SCHEME OF STUDIES AND EXAMINATIONS
(ALL SEMESTERS)

M.Tech. & Ph. D. Curricula in
MATERIALS SCIENCE AND NANOTECHNOLOGY

(Effective from Session 2011-12)
DEENBANDHU CHHOTU RAM UNIVERSITY OF SCIENCE & TECHNOLOGY, MURTHAL (SONEPAT)

DEPARTMENT OF MATERIALS SCIENCE AND NANOTECHNOLOGY (MSN)

The curricula for M.Tech. and Ph.D studies in the Department of Materials Science and Nanotechnology are attached as Annexures A and B respectively.
## ANNEXURE A

DEENBANDHU CHHOTU RAM UNIVERSITY OF SCIENCE AND TECHNOLOGY, MURTHAL

DEPT OF MATERIALS SCIENCE AND NANOTECHNOLOGY (MSN)

M. Tech. in Materials Science and Nanotechnology

SCHEME OF STUDIES & EXAMINATIONS

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Course No.</th>
<th>Course Title</th>
<th>Teaching Schedule</th>
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**SEMESTER-I**

**NOTE:**

1. Since this is a very broad and multidisciplinary programme, preference shall be given to the setting of examination papers by internal examiners for all the sessional and semester examinations. If an external examiner is asked to set the paper, then the MSN Department shall have the option of moderating the questions set in it.
### M. Tech. in Materials Science and Nanotechnology, Semester I

**MSN-601: PHYSICS AND CHEMISTRY OF MATERIALS**

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**Credits: 4**

**UNIT I: Elements of Physics:** Introduction to Quantum Mechanics: Wave-particle duality, Schrödinger equation and expectation values, Uncertainty principle, Solution of time independent Schrödinger equation, Particle in a box, Particle in an infinite well, linear harmonic oscillator and its solution, density of states.

**UNIT II: Solid State Chemistry:** Bonding in solids, Types of bonds: Metallic, Ionic, Covalent and Van der Waals forces; Hybridization; H- bonding; Ion dipole, and dipole-dipole interactions; Born-Haber cycle; Molecular orbital theory for simple molecules such as diatomic molecule etc. Crystal field theory.


**UNIT IV: Chemistry of Biological Systems:** Cell: structure and function; Bio-molecules į Carbohydrates (mono-, di- and poly- saccharides), Proteins (Hydrolysis to peptides, amino acid sequencing, geometry of peptide-linkage), Lipids (Essential fatty acids, structure and functions of tri-glycerols, cholesterol, bile acids), Nucleic acids (structure of RNA and DNA); ATP į biological energy currency. Hemoglobin and Myoglobin į structure and functions.

**TEXT/REFERENCE BOOKS**

2. Quantum Physics į A. Ghatak
3. Quantum Mechanics - Bransden and Joachen
5. Principals of Physical Chemistry-Marron-Pruton.
6. Physical Chemistry į Atkins, Peter W. and Paula Julio, OUP.
8. Introduction to Theoretical Chemistry į Jack Simons.

**Notes:**

1. Eight (8) questions are to be set į uniformly distributed over the entire content of the course syllabus. Students shall have to attempt any five (5) of those questions.
MSN 603: COMPUTATIONAL PHYSICS


UNIT II: Basic concepts: Elementary error analysis techniques including importance of sampling, Curve-fitting techniques, Introduction to Graphical packages (Mathematica or Maple or Matlab), Phase diagram calculations, Monte Carlo method: simple simulations of segregation and precipitation phenomena.


UNIT IV: Matrices, solution of systems of linear equations, Tensor notations and conventions, tensor treatment of material properties such as elasticity. Eigen values and Eigen vectors. Basics of Fourier Transforms.

TEXT/REFERENCE BOOKS
3. Numerical Analysis - Carl-Eric Froberg
4. Computational Physics - F J Vessley
7. Computational Materials Design - Tetsuya, Springer
11. Wesely Addisom, Mathematica, S. Wolfram

Notes:
1. Eight (8) questions are to be set uniformly distributed over the entire content of the course syllabus. Students shall have to attempt any five (5) of those questions.
UNIT I: Metals: Atomic structure and bonding, crystal structures (lattices, indices etc with examples of atomic structures and bonding types, order and disorder, diffusion mechanisms, deformation mechanisms, classes of metals, point defects, line defects, surface and volume defects, strengthening mechanisms, simple alloys and intermetallics.

