PANJAB UNIVERSITY

M. Tech.

Nanoscience and Nanotechnology

Syllabus: 2024-26

ELIGIBILITY CRITERIA

M. Sc. or M. S. in Chemistry / Physics / Materials Science / Nanoscience / Biophysics / Biochemistry-

SUMMARY OF THE COURSE STRUCTURE

GENERIC ELECTIVE COURSES (MNT-GE) OFFERED BY CNSNT TO STUDENTS FROM

COURSE DETAILS

Semester-I

Sl. No.	Course Code	Subjects	Teaching Scheme			Examination Scheme			Subject Credits
			L	T	P	Exam.	Sess.	Total	
1	MNT-6101								

solutions. 1-D and 3-D square well potential, tunnelling effect, particle in a box, H-atom problem.

Applications of barrier penetration - tunnelling phenomenon, solution of Schrödinger equation for various dimensional nanomaterials, quantum confinement. Electron wave functions in semiconductor nanocrystals: Brus relation. Changes of Fermi levels in nanomaterials as a consequence of quantization.

Section-B

Concept of quantum computation, quantum Qbits, introduction to nuclear spin, quantum devices, single electron devices. Many electron phenomena- statistical description of a physical system, phase space, microstates and macrostates, density of states, classical and quantum statistics, ideal gas and Gibbs paradox.

Theory of ensembles - canonical, micro-canonical and grand canonical ensemble, the micro-canonical ensemble theory and its application to ideal gas, the canonical ensemble and its thermodynamics, partition function, energy fluctuations, equipartition, harmonic oscillator as canonical ensemble, grand canonical ensemble and significance of statistical quantities.

Quantum statistics- quantum ensemble, statistics of occupation, thermodynamical behaviour of ideal Bose gas, Bose-Einstein condensation, discussion of a gas of phonons, thermodynamics of a Fermi gas, introduction to free electron gas theory.

MNT 6103
CHEMISTRY OF NANOMATERIALS

The question paper for end-semester examination will consist of seven questions of equal marks, viz. 10. The first question will be compulsory and will consist of several short questions/problems covering the entire syllabus. The rest of the questions shall be distributed evenly over the whole syllabus, such that there are at least three questions from each unit. The candidates will attempt five questions in all, selecting at least 02 questions from each section, and the compulsory question.
The books indicated as text-book(s) are suggestive of the level of coverage. However, any other book may be followed considering it an emerging subject.

COURSE OBJECTIVES

To provide the students with the chemical foundation of nanoscience and the concepts of solid state chemistry, colloidal & surface chemistry**,** so that they would be able to understand and distinguish between variety of nanomaterials based on their chemical structure and properties and understand the chemistry behind the formation of nanomaterials.

COURSE OUTCOMES

Students will get to know the

extrinsic defects, point defects, line and plane defects, vacancies - Schottky and Frankel defects, color centres and other defects in non-stoichiometric crystals.

Section-B

Adsorption and absorption, adsorption isotherms - adsorption and desorption kinetics. Wetting behaviour of surfaces - concept of contact angle and measurement techniques. Introduction to thermodynamics - enthalpy and entropy, introduction to the concept of chemical potential, surface energy and surface tension, its consequences in nanomaterials.

Classification of colloids and purification of colloidal solution (dialysis, electro-dialysis, ultrafiltration). Chemistry of surfaces - curvature and neighbouring charge effects on chemical reactivity and equilibria (pKa's, redox potentials), electrical double layer and zeta potential. I

Students will get to know the techniques of synthesis of nanomaterials.

Focused ion beam lithography, working principal, instrumentation and uses in nanostructure, preparation of TEM lamella. Nanoimprint lithography working principal, instrumentation and uses. Scanning near field lithography, scanning probe based lithography methods - AFM and STM lithography, dip pen lithography.

BOOKS AND REFERENCES

1. -10, by Hari Singh Nalwa, American Scientific Publishers; 1st edition (1 January 2004)
2. by M.H. Fulekar, IK International 2010.
3.
4. 15 Oct 2010.
5.
6. . B., Elsevier publication 2006.
7. Imperial College Press 2004.
8.

