical & electron beam lithography, Molecular beam lithography. MEMS and NEMS: Development of micro electronics - Region of Nanostructures - methods and limits on microminiaturization in semiconductors- micro electro mechanical systems.

Silicon micromachining- semiconductors and insulators - Microsystems fabrication techniques - Silicon MEMS fabrication technology - Single crystal reactive etching and metallization process. Non-silicon MEMS and fabrication techniques - SIC MEMS - Biomedical-MEMS techniques - Integration of microsystems with electronics – RF MEMS – Applications


Unit – II Electronics and Nano Optical application  


Unit – III Role of Nanotechnology in harvesting Solar Energy  

Unit – IV Applications of Nanotechnology in Energy

Hydrogen Fuel Cell: Thermodynamics of conversion of chemical energy into electrical energy, Basic design of fuel cell, comparison of fuel cell with battery, types of fuel cell and their merits & demerits.

Hydrogen Storage: as liquid and gaseous form, Thermodynamics of storage of hydrogen by metal hydride, different types of metal hydrides & their properties, hydrogen storage by carbon nanoparticles.


Introduction to various types of batteries. Lithium batteries and application of Carbon and Nano-carbon in Lithium batteries.

REFERENCES:

UNIT - I NANOMOLECULAR DIAGNOSTICS - ARRAY AND CHIPS (15)

UNIT - II NANOMACHINES AND NANOBARCODES, NANOBIOSENSORS (15)
UNIT - III NANOPHARMACEUTICALS


UNIT - IV ROLE OF NANOTECHNOLOGY IN BIOLOGICAL THERAPIES

UNIT - V APPLICATION IN CANCER THERAPY & NANOMEDICINE


References:

OET 2.2 GREEN MANUFACTURING TECHNOLOGY

60 Hrs
Total marks: 100

(Credits-4)

UNIT - I GREEN MANUFACTURING TRENDS (15)
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- surrounding green manufacturing - the areas of automotive, semiconductor and medical areas as well as in the supply chain and packaging areas Green Manufacturing.

UNIT - II SUSTAINABLE GREEN MANUFACTURING (15)

UNIT - III WASTE MANAGEMENT (15)
Sustainability and global conditions - Material and solid waste management - Energy management - chemical waste management and green chemistry - Climate change and air emissions management - Supply water and waste water management - Environmental business management .

UNIT - IV INDUSTRIAL ECOLOGY (15)
Introduction to commercial plastics and elastomers - Natural Rubber (NR), modified NR and blends - Polyesters from microbial and plant biofactories (polylactic acid and poly hydroxyalkanoates) - Plastics from vegetable oils – Cellulose and starch based materials - Natural fillers, fibers, reinforcements and clay nanocomposites - Biodegradability, life cycle assessment and economics of using natural materials.

References:
HCP 2.1 SYNTHESES & PURIFICATION OF NANO-MATERIALS

60Hrs
Total marks: 100
(Credits-4)

SYNTHESIS NANO-MATERIALS

1. Synthesis of Carbon Nano-materials by Chemical Vapor Deposition (CVD) method at
   i. Different temperatures
   ii. Duration of Pyrolysis
   iii. Effect of flow rate of carriers
   iv. Using different chemical precursors
   v. Using Biological precursors
   vi. Effect of different catalysts (Fe, Ni, Co) on Nanomaterial formation

2. Nano-material Synthesis by Sputtering technique: Using following parameters
   i. Voltage
   ii. Current
   iii. Distance between substrate & filament
   iv. Precursor quantity
   v. Under vacuum
   vi. Using Argon, Nitrogen and Hydrogen gas

3. PURIFICATION OF CARBON NANO-MATERIALS
   - Purification of synthesized Nano-materials by
   - Physical techniques.
   - Chemical method
   i. Effect of temperature
   ii. Effect of vacuum
   iii. Effect of different gases (Ar, H₂ & N₂)
CHARACTERIZATION OF NANO-MATERIALS

   i. Transmission/absorption spectra in range of 300nm to 1500nm
   ii. Determination of absorption coefficient for different wavelength
   iii. Determination of band gap using Lau model

   i. Study the morphology of nanomaterials and determine its dimensions.
   ii. XRD study of powder nanomaterials and determination of its characteristics
1. In this course, the students are expected to read and present research papers on current topics in Nanotechnology leading to advances in Nanotechnology or Nano-electronics.

2. Each student is expected to present minimum of 10 lectures of 30 min each followed by questions and discussion.

3. Background knowledge related to the topic would be considered as the part of the presentation.
OEP 2.1 NANO-MEDICINE

60 Hrs
Total marks: 50
(Credits-2)

NANO-MEDICINE

1. In this course, the students are expected to read and present research papers on current topics in Nanotechnology leading to advances in Nanotechnology or Nano-Medicine

2. Each student is expected to present minimum of 10 lectures of 30 min each followed by questions and discussion.

3. Background knowledge related to the topic would be considered as the part of the presentation.

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OEP 2.2 GREEN MANUFACTURING TECHNOLOGY

60 Hrs
Total marks: 50
(Credits-2)

GREEN MANUFACTURING TECHNOLOGY

1. In this course, the students are expected to read and present research papers on current topics in Nanotechnology leading to advances in Green Manufacturing Technology

2. Each student is expected to present minimum of 10 lectures of 30 min each followed by questions and discussion.

3. Background knowledge related to the topic would be considered as the part of the presentation.