UNIT II: Ceramics: Atomic structure including ionic and covalent bonding, ceramic crystal structures, Atomic defects including intrinsic and extrinsic point defects, Electrical properties including ferroelectrics, thermistors, electrical conductors, dielectrics, Magnetic properties including ferromagnetic and ferrimagnetic materials.

UNIT III: Microstructural effects: Solid state sintering, densification and coarsening processes, grain boundary mobility, porosity evolution (stability/entrainment). Thermal properties including thermal expansion, creep, and thermal stresses. Mechanical properties including strength, toughness, and microstructural design.

UNIT IV: Composites: Composite Interfaces, Bonding Mechanisms, other Interfacial properties, Polymer Matrix Composites, Metal Matrix Composites, Ceramic Matrix Composites, Composite Strengths; Fibers as reinforcements.

TEXT/REFERENCE BOOKS:

1. Introduction to Materials Science and Engineering, William J Callister, John Wiley & Sons, Inc.

Notes:

1. Eight (8) questions are to be uniformly distributed over the entire content of the course syllabus. Students shall have to attempt any five (5) of those questions.

UNIT II: X-ray Diffraction techniques: Production of X-rays, its properties and hazards, X-ray Diffraction and Bragg's law, Laue techniques, Debye-Scherrer techniques. Determination of crystal structure of powder sample, line broadening, particle size, residual stress measurement, Phase identification, phase quantification, introduction to pole figure and texture analysis; chemical/elemental analysis by X-ray Fluorescence.

UNIT III: Electron microscopy (SEM and TEM): Electron diffraction, Principles and operation of scanning electron microscope. Geometry of electron microscopes, Electron Sources, Production of Vacuum, Pressure measurement, Specimen Handling and preparation, Secondary electron image, Backscattered electron image, Example of scanning electron micro-graphs and fractography studies. HRTEM.


TEXT/REFERENCE BOOKS
1. Solid state chemistry and its Applications - Antony R. West, Wiley Student Edition
8. Transmission Electron Microscopy - Eddington

Notes:

1. Eight (8) questions are to be set uniformly distributed over the entire content of the course syllabus. Students shall have to attempt any five (5) of those questions.
UNIT I: Introduction to Nanotechnology: Nano technology, Nano science, MEMS, CNT, Fullerene, Nano machines. Top-down and bottom-up approaches for preparing nanomaterials. Bringing Visibility to the Invisible: Towards a social understanding of Nanotechnology, Societal implications, Health hazards & Ethical issues in Nano-science and Nanotechnology.

UNIT II: Properties of Nano-Particles; Physical, electrical, Ferroelectric and dielectric properties, Metal Nano-Clusters, Semi conducting Nano-Particles, Bulk vs Nano: elementary mechanical, electrical and magnetic properties.

UNIT III: Introduction to nanocomposites: Bulk metal and nano-ceramic composites, optical, electrical and magnetic applications of nano composites, Nano-porous structures and membranes. Introduction to biomaterials: Need for biomaterials and composites & their applications.


TEXT/REFERENCE BOOKS

Notes:
1. Eight (8) questions are to be set uniformly distributed over the entire content of the course syllabus. Students shall have to attempt any five (5) of those questions.
M. Tech. in Materials Science and Nanotechnology, Semester I

MSN-611: MATERIALS LABORATORY

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Sessional : 50 Marks  
Exam : 50 Marks  
Total : 100 Marks  
Duration of exam : 6 hrs

List of Experiments:

1. To study the Vickers/Brinell/Rockwell hardness testing machine & perform the Vickers hardness test.
2. Any Non-Destructive Evaluation Test e.g. by Ultrasonic method
3. Mechanical testing - Tensile/compression/creep/fracture/fatigue test
4. Ball milling and pellet pressing.
5. Alloy preparation by induction melting / thermal processing.
6. Surface treatment i.e. hardening, etching, welding, bonding etc.
7. Polymer processing methods i.e. pressing, injection molding etc.
8. Metallurgical sample preparation - Al Alloys/Steels/Cu Alloys/ Fe Alloys
9. Metallurgical treatments and microscopic examination i.e. Al Alloys/Steels/Cu Alloys/ Fe Alloys
10. Simulation and modeling of material crystal- and micro-structures

Note:

At least 7 experiments shall be conducted out of the above list.
### DEPARTMENT OF MATERIALS SCIENCE AND NANOTECHNOLOGY (MSN)