MNT 6105
SCIENTIFIC COMPUTATION AND SIMULATION IN NANOSCIENCE & NANOTECHNOLOGY

The inG* nor)640(iqcsu0032 84.q0.000008871 0 595.32 841.90.0000088)>BDC2teW* nCreW*i

Tools - practical approach to learning operating systems (DOS, UNIX, Windows) and Graphical packages

(Origin)

Programming - C++ Programming, c

List of open ended experiments:

1. Hall effect measurement.
2. Four probe conductivity measurement.
3. Dielectric constant as a function of temperature.
4. Surface functionalization and characterization of 2D surfaces.
5. Synthesis of metal nanomaterials, characterization, and data analysis.
6. Preparation of oxide nanomaterials, characterization and data analysis.
7. Visualization and study of protein structures.
8. Enzyme reactions and study of kinetics.
9. Synthesis of silver nanoparticles using green chemistry.
10. .
11. Dispersion of functionalized carbon nanotubes and characterization.

ELECTIVE COURSES (MNT-6102 E)

MNT-6102 E1

INTRODUCTION TO BIONANOTECHNOLOGY

The question paper for end-semester examination will consist of seven questions of equal marks, viz. 10. The first question will be compulsory and will consist of several short questions/problems covering the entire syllabus. The rest of the questions shall be distributed evenly over the whole syllabus, such that there are at least three questions from each unit. The candidates will attempt five questions in all, selecting at least 02 questions from each section, and the compulsory question.
The books indicated as text-book(s) are suggestive of the level of coverage. However, any other book may be followed considering it an emerging subject.

COURSE OBJECTIVES

To provide the students with the knowledge of application of nanotechnology in biotechnology, so that they would be able to apply it in industrial applications of biological process.

COURSE OUTCOMES

Students will get to know the fundamentals nanobiotechnology.
Students will get to know the international standards and practices of nanobiotechnology.
Students will get to know DNA, proteins, amino acids, drug delivery, biomedicine etc.
Students will get to know the functional principles of bionanotechnology.
Students will get to know the applications and possibilities of biomaterials to enhance the quality of life.
Students will get to know the various classes of biomaterials and process like enzyme kinetics.
Students will get to know the characteristics of the biomaterials for technology development.

Syllabus: Introduction to microbes and cell biology, bio-conjugation, surface functionalization/modification cellular imaging, classes of materials used in medical applications, enzymes & enzyme kinetics, in vitro and in vivo assessment of tissue compatibility, testing methods and interactions of nanomaterials, polymers in drug delivery, targeted drug delivery. Passive or active targeting, ISO, FDA and ASTM standards, degradation of materials. Cytotoxicity, bio mineralization, bioactive glasses and glass-ceramics, dental materials, pharmacokinetics, hydrogels in controlled drug delivery, smart biomaterials, stimuli responsive hydrogels, 3D bio-printing, bio inspired nanomaterials.

Detailed version:

Section -A

Introduction to microbes and cell biology. Preparation of bacterial culture and study of its growth, isolation, preservation. Introduction to bio-conjugation, interaction of biomolecules with nanoparticles, surface functionalization/modification of nanoparticles, nanoparticles in biological labelling and cellular imaging: science of nanoparticles functionalization. Introduction to classes of materials used in medical applications: metals, polymers, ceramics, biodegradable materials, coatings, medical fibers, non-fouling surfaces. Enzymes- enzyme kinetics and industrial applications of enzymes.

In

systems, targeted drug delivery. Passive or active targeting, targeting tumor cells, polymer-protein conjugates, polymer drug-conjugates. Degradation of materials in the biological environment: Effects of the biological environment on metals, polymers and ceramics. Relevant international standards: ISO, FDA and ASTM. Cytotoxicity, systemic effects, genotoxicity, carcinogenicity, reproductive toxicity, sensitization & irritation, tissue compatability and inflammatory response, evaluation of host response.

Section - B

Bio mineralization, bioactive glasses and glass-ceramics, calcium phosphate ceramics, calcium phosphate coatings, calcium phosphates, clinical applications of hydroxyapatite. Dental materials-introduction to dental

The books indicated as text-book(s) are suggestive of the level of coverage. However, any other book may be followed considering it an emerging subject.

COURSE OBJECTIVES

To provide the students with the knowledge of coating science and technology of nanomaterials with a broad perspective covering the theoretical part, raw materials, coating formulation, coating production, coating application, coating testing and challenges of the coatings industry.

COURSE OUTCOMES

Students will get to know the surface engineering techniques and identify the appropriate manufacturing processes for nanocoatings.
Students will get to know the difference between traditional coating and nanocoating techniques.
Students will get to know the various techniques of nanocoatings.
Students will get to know the materials and mechanism of nanocoatings.
Students will get to know the various devices based on nanocoatings.

Syllabus: Introduction to coatings, coating methods and fabrication, characterization of coatings, mechanical behaviour and machining performances, cleaning & roughening of surfaces, concept of color, determination of internal and residual stresses, high temperature oxidation resistance. Case studies, tribology, surface engineering, polymer nanocomposites, silane & silica coating. Properties of nano coatings, rheology, processing of plastics and rubbers, fibre spinning and manufacturing processes, processing of metallic materials, casting design and defects, deformation processing, hot and cold working, metal joining process, materials selection and design, materials performance index, modern devices and components by nanocoatings.

Detailed version:

Section A

Introduction to chemical & physical vapour deposition, RF sputtering, arc-discharge, laser ablation, thermal evaporation, e-beam techniques, MBE & MOCVD. Nanopowders and nanolayered hard coatings, nanostructuring methods -

situ synthesis. Optical, thermomechanical and mechanical properties of the nano coatings. Polymer processing - rheology, compounding and processing of plastics and rubbers, fibre spinning and manufacturing processes. Ceramic processing- pressing, CIP, HIP, slurry processing, slip casting, pressure casting, tape casting, gel casting, rapid prototyping, sol-gel processing, thermal and plasma spraying, thick and thin film coatings. Processing of metallic materials- casting processes, casting design and defects. Fundamentals of deformation processing, hot and cold working, metal joining process, design aspects, Materials selection and design, weighting factors, materials performance index. Design of engineering structures. Modern metallic, ceramic, polymeric and biomaterials devices and components by nanocoatings.

BOOKS AND REFERENCES

Sons, Inc. 2009.

-C. Nièpce, Wiley

Syllabus: Patentability requirements, nanotech patents, copyright. Delegation of power of agencies, regulation, political and judicial control. Economic impacts and commercialization, initial results and managing the nanotechnology revolution- Malcolm Baldrige national quality criteria. The emerging of nano economy, - nanotechnology based surveillance and society. Methodological issues and innovations, societal implications.

Detailed version:

Section - B

The applications of civil & criminal laws- national and international scenario. Civil liability and application of negligence to nanotechnology. Liability for nanotechnology products warranty issues and nanotechnology business organization-criminal liability.

Ethics and law - ethical issues in nanoscience and nanotechnology. Reflections and suggestions-ethics and nanotechnology. Survey for law in a new frontier- exploration of patent matters associated with nanotechnology. The ethics of ethics -negotiations o

Semester-II

MNT 6201
NANOMATERIALS BASED DEVICES: MEMS AND NEMS

The question paper for end-semester examination will consist of seven questions of equal marks, viz. 10. The first question will be compulsory and will consist of several short questions/problems covering the entire syllabus. The rest of the questions shall be distributed evenly over the whole syllabus, such that there are at

dynamic characteristics-mechanical, optical, spintronic, bio-electronic and bio-magnetic sensors-surface modification-surface materials and interactions, micro-actuation, scaling laws.

Transistors-bipolar transistor, fabrication techniques of bipolar transistor, transistor action, static characteristics of bipolar transistor, frequency response and switching of bipolar transistor, heterojunction bipolar transistor. Metal semiconductor contacts, basic characteristics, Schottky barrier, Ohmic contact, MOS structure, MIS diode, operation and its characteristics, MOSFET scaling and modelling, scaling effects, charge coupled device (CCD). Hetero-junction and hetero structure devices.