#### M. Tech. in Materials Science and Nanotechnology

#### SCHEME OF STUDIES & EXAMINATIONS

**SEMESTER-II**

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<td>3</td>
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**ELECTIVES**

1. MSN-622 Mechanical Behaviour of Materials
2. MSN-624 Transport phenomena in materials
3. MSN-626 Study of novel and smart materials
4. MSN-628 Physics of Amorphous Materials

**NOTES:**

1. The Department shall offer an elective contingent upon the expertise available.
2. *: Audit Pass / Audit Fail Ê Compulsory qualifying Examination
UNIT I: Introduction and background to Materials Synthesis; Principles of Synthesis (through case studies drawn from metals (Fe, Al, Ni and Nd), ceramics (Al₂O₃, BaTiO₃, Ferrites, ZnO/ZrO₂)), glassy materials, glass ceramics. Synthesis of commercial polymers.

UNIT II: General Synthesis Methodologies: preparation of materials - Melting and solidification, ball milling, solid-state reactions, sputtering etc., sol-gel synthesis, chemical conversion of a precursor, chemical vapor deposition and infiltration, doping and lithography.


UNIT IV: Design of Advanced Materials and Their Applications:
Materials for Environmental Monitoring and Control, Biomaterials Synthesis of Nanomaterials Synthesis Methods - General methods and examples: Chemical Methods, Plasma Methods, Vapor Deposition Methods, Hydrothermal Synthesis.

TEXT/REFERENCE BOOKS
1. Treatise on Inorganic Chemistry, Vol. II: Subgroups of the periodic table and general topics,
8. Synthesis and technique in inorganic chemistry:a laboratory manual - Girolami, Gregory S. - Rauchfuss,
Notes:

1. Eight (8) questions are to be set uniformly distributed over the entire content of the course syllabus. Students shall have to attempt any five (5) of those questions.


UNIT III: Supramolecular Chemistry — Concepts and language, Transport processes and carrier design: Cation carriers, anion carriers, coupled transport processes in redox gradient and pH gradient; photo-switching devices; Self assembly / organization.


TEXT/REFERENCE BOOKS


Notes:

1. Eight (8) questions are to be set — uniformly distributed over the entire content of the course syllabus. Students shall have to attempt any five (5) of those questions.
UNIT I: Phase Equilibria: Thermodynamics of solutions, Methods for calculation of thermodynamic equilibrium, equilibrium stability of phases, single phase system (polar and non-polar solvents), Phase rule, free-energy, solidus-liquidus lines; binary and ternary systems using examples of Steel, Cu-Zn etc. Properties of Materials: Specific heat - Debye and Einstein models, heat capacity, thermal expansion, thermal conduction, thermal stress and shock, melting point.

UNIT II: Crystal Growth: Nucleation of crystals, theories of crystal growth, criteria for equilibria in crystal growth; solid solubility; super-cooling; whiskers and whiskers growth. Importance of thermodynamics in materials science-illustrations and examples; applications in areas of materials technology

UNIT III: Thermodynamics of Surfaces and Interfaces: Surface energy, surface tension, absorption kinetics of diffusion in solids. Catalysis: introduction and surface thermodynamics. Introduction to non-equilibrium thermodynamics.

UNIT IV: Fermi-Dirac statistics; Bose-Einstein statistics; Statistical distribution functions

TEXT/REFERENCE BOOKS

Notes:

1. Eight (8) questions are to be set uniformly distributed over the entire content of the course syllabus. Students shall have to attempt any five (5) of those questions.
UNIT I: Types of polymeric materials and their structures, Classification of polymerization reactions, Step growth and chain growth polymerization. Inter and intra molecular reactions. Average molecular weight concept. General theory of chain growth polymerization. Copolymerization;Crystalline and amorphous polymers, conducting polymers introduction, classification, preparation and properties.


UNIT III: Plastics, Rubbers and fibres of commercial importance, Additives: Plasticisers, fillers, Stabilisers, lubricants, Retarders, Inhibitors etc., Tensile properties of polymers, Impact strength, Softening point, Heat distortion temperature, Melt flow index, Mouldability. General applications of polymers, polymer blends, polymers for biomedical applications.


TEXT/REFERENCE BOOKS:

Notes:

1. Eight (8) questions are to be set uniformly distributed over the entire content of the course syllabus. Students shall have to attempt any five (5) of those questions.
In this course, each student shall be required to give a PowerPoint presentation on a topic allotted to him/her. The evaluation of presentation and communication skills shall be made by a committee duly constituted by the Chairperson of the Department.