Section-B

MEMS and NEMS definitions, synthesis and design. Materials for MEMS & NEMS- active substrate materials and polymers. Consideration for microfabrication materials, LIGA process, microsystem packaging, die, device and system level packaging, interfaces in microsystem packaging for different application, signal mapping and transduction, micro system design consideration, process design, mechanical design, mechanical design using Fem, design considerations for optical, fluidic, RF and bio MEMS & NEMS, overview of CAD tools for design and simulation.

Biomimetic devices- biological analogies and design biomimetic fundamentals, biomimetic for NEMS and MEMS. Nano machines and molecular electronics. Nano-ICs and nano-computer architectures - quantum computation and introduction to nanoelectronics, future of nanoelectronics - interfacing with the Brain, lab-on-biochips, challenges and solutions in nano manufacturing technology.

BOOKS AND REFERENCES

-Electro Mechanical and Nano-Electro Mechanical Systems, Fundamental of Nano-and Micro-Engin

Cammarata, Bristol, Philadelphia: Institute of Physics 2002.

Springer. 2nd edition 2008.

Zadeh. K., Springer 2010.

Sons, Inc.

Hoboken, New Jersey 2007.

MNT 6203

least three questions from each unit. The candidates will attempt five questions in all, selecting at least 02 questions from each section, and the compulsory question.
The books indicated as text-book(s) are suggestive of the level of coverage. However, any other book may be followed considering it an emerging subject.

COURSE OBJECTIVES

To provide the students with the physics of nanomaterials and the origin of various physical properties, so that they become familiar with the underlying basic principles.

COURSE OUTCOMES

Students will get to know the lattice dynamics and thermal properties.
Students will get to know the band theory and the origin of various physical properties.
Students will get to know the electrical and thermal transport properties and estimation of relaxation time.
Students will get to know the fabrication of field effect transistors made of nanowires and graphene.

Syllabus: Crystal lattice structures, density of states, conductivity and band gap, properties, thermal expansion. Overview of band theory, electrons in a periodic potential, bands in pure and doped semiconductors, electronic transport, relaxation time, Hall effect, and magnetoresistance, origin of GMR. Quantum dots, reciprocal lattice and Brillouin zone. Band structure engineering, transport theory, ballistic transport, quantum dots and spectroscopic analysis.

Detailed version:

Section-A

Lattice structures, bindings in solids, elastic constants, lattice vibrations, normal modes, density of states, conductivity and band gap, metal to insulator transition. Overview of reciprocal lattice, Brillouin zone, quantization of elastic waves, phonon momentum, density of states.

Overview of band theory of solids, bands in pure and doped semiconductors, Drude and Sommerfield models and their failures, review of electrons in a periodic potential, Bloch theorem, nearly free electron model, tight binding method, Van hove singularities, dispersion relations of graphene and carbon nanotubes using tight binding method.

Electrons in magnetic field - Hall effect, magnetoresistance, landau levels, quantum hall effect, quantum oscillatory phenomena, oscillations of the magnetisation (the de Haas-van Alphen effect), oscillations of the magnetoresistance (Shubnikov de Haas effect). Origin of GMR in nanomaterials.

Sectionuctivity and band gap

Electronic transport theory- from classical kinetic theory, calculation of relaxation time in metals and insulators, electronic transport in 1, 2 and 3 dimensions, energy sub-bands, effective mass, Drude conduction, ballistic transport, phase coherence length, quantized conductance. Landau equation, ballistic transport in carbon nanotubes, Luttinger liquid model for 1D conductors.

Quantum dots - electron confinement, single and interacting quantum dots. Lithographic fabrication of III-V and graphene quantum dots. PL, Raman and optical spectroscopy to characterize quantum dots, Kondo Effect in quantum dots. Coulomb blockade in a nanocapacitor, Fock space, tunnel junctions and excitations by a current source, coulomb blockade in a quantum dot circuit, single electron transistor, examples of nanoscale field effect transistors made of nanowires and graphene.