The committee will award Audit Pass / Audit Fail grade. Passing this course is compulsory.
List of Experiments:

1. Synthesis of Nano-ferrite particles by chemical co-precipitation method.
3. Analysis of Powder Diffraction Patterns using XRD.
4. TEM/SEM/AFM – Analytical techniques for nanomaterials.
5. Study the annealing effects on the physical size and properties of nano-particles.
6. To study the magnetic property of the various materials.
7. Synthesis of crystalline materials and amorphous materials – 2 labs
8. Impedance spectroscopy / A.C. conductivity of materials
9. To study the thermal properties of materials using TGA/DSC/DTA etc.
10. Biological applications of nanoparticles – Ag, Cu effects on bacterial cultures
11. Synthesis and characterization of conducting polymers and their composites

Note:

At least 7 experiments shall be conducted out of the list.
UNIT I:
Elastic Behaviour: Mechanisms, Stress and Strain relations and Analysis
Plastic Behaviour: Mechanisms, Yielding, Stress and Strain relations and Analysis
Anelastic and Visco-elastic behaviour: Mechanisms, relations, Analysis
Hardness: Vicker’s, Brinell, Rockwell, Impact / shock deformation behaviour

UNIT II:
Creep: Mechanisms, creep laws, Analysis and Applications in Design
Fractures: Types and their characteristics. Nucleation of cracks and their growth, Variables influencing the fracture, Brittle fracture theories, Cleavage fracture, Methods to improve fracture strength, Cracks as Stress Raisers, Effects of Cracks on Strength, Effects of Cracks on Brittle versus Ductile Behaviour.

UNIT III: Stress intensity factor K, Application of K to Design & Analysis, Energy principles and criteria for crack growth, Effects of Temperature and loading rate, Micro-structural Influences on K_c, Plane strain and plane stress fracture toughness, crack tip plastic zones, Plastic zone size and Plasticity limitation on LEFM for FCG, The J integral - Extension of Fracture Mechanics beyond linear Elasticity CTOD, Crack opening displacement criteria, Fatigue crack propagation under constant and variable amplitude loading, Crack closure, Effective stress intensity range, Physical nature of Fatigue Damage Failure modes,

Non-destructive testing techniques: Ultrasonic testing, Radiography, Acoustic emission, eddy current testing, Liquid penetrates testing, Magnetic method of crack detection, Macro-fractography and micro-fractography techniques

TEXT/REFERENCE BOOKS:
2. Fracture Mechanics - Prashant Kumar
3. Mechanical Behaviour of Materials - Keith Bowman

Notes:

1. Eight (8) questions are to be set Ŧ uniformly distributed over the entire content of the course syllabus. Students shall have to attempt any five (5) of those questions.
UNIT I: Diffusion
Coupling conservation and constitutive equations to give closed-form (partial) differential equation(s) in one or more field variables, dimensional analysis, mass transfer Biot number.

UNIT II: Heat Conduction and Radiation
Mathematical similarity between diffusion and heat conduction. Solutions to the (thermal) diffusion equation, the heat transfer Biot number, and examine conduction in a solid with moving boundaries. Heat transfer by radiation, conduction as a boundary condition and convection with examples.

UNIT III: Fluid Dynamics
Newtonian and non-Newtonian fluid dynamics using principles of conservation of mass and momentum in the same methodology as was used for diffusion and heat conduction. Navier-Stokes equations describing fluid flow, to solve problems in flow velocity which varies in one direction. Reynolds number related to the transition to turbulence. Boundary layer descriptions of flow near surfaces drag force on simple bodies moving relative to a fluid. Turbulence, modelling methods based on Reynolds stresses related to effective turbulent viscosity and eddy length scales, mass and momentum balances on large control volumes.

UNIT IV: Heat and Mass Transfer
Batch/continuous reactor design, Navier-Stokes equations and their coupling with species diffusion, heat conduction to describe heat and mass transfer in fluids. Heat and mass transfer coefficients under steady laminar and turbulent flow conditions in simple geometries, driven both by external forces and thermal/solutal buoyancy, application to materials process engineering.