BOOKS AND REFERENCES

-Günter Rubahn;

John-Wiley and Sons, Inc. 2005.

Cash, McGraw Hill, 4th edition 2017.

-

Rouessac, Wiley, 2nd edition 2013.

rd edition 2010.

Cengage Learning, 5th Edition 2014.

2009.

by C. Kittel, Wiley Eighth edition 2012.

by Owen and Poole, Wiley. First edition, 2008

by Paul Harrison, Wiley Blackwell, 2nd edition 2005.

Dienstuhl Springer 2004.

MNT 6204
CHARACTERIZATION TECHNIQUES FOR NANOMATERIALS

The question paper for end-semester examination will consist of seven questions of equal marks, viz. 10. The first question will be compulsory and will consist of several short questions/problems covering the entire syllabus. The rest of the questions shall be distributed evenly over the whole syllabus, such that there are at least three questions from each unit. The candidates will attempt five questions in all, selecting at least 02 questions from each section, and the compulsory question.

The books indicated as text-book(s) are suggestive of the level of coverage. However, any other book may be followed considering it an emerging subject.

COURSE OBJECTIVES

This course is intended for the students to teach important techniques, basic principles and sample preparation for the analysis, so that they become familiar with characterization of various nanomaterials.

Scanning probe techniques- basic principle of scanning tunnelling spectroscopy, instrumentation and applications, constant current and constant height mode. Atomic force microscopy - tip-surface interaction, different imaging modes, force sensor, deflection detection, working with biological samples. Basic understanding of each technique with special emphasis on characterization at nanoscale.

BOOKS AND REFERENCES

electronic, and biological devices. Composites of carbon nanomaterials and their applications in paint industry, aerospace industry, electronics, etc.

Detailed version:

Section-A

Introduction-carbon materials carbon molecules- nature of the carbon bond, allotropes of carbon new carbon structures, discovery of C60 - structure of C60 and its crystal. Structure of carbon nanotubes (CNTs) types of CNTs electronic properties of CNTs band structure of CNTs and graphene electron transport properties of CNTs scattering in CNTs carrier mobility in CNTs. From a graphene sheet to a

MNT 6206
LABORATORY-II

Introduction to universal safety standards- hazard classification-flammable, combustible, explosive, bio-hazard, carcinogens, ion and laser radiation, etc. Standard laboratory practices chemicals classification for storage, safe bulk solvent storage, ventilation requirement, first aid practices.

COURSE OBJECTIVES

To provide the students with hands-on-training for the synthesis and fabrication of various nanomaterials.

ELECTIVE COURSES (MNT-6202 E)

MNT-6202 E1

ADVANCEMENT IN BIONANOTECHNOLOGY

The question paper for end-semester examination will consist of seven questions of equal marks, viz. 10. The first question will be compulsory and will consist of several short questions/problems covering the entire syllabus. The rest of the questions shall be distributed evenly over the whole syllabus, such that there are at least three questions from each unit. The candidates will attempt five questions in all, selecting at least 02 questions from each section, and the compulsory question.
The books indicated as text-book(s) are suggestive of the level of coverage. However, any other book may be followed considering it an emerging subject.

COURSE OBJECTIVES

To provide the students with the knowledge of recent advancement in nanobiotechnology, so that they would be able to apply their knowledge in industrial applications.

COURSE OUTCOMES

Students will get to know the advanced nanobiotechnology.
Students will get to know various assays and working antimicrobial drugs.
Students will get to know the fundamentals of biomechanics and biotribology.
Students will get to know various nanotechnology devices for the detection and diagnostics.
Students will get to know the applications and possibilities of biomaterials like tissue engineering to enhance the quality of life.
Students will get to know the targeted drug delivery mechanism.
Students will get to know the advancement in nanotechnology based cancer therapy.

Syllabus: Antimicrobial activity of nanoparticles, bacterial growth inhibition assay and minimum inhibitory concentration (MIC), bio-electromagnetism, working of EEG & ECG, biomechanics, bio-tribology, biological/circadian rhythms. Protein-based nanostructures, nanopump and molecular motors, self-assembly, nano printing of DNA, RNA, and proteins, nanodiagnostics, nanorobotics, nanofluidic/nanoarray devices, nanomaterials photodetectors, nanoparticles for molecular diagnostics, imaging applications of nanoparticles, AFM in study of bio-molecules. DNA nanotechnology, biosensors, viral nanosensors, erasable biodetectors. Tissue engineering, smart materials, concept of gene editing. Nanomaterials for drug discovery and therapy. Dendritic nanostructures, nanomaterials for targeted drug delivery, Trojan nanoparticles. Intracellular drug delivery - nanoparticle combinations with liposomes hybrids - molecular valves for controlled drug release, point-of-care diagnostics, applications of nanotechnology in food microbiology. Nanotechnology in cancer therapy, neutron capture therapy of cancer, nanotechnology for - oncology, neurology, cardiology, orthopaedics, and ophthalmology.

Detailed version:

Section-A

Study of antimicrobial activity of nanoparticles. Bacterial growth inhibition assay, minimum inhibitory concentration (MIC). Introduction to bio-electromagnetism, neuro-transport, nerve impulse conduction and

Humana 2014.

Analytical Techniques: Student will get hands on experience on Origin Lab software and perform data analysis and modelling using the inbuilt examples.

Band structure and physical property modelling: Student will get hands on experience on understanding the Density Functional Theory (DFT) based materials properties simulations using either VASP or Quantum Expresso software tools. Using this software, a minimum of two of the materials property projects will be executed to understand the band structure and optical properties of metals/semiconductors/insulators and their nanostructures. Solution for systems of non-linear equations. Introduction to finite difference time domain and green functions for nanoscale materials systems.

BOOKS AND REFERENCES

1. M. K. Jain, S. R. K. Iyengar and R. K. Jain, New Age International Pvt Ltd Publishers. 1996.
2. Eds. Michael Rieth and Wolfram Schommers, American Scientific Publishers, 2006.
3. Andi Klein and Alexander Godunov, Cambridge University Press, August 2010.
4. by Allan Hinchliffe, 2nd edition, Wiley Blackwell 1995.
5. KHANNA PUBLISHERS 44th Edition 1965.
6. Prentice Hall India Learning Private Limited. 4th edition 2005.
7. Edward Lyshevski CRC Press 2017.
8. Group 2008.
9. ++ -Wesley 2013.
10. ++ Willey & Sons 1996.
11. Bandana Lambert Academic Publishing 2015.

MNT-6202 E3

NANOCOMPOSITES - FABRICATION, PROPERTIES, AND APPLICATIONS

The question paper for end-semester examination will consist of seven questions of equal marks, viz. 10. The first question will be compulsory and will consist of several short questions/problems coverin TJps2 841.92 reW

COURSE OBJECTIVES

To provide the students with the knowledge of synthesis, properties, and applications of composite and nanocomposite materials, so that they would be able to understand their industrial use.

COURSE OUTCOMES

Students will get to know the various types of

chemistry: guests in solution, macrocyclic versus acyclic hosts, complexation of cations, anions & neutral molecules. Receptors- metal containing receptors, simultaneous cation and anion receptors, supramolecular catalysis and enzyme mimics.

Structures and molecular devices- catenanes, rotaxanes, molecular wires, molecular rectifiers. Soft materials classification, examples, formation, properties, applications.

Section-B

Surfactants - types and theory of surfactants: anionic, cationic, gemini, zwitterionic & non-ionic. Micelle formation- micelle type, micellar growth, micellar solution saturation, structure of liquid crystalline phases, surfactant geometry & packing. The critical micelle concentration (CMC), factors affecting CMC, effect of chemical structure, temperature, Kraft temperature.

Overview of soft matter and surface chemistry the concept of supramolecular self-assembly, 1, 2, and 3 dimensional self-assemblies: phthalic acid based self-assemblies, cyanuric acid & melamine assemblies. Supramolecular polymers and molecular capsules.