TEXT/REFERENCE BOOKS

Notes:
1. Eight (8) questions are to be set uniformly distributed over the entire content of the course syllabus. Students shall have to attempt any five (5) of those questions.
M. Tech. in Materials Science and Nanotechnology, Semester II

**MSN-626: STUDY OF NOVEL AND SMART MATERIALS**

**L T P**

4 0 0

**Internal Marks:** 50

**External Marks:** 100

**Credits:** 4

**Duration of Exam:** 3 hours

**UNIT I: Introduction:** Basic concepts of smartness, Definition and characteristics.

**Smart Behaviours and Materials:** Piezoelectric, electrostrictive, magnetostrictive, pyroelectric, electro-optical materials, Piezomagnetism, Pyromagnetism, Piezoresitivity, Thermoelectricity, photostriction, shape memory alloys, Superelastic, Viscoelastic, Elastoresistive, Electrorheological, Thermochromatic, Superconductivity

**UNIT II: Superconductivity and Superconducting Materials:** Concept of superconductivity, Phenomenon, properties of superconductors, Meissner effect, Critical magnetic field & critical temperature. Types of superconducting materials. Type I & II superconductors, Silsbee rule. Mechanism of superconduction. BCS theory, Debye temperature. London's & Glag theories, High temperature ceramic superconductors, applications: NMR, Maglev, MHO etc., recent advances. Related calculations.

**UNIT III: Measurement of properties:** Novel testing and characterisation methods of materials. Novel Ceramic, Polymer and Biomaterials.

**UNIT IV: Commercial Devices:** Design and fabrication of devices and structures and their integration with system: Biomorphs/Moonies, Chip capacitor, Memory devices (FRAM), Sensor, actuator and transducers, Accelerometer, Gyroscopes, Ultrasonic Motor, Liquid Crystal display, Photonics, Structure Health Monitoring

**TEXT/REFERENCE BOOKS**

5. Smart Materials and Structures - M.V. Gandhi, B.S. Thompson, Chapmann and Hall, London 1992

Notes:
1. Eight (8) questions are to be set uniformly distributed over the entire content of the course syllabus. Students shall have to attempt any five (5) of those questions.
M. Tech. in Materials Science and Nanotechnology, Semester II

MSN-628 Physics of Amorphous Materials

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Unit I: Physics of Amorphous material: preparation of amorphous materials, thermal evaporation techniques, sputtering, CVD techniques, melt-quenching Technique.

Unit II: Types of Glasses, Applications of glasses, glass transition temperature, characterization of amorphous materials.

Unit III: Models of electronic structure of Chalcogenide glasses. Structures of disordered materials, oxide glasses and glass formation criteria.

Unit IV: Electronic density of states, localization phenomenon, transport, optical and dielectric properties.

TEXT/REFERENCE BOOKS

1. Amorphous Materials: S R Elliot
2. Physics of Amorphous Solids :Richard Zallen
3. Electronic Process in Non-Crystalline Solids: Davis & Mott
5. Glass Science-R H Doremus

Notes:

1. Eight (8) questions are to be set uniformly distributed over the entire content of the course syllabus. Students shall have to attempt any five (5) of those questions.
### M. Tech. Programme in Materials Science and Nanotechnology

#### SCHEME OF STUDIES & EXAMINATIONS

**SEMESTER-III**

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**ELECTIVES:**

1. MSN-721 Degradation of materials
2. MSN-723 Thin film technologies
3. MSN-725 Advanced Materials Science-II

**NOTE:**

1. The choice of students for any elective shall not be binding on the department to offer it.
2. Open elective may be chosen from permitted courses in other departments of this University.
UNIT-I Introduction to MEMs / NEMs, Electronic Transport in Nanostructures, Semiconductor devices to Single electron Transistors, Micro fluidics and their Applications, Materials for Micro fluidic devices, active and smart passive Micro fluidics devices, Lab-on-a-chip for Biochemical analysis.


TEXT/REFERENCE BOOKS
2. Between Technology & Science: Exploring an emerging field knowledge flows & networking on the nanoscale - Martin S. Meyer.
3. Nanoscience & Technology: Novel structure and phenomena - Ping Sheng


**Notes:**

1. Eight (8) questions are to be set uniformly distributed over the entire content of the course syllabus. Students shall have to attempt any five (5) of those questions.
M. Tech. in Materials Science and Nanotechnology, Semester III

MSN 703: Advanced Materials Science-I

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Credits: 4  
Duration of Exam: 3 hours

UNIT I: Classification of materials on the basis of energy gap: conductors, semiconductors, dielectrics, ferroelectrics, pyroelectrics, piezoelectrics. Polarizability, mechanism of polarization, factors affecting polarization, types of dielectric materials—solid, liquid and gaseous types; natural and synthetic types. Clausius - Mosotti equation.