Liquid crystals (LCs) - introduction and classification of LCs - nematic, cholesteric and smectic phases. Chemistry of conventional and unconventional low molar mass LCs - molecular arrangement in different calamitic and discotic LCs.

BOOKS AND REFERENCES

1. by K. Holmberg, B. Jonsson, B. Kronberg, B. Lindman, Wiley, 2nd

least three questions from each unit. The candidates will attempt five questions in all, selecting at least 02 questions from each section, and the compulsory question.
The books indicated as text-book(s) are suggestive of the level of coverage. However, any other book may be followed considering it an emerging subject.

COURSE OBJECTIVES

To provide students with knowledge of various modern industrial applications of nanomaterials.

COURSE OUTCOMES

Students will get to know the advantages of nanotechnology based applications in industries.
Students will get to know the contemporary industrial applications of nanomaterials.
Students will get to know an overview of future technological advancements and increasing role of nanotechnology in industries.

Syllabus: Recent trends and examples devices and commercial products, miniaturization - nano electronic devices and circuits, memory devices types, sensors and electronic noses, actuators- micro and nano - electromechanical systems. Electronic and display devices, energy devices batteries fuel cells, and super capacitors. Hydrogen production, mechanism of H_2

MNT 7104
LABORATORY III

Introduction to universal safety standards- hazard classification-flammable, combustible, explosive, bio-hazard, carcinogens, ion and laser radiation, etc. Standard laboratory practices chemicals classification for storage, safe bulk solvent storage, ventilation requirement, first aid practices.

COURSE OBJECTIVES

To provide the students with hands-on-training for the synthesis of various nanomaterials and some of the device fabrication methods.

COURSE OUTCOMES

Students will get to some of the chemical synthesis of nanomaterials.
Students will get to know basic universal safety standards and practices in laboratories.
Students will get to know some of the nano-fabrications techniques.
Students will get to know characterization and analysis methods for nanomaterials.

List of open ended experiments:

1. Fabrication of single and few-layer thick 2D-layerd materials using liquid exfoliation method.
2. Metal thin film deposition and crystal structure analysis.
3. Metal oxide nanostructures by sol-gel and dip coating method.
4. Carbon based nano material production, characterization, and analysis.
5. Experiments to understand the interacting nanomaterials, self-assembly, surface modifications by chemical methods and contact angle measurement.
6. Development of a basic solar cell using available materials.
7. Lab visit for demonstration of SEM, TEM and SPM methods.
8. Synthesis of nanoparticle film on glass substrate using L-B method and electrical characterization.
9. Deposition of polymer thin film on substrate using electrodeposition.
10. Longitudinal unzipping of carbon nanotubes for synthesis of graphene nanoribbons.

MNT- 7105
PROJECT/INTERNSHIP PROPOSAL PRESENTATION

COURSE OBJECTIVES

To provide the students with ability to identify a0( )- 0 RG[ ]JTJETQ EMC /P <MCID 34/Lang (en-IN)>BDC q0.000

The students are expected to identify their research topic, do literature study, and propose their supervisors based on identified research project topic. They will give a presentation on their identified research project topics of interest in front of a committee/examiners constituted for this purpose. This course is mandatory and a student has to pass the course to become eligible for the award of degree. Project supervisors and/or internship will be allotted based on the interest and availability.

ELECTIVE COURSES (MNT-7102 E)

MNT-7102 E1

THIN FILM TECHNOLOGY FOR NANOMATERIALS AND DEVICES

The question paper for end-semester examination will consist of seven questions of equal marks, viz. 10. The first question will be compulsory and will consist of several short questions/problems covering the entire syllabus. The rest of the questions shall be distributed evenly over the whole syllabus, such that there are at least three questions from each unit. The candidates will attempt five questions in all, selecting at least 02 questions from each section, and the compulsory question.
The books indicated as text-book(s) are suggestive of the level of coverage. However, any other book may be followed considering it an emerging subject.

COURSE OBJECTIVES

This course is intended for the students to teach important techniques, principles and underlying phenomena associated with thin film technology.

COURSE OUTCOMES

Students will get to know the scientific principles behind thin film technology.
Students will get to know the principles, equipment, applications, and limitations of different deposition techniques.
Students will get to know an overview of the phenomena and concepts involved in thin film deposition

COURSE OBJECTIVES

This course is intended for the students to understand the mechanisms for solute transport in different membrane types and industrial applications of separation techniques.

COURSE OUTCOMES

Students will get to know how to identify and describe the main unit operations associated with membrane technology.
Students will get to know the industrial applications of membranes.
Students will get to know various membrane modules and how they are used in different membrane processes.
Students will get to know the working principles nano-filtration.
Students will get to know pre- and post-treatment to address the fouling problems of membranes.

Syllabus: Introduction to membrane science, membrane materials, modules, mathematical models. Concentration polarization and membrane fouling, mechanism, effect of fouling. Technical evaluation of

Syllabus: Introduction to magnetism, domain walls, magnetic

refrigerant, high TC superconductor, ferro/bio-fluids. Biomedical applications of magnetic nanoparticles - diagnostic applications, therapeutic applications, physiological aspects - toxic effects.

BOOKS AND REFERENCES

Pearson Education, 7th edition 2015.

-thin Magnetic Structures III
B. Springer 2005.

2nd edition 2003.

CRC Press, 3rd edition 2015.
Springer, 2nd edition 2017.

COURSE CONTENTS (CORE COURSES)

Semester-IV

COURSE OBJECTIVES

To provide the students with project training and research experience.

COURSE CONTENTS

MNT-GE1

SYNTHESIS, CHARACTERIZATION, AND PROPERTIES OF NANOMATERIALS

The question paper for end-semester examination will consist of seven questions of equal marks, viz. 10. The

MNT-GE2

SPECIFIC APPLICATIONS OF NANOMATERIALS

The question paper for end-semester examination will consist of seven questions of equal marks, viz. 10. The first question will be compulsory and will consist of several short questions/problems covering the entire syllabus. The rest of the questions shall be distributed evenly over the whole syllabus, such that there are at least three questions from each unit. The candidates will attempt five questions in all, selecting at least 02 questions from each section, and the compulsory question.
The books indicated as text-book(s) are suggestive of the level of coverage. However, any other book may be followed considering it an emerging subject.

COURSE OBJECTIVES

To provide students with knowledge of various modern industrial applications of nanomaterials.

COURSE OUTCOMES

Students will get to know the

small angle X-ray scattering- - applications in determination of particle size.

Spontaneous emission -

MNT-GE4

TOXICITY OF NANOMATERIALS AND SOCIETAL IMPACTS

The question paper for end-semester examination will consist of seven questions of equal marks, viz. 10. The first question will be compulsory and will consist of several short questions/problems covering the entire syllabus. The rest of the questions shall be distributed evenly over the whole syllabus, such that there are at least three questions from each unit. The candidates will attempt five questions in all, selecting at least 02 questions from each section, and the compulsory question.
The books indicated as text-book(s) are suggestive of the level of coverage. However, any other book may be followed considering it an emerging subject.

COURSE OBJECTIVES

To provide the students with the knowledge of socio economic and health impact of nanotechnology and to handle the consequences effectively.

COURSE OUTCOMES

Students will have awareness about socio economic impact of nanotechnology and to handle the consequences effectively.
Students will get to know about various social impacts of nanotechnology trend and research.
Students will equip with ethical issues and public opinion effectively.
Students will understand the professional and ethical responsibility.
Students will get knowledge on social impact of nanotechnology.

Syllabus: Economic impacts and commercialization of nanotechnology, managing the nanotechnology revolution, Malcolm Baldrige national quality criteria, the emerging of nano economy, t
law, navigating nanotechnology - nanotechnology based surveillance and society. Methodological issues and innovations for social research. Nanoparticles in the environment, nanoparticles in mammalian systems, health threats, nanomaterials and toxicity, air pollution - introduction to air polluting particles, adverse effects of in the e

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