UNIT III: Introduction to biomaterials: Composite material; Biopolymers, Biodegradable polymers and drug delivery system. Materials for Orthopaedic implants, artificial organs, dental implant; Dermal and facial prosthesis.


TEXT/REFERENCE BOOKS


Notes:
1. Eight (8) questions are to be set uniformly distributed over the entire content of the course syllabus. Students shall have to attempt any five (5) of those questions.
Experiments to be covered (at least 6 & each sub-part is a full experiment):

1. To synthesize Oxide Thin film by Langmuir-Blodgett Deposition.
2. To synthesize conducting Polymer Thin film by Langmuir-Blodgett Deposition.
3. To synthesize thin film by Dip coating method.
4. To synthesize thin film by Spin coating method.
5. Synthesis of Multi-layer synthesis of composites
6. To study Electrical properties of various materials
   a. AC properties
   b. DC properties
7. To study Optical properties of advanced materials.
8. To study Thermal properties of materials
   a. Phase transformations by TGA, DTA, DSC
   b. Annealing behavior of different nonmaterial.
M. Tech. in Materials Science and Nanotechnology, Semester III

MSN 707: SEMINAR

L      T      P
0      0      2

Credits: 2

Internal Marks: 50
External Marks: 50
Duration of Exam: 1 hours

Relevant and advanced materials / nanotechnology topics shall be provided to the students. Each student will present at least one presentation before the departmental committee (formed of all Departmental teaching faculty members), each week.
M.Tech. in Materials Science and Nanotechnology, Semester III

MSN-709 DISSERTATION (MINOR)

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Credits: 4

Internal Marks: 50
External Marks: 100
Duration of Exam: 3 hours

M.Tech. candidates shall be expected to write a minor dissertation on a topic of their choice related to the fields of Materials Science and Nanotechnology. This will consist of a written report on a topic assigned to the student, based upon research and analysis by the student.

Evaluation of the minor thesis shall be done at the end of the semester. An evaluation committee will be formed by the Chairperson of the department to evaluate the work. Student candidates will present their work in one half-hour presentations before the committee.
UNIT I: Creep, fracture, buckling, delamination, grain growth, amorphization etc. (Oxidation, Radiation, wear and allied processes etc).


UNIT III: Liquid metal corrosion, molten salt corrosion. High temperature corrosion, Atmospheric corrosion, Inter-granular corrosion, pitting, Hydrogen embrittlement, Stress corrosion cracking, Cavitation corrosion. Pilling-Bedworth ratio, Corrosion in acidic and alkaline environments, Passivity, Anodic protection and preventive coatings, Materials selection for different environments.

UNIT IV: Corrosion testing techniques: Electrochemical measurements, Weight change measurements.
Radiation damage: Introduction and nature, types of radiation damage in different materials. Mechanical wear and basics of tribological studies.

TEXT/REFERENCE BOOKS

Notes:
1. Eight (8) questions are to be set uniformly distributed over the entire content of the course syllabus. Students shall have to attempt any five (5) of those questions.
M. Tech. in Materials Science and Nanotechnology, Semester III

MSN-723: THIN FILM TECHNOLOGIES

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Credits: 4

UNIT I: Physical Vapor Deposition - Hertz Knudsen equation; mass evaporation rate; Knudsen cell, Directional distribution of evaporating species Evaporation of elements, compounds, alloys, Raoult's law; e-beam, pulsed laser and ion beam evaporation, Vacuum vapor deposition, types of vacuum pumps.

UNIT II: Sputtering - mechanisms and yield, dc and rf sputtering, Bias sputtering, magnetically enhanced sputtering systems, reactive sputtering, Hybrid and Modified PVD- Ion plating, reactive evaporation, ion beam assisted deposition,

UNIT III: Chemical Vapor Deposition - reaction chemistry and thermodynamics of CVD; Thermal CVD, laser & plasma enhanced CVD, Chemical Techniques - Spray Pyrolysis, Electrodeposition, Sol-Gel method, Theory and principle of Dip coating, Spin coating and LB Techniques.

UNIT IV: Nucleation & Growth: capillarity theory, atomistic and kinetic models of nucleation, basic modes of thin film growth, stages of film growth & mechanisms, amorphous thin films, Epitaxy - homo, hetero and coherent epilayers, lattice misfit and imperfections, epitaxy of compound semiconductors, scope of devices and applications.

TEXT/REFERENCE BOOKS

Notes:

1. Eight (8) questions are to be set uniformly distributed over the entire content of the course syllabus. Students shall have to attempt any five (5) of those questions.

UNIT II: Introduction to optical fibres, Light propagation, Electro-optic effect, Kerr effect, Pockels effect, LCD materials, photo detectors, Fabrication of Electronic and Opto-electronic Devices: Methods of crystal growth, zone refining.

UNIT III: Biosensors: History, Clinical Diagnostics, generation of biosensors, immobilization, characteristics, applications, conducting Polymer based sensor, DNA Biosensors, optical sensors.

UNIT IV: Recent developments in Biomaterials. Legal issues related to development of biomaterials. Natural materials for various biomedical applications. Biomaterials world-wide market, technology transfer and ethical issues; Standards for biomaterials and devices.

TEXT/REFERENCE BOOKS

Notes:
1. Eight (8) questions are to be set uniformly distributed over the entire content of the course syllabus. Students shall have to attempt any five (5) of those questions.
DEENBANDHU CHHOTU RAM UNIVERSITY OF SCIENCE AND TECHNOLOGY, MURTHAL

DEPT OF MATERIALS SCIENCE AND NANOTECHNOLOGY (MSN)
M. Tech. Programme in Materials Science and Nanotechnology

SCHEME OF STUDIES & EXAMINATIONS

SEMESTER-IV

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**SUMMARY:**

Total credits for the M.Tech Programme : 90

*Distribution of credits*

Program Core Courses : 48 credits

Elective Courses : 8 credits

Labs, Projects and Seminars : 34 credits
### ANNEXURE B

DEENBANDHU CHHOTU RAM UNIVERSITY OF SCIENCE AND TECHNOLOGY, MURTHAL

DEPT OF MATERIALS SCIENCE AND NANOTECHNOLOGY (MSN)

Ph.D. Programme in Materials Science and Nanotechnology

**SCHEME OF STUDIES & EXAMINATIONS**

**SEMESTER-I**

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**NOTE:**

1. *=Eight questions will be set in the final exam out of which the candidate will have to answer any five questions. The questions will be spread evenly over the entire syllabus for any course.
**MSN 901: INTRODUCTION TO MATERIALS**

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**UNIT- I**

Atomic Structure & Bonding: Atomic energy levels, Atomic interactions, primary and secondary bonds, crystal lattices, Miller indices, Packing factor, planar density. Crystalline and Amorphous Structures: Metals, Ceramics and Glasses.

**UNIT- II**


**UNIT -III**


**UNIT IV**


**TEXT/REFERENCE BOOKS:**

MSN-902: EXPERIMENTAL TECHNIQUES IN MATERIALS

L T P Internal Marks: 50
4 0 0 External Marks: 100
Credits: 4 Total Marks: 150

Duration of exam: 3 hrs.

Unit-I

Optical Methods of structure determination: Principles and applications of following:

Unit-II

Detailed study of spectroscopic techniques: Principles and applications of following:
Nuclear Magnetic Resonance (NMR), Fourier transform Infrared Spectroscopy (FTIR), Electron Microscopy analysis (EM), Ultraviolet Visible Near Infrared spectroscopy (UV-VIS-NIR), Raman spectroscopy, Mössbauer spectroscopy.

Unit-III

Scanning Probe and Thermal Techniques: Principles and applications of following:
Scanning Probe Microscopy ; Scanning Tunneling Microscopy (STM), Atomic Force Microscopy (AFM) and Scanning Tunneling Spectroscopy (STS). Thermogravimetric analysis (TGA), Differential thermal analysis (DTA), Differential scanning calorimetry (DSC).

Unit-IV

Phase identification /molecular structure/ Surface/interface chemistry/ Phase changes: Principles and applications of following:
Neutron diffraction, Small-angle neutron scattering (SANS), Small-angle X-ray scattering (SAXS), X-ray photoelectron spectroscopy (XPS), Auger electron spectroscopy (AES), Secondary ion mass spectroscopy (SIMS), Rutherford backscattering spectrometry (RBS), X-ray diffraction (XRD).

TEXT/REFERENCE BOOKS: