DEPT OF MATERIALS SCIENCE AND NANOTECHNOLOGY (MSN)

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

SCHEME OF STUDIES & EXAMINATIONS

**SEMESTER-I**

| S. No. | Course No. | Course Title | Teaching Schedule | | | Marks | | | Credits | Duration of Exam |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | Sessional | Exam | Total | | |
| 1 | MSN-601 | Physics and Chemistry of Materials | 4 | 0 | 0 | 50 | 100 | 150 | 4 | 3 |
| 2 | MSN-603 | Computational Physics | 4 | 0 | 0 | 50 | 100 | 150 | 4 | 3 |
| 3 | MSN-605 | Metals, Ceramics and Composites | 4 | 0 | 0 | 50 | 100 | 150 | 4 | 3 |
| 4 | MSN-607 | Characterization Techniques for Materials | 4 | 0 | 0 | 50 | 100 | 150 | 4 | 3 |
| 5 | MSN-609 | Nanomaterials and Their Applications | 4 | 0 | 0 | 50 | 100 | 150 | 4 | 3 |
| 6 | MSN-611 | Materials Lab | 0 | 0 | 4 | 50 | 50 | 100 | 4 | 4 |
| | **TOTAL** | | **20** | **0** | **4** | **300** | **550** | **850** | **24** | |

**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

| L | T | P | | |
|---|---|---|---|---|
| 4 | 0 | 0 | **Internal Marks:** | **50** |
| | | | **External Marks:** | **100** |
| **Credits: 4** | | | **Duration of Exam:** | **3 hours** |

**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 III: Basic concepts of Electrochemistry** - Reaction Kinetics: Zero, First & Second order reactions. Dependence of **k** on Temperature. An overview of collision and activated complex theory. Electrochemical cells: Primary cell, Secondary cell, Fuel cell and super-capacitors. **Photochemistry** – Laws, Frank-Condon Principle Charge transfer spectra and excitations, Fluorescence, Phosphorescence, Chemiluminescence. Corrosion: Introduction, types, monitoring and prevention, economics of corrosion control, corrosion auditing, and corrosion map of India.

**UNIT IV: Chemistry of Biological Systems:** Cell: structure and function; Bio-molecules – 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 – biological energy currency. Hemoglobin and Myoglobin – structure and functions.

**TEXT/REFERENCE BOOKS**


1. The Physics and Chemistry of Materials, J.I. Gersten and F.W. Smith, John Wiley and Sons, 2001
2. Quantum Physics – A. Ghatak
3. Quantum Mechanics - Bransden and Joachen
4. Principles of Quantum Mechanics 2nd ed. - R. Shankar
5. Principals of Physical Chemistry-Marron-Pruton.
6. Physical Chemistry – Atkins, Peter W. and Paula Julio, OUP.
7. Inorganic chemistry-Cotton-Wilkinson.
8. Introduction to Theoretical Chemistry – Jack Simons.
9. Modern Electrochemistry – J.O.M. Bockris and A.K. N. Reddy
10. Principles of Biochemistry: A.L. Lehringer, Worth Publishers.
11. Outlines of Biochemistry – E.E. Conn and Strumpf, John Wiley.


**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 603: COMPUTATIONAL PHYSICS

| L | T | P | | |
|---|---|---|---|---|
| 4 | 0 | 0 | **Internal Marks:** | **50** |
| | | | **External Marks:** | **100** |
| **Credits: 4** | | | **Duration of Exam:** | **3 hours** |

**UNIT I: Statistical Mechanics:** Statistical distribution functions, Maxwell-Boltzmann Statistics, Molecular energies in an Ideal gas, Rayleigh jeans formula, Plank's Radiation law, Einstein's Approach, specific heat of solids, free electrons in a metal.

**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 III: Numerical Methods:**. Numerical differentiation and integration methods, Numerical methods for Ordinary and Partial differential equations. Interpolation and extrapolation methods.

**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**


1. Computational Material Science - Dierk Raabe, Wiley-VCH Verlag GmbH, 1998
2. Multiscale Materials Modelling: Fundamentals and Applications - Ed Z Xiao Guo, Woodhead Publishing Limited, Cambridge, 2007.
3. Numerical Analysis - Carl-Eric Froberg
4. Computational Physics - F J Vessley
5. Introduction to Materials Modelling - Ed Zoe H. Barber, Maney Publishing, 2005
6. Multi-scale Modelling & Simulation - Astringes & Coumoutsakos, Springer
7. Computational Materials Design - Tetsuya, Springer
8. Materials Informatics, Data-Driven Discovery in Material Sc - Krishana Rajan, Wiley, 2007.
9. Salaria R.S. 1996. Numerical Methods: A Computer Oriented Approach BPB.
10. Rajaraman, V. 1980, Computer based Numerical methods 3rd Ed. Prentice Hall India
11. Wesely Addisom, Mathematica, S. Wolfram
12. Binder K., Verlag Springer, Application of the Monte Carlo Method
13. Numerical Receipes in C: The Art of Scientific Computing, W.H.Press et al, Cambridge Press
14. Addison Wesley, Gould, H. and Toobochniik, J., 1996 An introduction to Computer Simulation Methods
15. Computational methods for smart structures and materials - P. Santini, M. Marchetti, C.A. Brebbia, W.I.T. Press, Computational Mechanics Publications, Boston, 1999.


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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-605: METALS, CERAMICS AND COMPOSITES

| L | T | P | | |
|---|---|---|---|---|
| 4 | 0 | 0 | **Internal Marks:** | **50** |
| | | | **External Marks:** | **100** |
| **Credits: 4** | | | **Duration of Exam:** | **3 hours** |

**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/entrapment). 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.
2. PhysicalMetallurgy Principles Reed-Hill - R. E., and R. Abbaschian, 3rd ed. Boston: PWS-Kent, 1992.
3. Structure and Properties of Engineering Alloys - Smith, W. F., McGraw-Hill, 1981.
4. Introduction to Ceramics –W.D. Kingery, H.K. Bowen, D.R. Ulhmann.
5. Treatise on Inorganic Chemistry, Vol. II: Subgroups of the periodic table and general topics, Preparation of Metals - H. Remy, Elsevier, 1956.
6. Synthesis of Advanced Ceramic Materials – David Segal.
7. Fundamentals of Polymer Science: An Introductory Text - P. Painter and M. Coleman, Technomic, 1997
8. Composite Materials: Engineering and Science - F. L. Matthews and R. D. Rawlings, Chapman & Hall 1994
9. Ceramic Processing and Sintering - M.N. Rahman, Marcel Dekker, Inc.
10. Handbook of Advanced Ceramics Vol.II, Processing and Their Applications - Shigeyuki Somiya, Elsevier Acadmic press.
11. Mechanical properties of ceramics – Watchman, J. B., John Wiley New York, 1996
12. Advanced Composite Manufacturing - Gutowski, Wiley.

13. Mechanics of Composite Material - R. M. Jones, McGraw Hill Pub., New York, 1975.
14. Composite Structures, Testing, Analysis and Design - J. N. Reddy and A.V. Krishna Moorty, Narosa Publishing House, New Delhi, 1992.

**Notes**:

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**M. Tech. in Materials Science and Nanotechnology, Semester I**

## MSN-607: CHARACTERISATION TECHNIQUES FOR MATERIALS

| L | T | P |
|---|---|---|
| 4 | 0 | 0 |

**Credits: 4**

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

**UNIT I: Spectroscopy:** Basics of UV and visible Spectroscopy: Electronic transitions, Beer-Lambert Law, visible spectrum and colour; **Infrared Spectroscopy:** Instrumentation and sample handling, overtones, applications of FT-IR and IR Spectroscopy; **NMR Spectroscopy:** General introduction and definition, chemical shift, spin-spin interaction, shielding and de-shielding mechanism; **Mass spectroscopy:** Introduction, ion-production, High resolution mass spectrometry (HRMS). **Raman spectroscopy:** Introduction, principle and applications.

**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.

**UNIT IV: Scanning Probe Microscopy:** Principles and operation of scanning probe microscopes: Scanning Tunnelling Microscope, Atomic Force Microscope, Magnetic and Piezo-Force microscopy.
**Thermal Analysis:** Thermo Gravimetric Analysis, Differential Thermal Analysis, Differential Scanning Calorimetry: Operating principles and their applications. Characterization based upon electrical properties.

**TEXT/REFERENCE BOOKS**


1. Solid state chemistry and its Applications - Antony R. West, Wiley Student Edition
2. Electron Microscopy and Analysis - P.J. Goodhew, F.J. Humphreys, Taylor & francis, 2nd edition, 1997
3. Fundamentals of Molecular spectroscopy - Colin N. Banwell and Elaine M. McCash, Tata McGraw-Hill Publishing Co. Ltd., Fourth edition
4. Modern Physical Metallurgy - Smallman R. E., 4th Edition, Butterworths, 1985
5. Modern Metallographic Techniques and their Applications - Philips V. A., Wiley Interscience, 1971
6. Elements of X-ray Diffraction - Cullity B. D., 4th Edition, Addison Wiley, 1978
7. Electron Beam Analysis of Materials - Loretto M. H., Chapman and Hall, 1984
8. Transmission Electron Microscopy – Eddington
9. Scanning Probe Microscopy and Spectroscopy: Theory, Techniques, and Applications – Dawn Bonnell, Wiley-VCH.
10. Scanning Probe Microscopy - Meyer, Ernst, Hug, Hans Josef, Bennewitz, Roland, Springer.

11. Basics of NMR: by Joseph P. Hornak, http://www.cis.rit.edu/htbooks/nmr/
12. Handbook of Spectroscopy, 2 Volumes, Günter Gauglitz (Editor), Tuan Vo-Dinh (Editor), John Wiley, ISBN: 978-3-527-29782-5

**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-609: NANO-MATERIALS AND THEIR APPLICATIONS

| L | T | P | | |
|---|---|---|---|---|
| 4 | 0 | 0 | **Internal Marks:** | **50** |
| | | | **External Marks:** | **100** |
| **Credits: 4** | | | **Duration of Exam:** | **3 hours** |

**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.

**UNIT IV: Nanomaterials applications in different areas**: In semi-conductors, sensors, molecular and nano-electronics. Nano structured bio-ceramics and nano-materials for drug delivery applications. Biological and diagnostic applications of nanotechnology; quantum dot devices.

**TEXT/REFERENCE BOOKS**


1. Nano: The Essentials - Pradeep T, Mc Graw Hill Publishing Co. Ltd., 2007
2. Nanotechnology - Mick Wilson et al, Overseas Press (India) Pvt. Ltd., 2005.
3. Introduction to nanotechnology - Charles P. Poole, Jr., Frank J. Owens, Wiley, 2003.
4. Nanoparticles: From Theory to Applications - Gunter Schmid, Wiley-VCH Verlag GmbH & Co., 2004.
5. There's Plenty of Room at the Bottom - Richard P. Feynman, http://www.zyvex.com/nanotech/feynman.html
6. Sweeney, A. E., Seal, S. & Vaidyanathan, P. 2003, 'The promises and perils of nanoscience and nanotechnology: Exploring emerging social and ethical issues', *Bulletin of Science, Technology & Society*, **23**(4), 236-245.
7. Wolfson, J.R.: 2003, 'Social and Ethical Issues in Nanotechnology: Lessons from Biotechnology and Other High Technologies', *Biotechnology Law Report*, **22**, no 4, 376-96.
8. Wilson, M., Kannangara, K., Smith, G., Simmons, M., Raguse, B. 2002, Nanotechnology- Basic Science and Emerging Technologies. Chapman and Hall/CRC.
9. New Nanotechniques, Eds A. Malik and R.J. Rawat, Nova Science, New York, 2009.
10. Bhushan, Bharat. 2004. Handbook of Nanotechnology. Springer.


**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

| | | | | | |
|---|---|---|---|---|---|
| | | | **Sessional** | **:** | **50 Marks** |
| | | | **Exam** | **:** | **50 Marks** |
| **L** | **T** | **P** | **Total** | **:** | **100 Marks** |
| **-** | **-** | **4** | **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 – hardening, etching, welding, bonding etc.
7. Polymer processing methods – pressing, injection molding etc.
8. Metallurgical sample preparation - Al Alloys/Steels/Cu Alloys/ Fe Alloys
9. Metallurgical treatments and microscopic examination – 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.**

**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

**SEMESTER-II**

| S. No. | Course No. | Course Title | Teaching Schedule | | | Marks | | | Credits | Duration of Exam |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | Sessional | Exam | Total | | |
| 1 | MSN-602 | Synthesis of Materials | 4 | 0 | - | 50 | 100 | 150 | 4 | 3 |
| 2 | MSN-604 | Bio-Nanotechnology | 4 | 0 | - | 50 | 100 | 150 | 4 | 3 |
| 3 | MSN-606 | Thermodynamics and Statistical Mechanics | 4 | 0 | - | 50 | 100 | 150 | 4 | 3 |
| 4 | MSN-608 | Polymer Science and Technology | 4 | 0 | 0 | 50 | 100 | 150 | 4 | 3 |
| 5 | *MSN-610 | Presentation and Communication Skills | 0 | 0 | 0 | 0 | 0 | 0 | 0* | 1 |
| 6 | MSN- | ELECTIVE-I | 4 | 0 | - | 50 | 100 | 150 | 4 | 3 |
| 7 | MSN-612 | Synthesis and Characterization Lab | 0 | 0 | 4 | 50 | 50 | 100 | 4 | 3 |
| | **Total** | | **20** | **0** | **4** | **300** | **550** | **850** | **24** | |

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 – Compulsory qualifying Examination

**M. Tech. in Materials Science and Nanotechnology, Semester II**

## MSN-602 SYNTHESIS OF MATERIALS

| L | T | P | | |
|---|---|---|---|---|
| 4 | 0 | 0 | **Internal Marks:** | **50** |
| | | | **External Marks:** | **100** |
| **Credits: 4** | | | **Duration of Exam:** | **3 hours** |

**UNIT I:** Introduction and background to Materials Synthesis; Principles of Synthesis (through case studies drawn from metals (Fe, Al, Ni and Nd), ceramics ($Al_2O_3$, $BaTiO_3$, Ferrites, $ZnO/ZrO_2$)), 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 III:** Misc. Synthesis Topics: High Strength/Modulus Materials-Synthesis and Structure - Diamond thin films, nanocomposites, Carbon fibers, high-strength steels, Ni and Ti alloys. Electronic Materials Synthesis – Methods and Challenges. Basic elements of catalysis. Catalytic Synthesis of Materials – ZnO, C-Nanotubes.

**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,
2. Preparation of Metals - H. Remy, Elsevier, 1956.
3. Chemical Synthesis of Advanced Ceramic Materials –David Segal, Camb. Univ. Press.
4. Diffraction of X-rays by Chain Molecules - B. K. Vainshtein, , Elsevier, Amsterdam, 1966
5. Polymer Single Crystals - P. H. Geil, Interscience-Wiley, New York, 1963
6. Fundamentals of Polymer Science - P. Painter and M. Coleman, Technomic, 1997
7. Composite Materials: Engineering and Science - F. L. Matthews and R. D. Rawlings, Chapman & Hall 1994
8. Synthesis and technique in inorganic chemistry:a laboratory manual - Girolami, Gregory S. - Rauchfuss,
9. Thomas B. - Angelici, Robert J., 3rd ed. Sausalito, Calif. University Science Books, 1998.
10. Solid State Chemistry - Techniques - Cheetham, A K - Day, Peter, OUP, 1987.
11. *Solid State Chemistry – Compounds* - Cheetham, A K &Day, Peter, OUP, 1992.
12. Materials Syntheses – A Practical Guide, U. Schubert, N. Husing and R.M. Laine, Springer Verlag.

**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–604: BIO-NANOTECHNOLOGY

| L | T | P | | |
|---|---|---|---|---|
| 4 | 0 | 0 | **Internal Marks:** | **50** |
| | | | **External Marks:** | **100** |
| **Credits: 4** | | | **Duration of Exam:** | **3 hours** |

**UNIT I:** Bio-nanotechnology – An Overview: What can engineers learn from biology? From biotechnology to Bio-nanotechnology. Bio-nanomachines in action. Molecular recognition: How molecular recognition underlies cellular communication, material transfer into and within cells, and bio-transformations. Information: How information is stored in the cell and how it is read?

**UNIT II:** Bio-physics: Bio-electromagnetism, bioenergetics, biomechanics, Neuro-transport, Biological Rhythms. Modern Bio-materials: Proteins, Nucleic acids, Lipids, Polysaccharides. Bio-molecular Design and Bio-technology: Recombinant DNA Technology, monoclonal antibodies, Molecular Modeling and Biomolecular structure determination.

**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.

**UNIT IV:** Structural Principles of Bio-nanotechnology: Natural Bio-nanomachinery, Hierarchical strategy, raw materials, Protein folding. Bio-nanotechnology Today and Future: Basic capabilities, Nano-medicine today, DNA computers, hybrid materials, artificial life and biosensors.

**TEXT/REFERENCE BOOKS**


1. Goodsell, David S. 2004. Bionanotechnology- Lessons from Nature. John Wiley & Sons, INC., Publication.
2. Niemeyer C.M. & Mirkin, C.A. 2004. Nanobiotechnology- Concepts, Applications and Prespectives, Wiley-VCH Verlag.
3. Avouris, P., Klitzing, K. Von, Sakaki H. & Wiesendanger, R. 2003. NanoScience and Technology Series. Springer.
4. Pattabhi,V & Gautham, N. 2002. Biophysics. Narosa Publications.


**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-606: THERMODYNAMICS AND STATISTICAL MECHANICS

| L | T | P | | |
|---|---|---|---|---|
| 4 | 0 | 0 | **Internal Marks:** | **50** |
| | | | **External Marks:** | **100** |
| **Credits: 4** | | | **Duration of Exam:** | **3 hours** |

**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**


1. The Structure and Properties of Materials, Vol II; Thermodynamics of structure - Jere H. Brophy, Robert M. Rose and John Wulff, Wiley Èastern Pvt. Ltd., N. Delhi.
2. Introduction to Metallurgical Thermodynamics – Gaskell, David R, McGraw Hill.
3. Introduction to Materials Science and Engineering - Kenneth M. Ralls, Thomas H. Courtney and John
   Wulff, Wiley Eastern Ltd.
4. Introduction to Metallurgical Thermodynamics - Tupkary R.H., Latest edition. Tu Publishers, Nagpur.
5. Problems in Metallurgical Thermodynamics and kinetics - Upadhyaya G.S. and R.K.Dube, Pergamon Press..
6. Rate Processes in Metallurgy - Mohanty, A. K., Prentice Hall of India (EEE), 2000
7. The Second Law: An Introduction to Classical and Statistical Thermodynamics - Bent, Henry A. . Oxford University Press, 1965.
8. The Principles of Chemical Equilibrium - Denbigh K., 3rd edition. Cambridge Univ. Press, 1971.
9. Thermodynamics - Fermi, Enrico, New York: Dover Publications, 1936.
10. On the equilibrium of heterogeneous substances - Gibbs, J. Willard. (1876). In Collected Works 1, Longmans, Green, and Co., 1928.

11. Treatise on Thermodynamics - Planck, , 7th edition. New York: Dover Publications, 1926.
12. Chemical Thermodynamics of Materials – C.H.P Lupis, Elsevier Science Ltd.
13. Chemical and Metallurgical Thermodynamics – K.K. Prasad, New Age Publishers.

**Notes**:

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**M. Tech. in Materials Science and Nanotechnology, Semester II**

## MSN -608: POLYMER SCIENCE AND TECHNOLOGY

| L | T | P | | |
|---|---|---|---|---|
| 4 | 0 | 0 | **Internal Marks:** | **50** |
| | | | **External Marks:** | **100** |
| **Credits: 4** | | | **Duration of Exam:** | **3 hours** |

**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 II: Polymers:** Polymerization, Degree of polymerization, Structural features, Thermoplastic and thermosetting polymers, Mechanical properties, Thermal properties. Strengthening mechanism, Fibres. Special purpose plastics. Glass transition temperature and its importance.

**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.

**UNIT IV: Processing of polymers :** Flow properties of polymers, Extrusion, Injection and blow moulding. Calendaring, Vacuum and pressure forming and warm forging. Casting of fibres and filaments. Assembly by adhesion. **Properties in Service Environments :** Effects of vapours and solvents on polymeric materials. Oxidation and thermal degradation of polymers. Solubility, permeability, radiation damage and chemical resistance of polymers.

**TEXT/REFERENCE BOOKS:**


1. The Plastic Engineer's Data Book – A. B. Glanvill, The Machinery Pub.
2. A review of The Goodyear Story: An Inventor's Obsession and the Struggle for a Rubber Monopoly -Richard Korman, Encounter Books, 2002.
3. Engineering Properties of Spider Silk - Ko, Frank K., Sueo Kawabata, Mari Inoue, Masako Niwa, Stephen Fossey and John W. Song.
4. Textbook of Polymer Science - Billmeyer F, Wiley Interscience, 1994
5. Principles of Polymer Chemistry – P.J. Flory, Cornell University Press.
6. Polymers: Chemistry and Physics of Modern Materials, J.M.G. Cowie, Blackie Academic and Professional.
7. Principles of Polymerization, G. Odion, John Wiley publishers.
8. Polymer Science, V.R. Gowariker, N.V. Viswanathan and J. Sreedhar, Wiley-Eastern.
9. Functional Monomers and Polymers, K. Takemoto, Y. Inake and R.M. Otta.

**Notes**:

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**M. Tech. in Materials Science and Nanotechnology, Semester II**

## MSN -610: PRESENTATION AND COMMUNICATION SKILLS

| L | T | P | | |
|---|---|---|---|---|
| **0** | **0** | **0** | **Internal Marks:** | **0** |
| | | | **External Marks:** | **0** |
| **Credits: 0** | | | **Duration of Exam:** | **1 hour** |

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.

**M. Tech. in Materials Science and Nanotechnology, Semester II**

## MSN 612: SYNTHESIS AND CHARACTERISATION LAB

| | | | | | |
|---|---|---|---|---|---|
| | | | **Internal** | **:** | **50 Marks** |
| | | | **Final Exam** | **:** | **50 Marks** |
| **L** | **T** | **P** | **Total** | **:** | **100 Marks** |
| **0** | **0** | **4** | **Duration of exam** | **:** | **6 Hrs.** |

**List of Experiments:**

1. Synthesis of Nano-ferrite particles by chemical co-precipitation method.
2. Synthesis of oxide nanoparticles by Sol-gel technique.
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.**

**M. Tech. in Materials Science and Nanotechnology, Semester II**

# MSN – 622: MECHANICAL BEHAVIOUR of MATERIALS

| L | T | P | | |
|---|---|---|---|---|
| 4 | 0 | 0 | **Internal Marks:** | **50** |
| | | | **External Marks:** | **100** |
| **Credits: 4** | | | **Duration of Exam:** | **3 hours** |

**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.
**Fatigue:** Sources of cyclic loading, defining cyclic loading, Variable Amplitude Loading, The Palmgren-Miner Rule, Cycle Counting For irregular Histories, S-N Curves, Life Estimates, Mechanisms of Fracture and crack growth, Fatigue Crack Growth, Trends in FCG behaviour, Effect of R and stress Range, Design Considerations, Elastic crack tip stress field.

**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 $K_{IC,}$ 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,

**UNIT IV: Measurement of stress and strain**: Load cells, Optical, electrical and electronic strain measuring devices, Computer controlled Servo-hydraulic test machines, Brittle lacquers. Measurement of residual stress
**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:**

1. Mechanical Behaviour of Material - Englewood Cliffs, Prentice Hall, New Jersey, 1993
2. Fracture Mechanics - Prashant Kumar
3. Mechanical Behaviour of Materials - Keith Bowman
4. Mechanical Behaviour of Materials - Norman E. Dowling, Prentice Hall.
5. Mechanical Behaviour of Material - Courtney Browne, McGraw Hill, 1990
6. Introduction to Fracture Mechanics - Kare Hellan, McGraw Hill.
7. Introduction to Fracture Mechanics - David Brookes.
8. The Nature and Properties of Engineering Materials - Binges D.Jastrzebski, 3rd ed. John Wiley & Sons.
9. Theory of Dislocations, McGraw Hill - J. P. Hirth and J. Lothe.
10. Mechanical Behavior of Materials – Courtney, 2nd ed. Long Grove, IL: Waveland Press Inc., 2005.
11. Mechanical Metallurgy - Dieter, G. E. . New York, NY: McGraw-Hill, 1986.
12. A Treatise on the Mathematical Theory of Elasticity - Love, A. E. H.New York, NY: Dover Publications, 1927.
13. Physical Properties of Crystals: Their Representation by Tensors and Matrices - Nye, J. F., New York, NY: Oxford University Press, 1985.
14. Introduction to Dislocations - Bacon, D. J., and D. Hull, New York, NY: Pergamon Press, 1984.
15. Theory of Dislocations- Hirth, J. P., and J. Lothe, Malabar, FL: Krieger Publishing Company, 1992.
16. Crystals, Defects and Microstructures- Phillips, R. New York, NY: Cambridge University Press, 2001.
17. Fracture Mechanics: Fundamentals and Applications - Andersen, T. L., New York, NY: CRC Press, 1994.
18. Deformation and Fracture Mechanics for Engineering Materials - Hertzberg, R. W., New York, NY: John Wiley & Sons Inc., 1995.
19. Fatigue of Materials - Suresh, S., New York, NY: Cambridge University Press, 1998.
20. Mechanics of Materials- Hibbeler, R. C. . Upper Saddle River, NJ: Prentice Hall, 2004.

**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 624: TRANSPORT PHENOMENA IN MATERIALS

| L | T | P | | |
|---|---|---|---|---|
| 4 | 0 | 0 | **Internal Marks:** | **50** |
| | | | **External Marks:** | **100** |
| **Credits: 4** | | | **Duration of Exam:** | **3 hours** |

**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**


1. Fundamentals of Momentum, Heat, and Mass Transfer- Welty, James, Charles E. Wicks, Robert E. Wilson, and Gregory L. Rorrer, 4th ed. New York: John Wiley and Sons Inc., January 2000.
2. Transport Phenomena in Materials Processing- Poirier, D. R., and G. H. Geiger. Warrendale, PA: TMS, 1994.
3. Introduction to Heat and Mass Transfer - Incropera, Frank P., and David P. DeWitt., New York: John Wiley & Sons Inc., July 2000.


**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, photo-striction, shape memory alloys, Superelastic, Viscoelastic, Elastoresistive, Electrorheological, Thermochromic, 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**


1. Smart Materials and Structures - M.V. Gandhi, B.S. Thompson, Chapman and Hall, London 1992.
2. Electromechanical Sensors and Actuators - Ilene J. Busch-Vishniac, Springer-Verlag NY, 1999.
3. Smart Material Structures: modelling, estimation and control - H.T. Banks, R.C. Smith and Y. Wang, John Wiley & Sons Inc. NY, 1996.
4. Smart material Systems and MEMS-Design & Development Methodologies - Vijay Varadan, S. Gopalkrishnan, Wiley, 2006
5. Smart Materials and Structures - M.V. Gandhi, B.S. Thompson, Chapmann and Hall, London 1992
6. Smart materials, structures and mathematical issues - Rogers A Craig, Technomic Publishing Company, Inc, 1991.

7. Computational methods for smart structures and materials - P. Santini, M. Marchetti, C.A. Brebbia, W.I.T. Press, Computational Mechanics Publications, Boston, 1999.
8. Smart Material Systems: Model Developments - Ralph C. Smith, Cambridge University Press, Series: Frontiers in Applied Mathematics (No. 32) 2005.
9. Smart Material Structures: modeling, estimation and control - H.T. Banks, R.C. Smith and Y. Wang, John Wiley & Sons Inc. NY, 1996.
10. Smart/Intelligent Materials and Structures - B. Tao, Defence Industry Press, Beijing, 1997
11. Functional & Smart materials: Structural Evolution and Structure Analysis - Zhong Ling Wang, Zhen Chuan Kang, 1998.
12. Ferroelectrics: An introduction to the physical Principles - J.C. Burfoot, Van Norstrand, London, 1967.
13. Ferroelectric materials and their Applicatuions - Y. Xu, North Holland, Amsterdam, 1991.
14. Ferroelectric Polymers: chemistry, physics and appliocations - HS Nalwa (Ed.) Marcel Dekker, NY, 1995.
15. Ferroelectric Materials - Ratnakar R. Neurgaonkar, Rockwell Scientific Company thousand oaks, CA 2005.
16. Piezoelectricity - Gordon and Beach Science Publishers, Switzerland, 1985.
17. Electronic Ceramics: Properties, devices and applications - L.M. Levinson, GEC, NY, Marcel and Dekker, NY, 1987, Basal, 1988.
18. Electroceramics: Material Properties applications - A.J Moulson and J.M. Herbert, Chapman and Hall, London, NY, 1992.
19. Ceramic materials for Electronics: Processing, Properties and Applications - R.C. Buchanan, Marcel and Dekker Inc., NY, 1991.
20. Advanced Ceramics - S Saito (Ed), Oxford University Press, 1988.
21. Shape Memory Materials - K. Otsuka & C.M. Wayman, Cambridge University Press.
22. Visco-elastic Solids - Robert S. Lakes, CRC Press.

**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

| L | T | P | | |
|---|---|---|---|---|
| 4 | 0 | 0 | **Internal Marks:** | **50** |
| | | | **External Marks:** | **100** |
| **Credits: 4** | | | **Duration of Exam:** | **3 hours** |

**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
4. Disordered Materials an Introduction: Paolo M Ossi.
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.

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-III**

| S. No. | Course No. | Course Title | Teaching Schedule | | | Marks | | | Credits | Duration of Exam Sessional |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | Sessional | Exam | Total | | |
| 1 | MSN-701 | Nanodevices and Nanosensors | 4 | 0 | - | 50 | 100 | 150 | 4 | 3 |
| 2 | MSN-703 | Advanced Materials Science-I | 4 | 0 | - | 50 | 100 | 150 | 4 | 3 |
| 3 | MSN-705 | Advanced Materials Lab | 0 | 0 | 4 | 50 | 50 | 100 | 4 | 3 |
| 4 | MSN-707 | Seminar | 0 | 0 | 2 | 50 | 50 | 100 | 2 | - |
| 5 | MSN- | ELECTIVE-I | 4 | 0 | 0 | 50 | 100 | 150 | 4 | 3 |
| 6 | MSN-709 | Minor Dissertation | 0 | 0 | 4 | - | 100 | 100 | 4 | - |
| | **Total** | | **12** | **0** | **8** | **250** | **500** | **750** | **22** | |

ELECTIVES:

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

**M. Tech. in Materials Science and Nanotechnology, Semester III**

## MSN 701: NANO DEVICES AND NANO SENSORS

| L | T | P | | |
|---|---|---|---|---|
| 4 | 0 | 0 | **Internal Marks:** | **50** |
| | | | **External Marks:** | **100** |
| **Credits: 4** | | | **Duration of Exam:** | **3 hours** |

**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.

**UNIT-II Micro/Nanofabrication Techniques:** Stamping techniques for Micro and Nanofabrication**,** Material aspects of MEMS and NEMS. Packaging and characterization of sensors; Packaging & Reliability. Method of packaging.

**UNIT-III Micro and Nano-sensors:** Fundamentals of sensors, Temperature Sensors, Smoke Sensors, Sensors for aerospace and defense, Accelerometer, Pressure Sensor, Night Vision System, Nano tweezers, nano-cutting tools, Integration of sensor with actuators and electronic circuitry.

**UNIT-IV Molecular Devices**: Molecular-scale elements, Molecules that emulate conventional electronic circuit elements, Logic circuits using molecular diodes, Semiconductor nanocrystals, Directed self-assembly of molecular circuits, Properties of DNA and its potential applications in molecular electronics, possible self-assembled molecular-scale circuits of the future.

**TEXT/REFERENCE BOOKS**


1. Sensors: Micro & Nanosensors, Sensor Market trends (Part 1&2) - H. Meixner.
2. Between Technology & Science: Exploring an emerging field knowledge flows & networking on the
3. nanoscale - Martin S. Meyer.
4. Nanoscience & Technology: Novel structure and phenomena - Ping Sheng
5. Nano Engineering in Science & Technology: An introduction to the world of nano design - Michael
6. Rieth.
7. Enabling Technology for MEMS and nano devices - Balles, Brand, Fedder, Hierold.
8. Optimal Synthesis Methods for MEMS - G. K. Ananthasuresh.
9. MEMS & MOEMS Technology and Applications - P. Rai Choudhury.
10. Poole Jr., C.P., Owens, F.J. "Introduction to Nanotechnology", Wiley (2003).

11. Sweeney, A. E., Seal, S. & Vaidyanathan, P. 2003, 'The promises and perils of nanoscience and nanotechnology: Exploring emerging social and ethical issues' , *Bulletin of Science, Technology & Society*, **23**(4), 236-245.
12. Wilson, M., Kannangara, K., Smith, G., Simmons, M., Raguse, B. 2002, Nanotechnology- Basic Science and Emerging Technologies. Chapman and Hall/CRC.
13. Goodsell, David S. 2004. Bionanotechnology- Lessons from Nature. John Wiley 7 Sons, INC., Publication.
14. Bhushan, Bharat. 2004. Handbook of Nanotechnology. Springer.

**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

| L | T | P | | |
|---|---|---|---|---|
| 4 | 0 | 0 | **Internal Marks:** | **50** |
| | | | **External Marks:** | **100** |

**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 II: Introduction to magnetic materials**: Laws of magnetic materials. Domain theory, Domain growth and domain wall rotation, Magnetic anisotropy. Magnetostriction & its mechanisms. Ferromagnetic domains. Hard and soft magnetic materials. Textured magnetic materials, Oxide magnetic materials. Ferromagnetic semiconductors.

**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.

**UNIT IV: Functionalization of Carbon Nanotubes:** Carbon Nanotubes, Functionalization of Carbon Nanotubes, Reactivity of Carbon Nanotubes, Covalent Functionalization & Purification methods: Oxidation, Acid treatment, Annealing, Ultrasonication, Micro filtration, Ferromagnetic separation, Cutting, Functionalisation, and Chromatography techniques. Quantum dots and wires.

**TEXT/REFERENCE BOOKS**


1. Artificial organs and Tissue Engineering Biomaterials - Hench L. Larry and Jones J., (Editors), Woodhead Publishing Limited, 2005.
2. An Introduction to Bio-ceramics - Hench L. Larry, & Wilson J., (Editors), World Scientific, 1994.
3. Biomaterials: An Introduction - Park .J.B. & Lakes R.S., Plenum Press, New York, 1992.
4. Biomaterials, Medical Devices & Tissue Engineering: An Integrated approach - Silver F. H., Chapman & Hall, 1994.


**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 705: ADVANCED MATERIALS LABORATORY

| L | T | P | | |
|---|---|---|---|---|
| 0 | 0 | 4 | **Internal Marks:** | **50** |
| | | | **External Marks:** | **50** |
| **Credits: 4** | | | **Duration of Exam:** | **3 hours** |

### 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.
9. Synthesis and characterization of amorphous materials.

**M. Tech. in Materials Science and Nanotechnology, Semester III**

## MSN 707: SEMINAR

| L | T | P | | |
|---|---|---|---|---|
| 0 | 0 | 2 | **Internal Marks:** | **50** |
| | | | **External Marks:** | **50** |
| **Credits: 2** | | | **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)

| L | T | P | | |
|---|---|---|---|---|
| 4 | 0 | 0 | **Internal Marks:** | **50** |
| | | | **External Marks:** | **100** |
| **Credits: 4** | | | **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.

**M. Tech. in Materials Science and Nanotechnology, Semester III**

## MSN 721: DEGRADATION OF MATERIALS

| L | T | P | | |
|---|---|---|---|---|
| 4 | 0 | 0 | **Internal Marks:** | **50** |
| | | | **External Marks:** | **100** |
| **Credits: 4** | | | **Duration of Exam:** | **3 hours** |

**UNIT I:** Creep, fracture, buckling, delamination, grain growth, amorphization etc. (Oxidation, Radiation, wear and allied processes etc).

**UNIT II: Corrosion :** Types, Galvanic cell, wet and dry corrosions , Laws of corrosion, Oxidation, Mechanisms, Passivity , Special types of corrosions , Methods of protection against corrosion. Electrochemical and thermodynamic principles of corrosion, Electrode potential of metals, Nernst equation, Reference electrodes, E-pH diagrams, Exchange current density.

**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 :** Electroc-chemical 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**

1. The Fundamentals of Corrosion - J. C.Scully, Pergamon.

**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

| L | T | P | | |
|---|---|---|---|---|
| 4 | 0 | 0 | **Internal Marks:** | **50** |
| | | | **External Marks:** | **100** |
| **Credits: 4** | | | **Duration of Exam:** | **3 hours** |

**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**


1 The Materials Science of Thin Films - Milton Ohring, academic Press Sanden, 1992.

2 Thin Film Phenomena - Kasturi L. Chopra, Mc Graw Hill (NewYork), 1969.

3 Thin – Film Deposition properities; Principles and practices - Denald L. Smith, McGraw Hill, Inc. 1995.

4 Thin Film Materials Technology, Shurtting of Compound Materials - Kigotaka wasa, Mokota Kitabatke and Hineaki Adadi, Elecwier Science and Technolgy Book, 2004.

5 Hand book of Physical Vapor Deposition Processions - Renald M. Matten Norses Publication 1998.

6 Physical Vapor Deposition of Thin Film - John E. Mohan, John Wiley & Sons, 2000.

7 Principles of Chemical Vapor Deposition - D. M. Dolokin, M.K. Zwrow, Kluwer Academic Publisher,
Natterlande, 2003.
8 Chemical Vapor Deposition - Pradeep George, VDM Verles Dr. Mueller E.K., 2007.

**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 725: ADVANCED MATERIALS SCIENCE-II

| L | T | P | | |
|---|---|---|---|---|
| 4 | 0 | 0 | **Internal Marks:** | **50** |
| | | | **External Marks:** | **100** |
| **Credits: 4** | | | **Duration of Exam:** | **3 hours** |

**UNIT I:** Optical and Optoelectronic Materials: Optical properties, Solar cell, Principles of photoconductivity. simple models, effect of impurities. Principles of luminescence, types; semiconductor lasers; LED materials, binary, ternary photo-electronic materials, effect of composition on band gap, crystal structure and properties.

**UNIT II:** Introduction to optical fibres, Light propagation, Electro-optic effect, Kerr effect, Pockel's 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**


1. Electrical Properties of Materials - L. Solymar, D. Walsh, Oxford University Press, USA, 2004. ,
2. Introduction to the Electronic Properties of Materials - David C. Jiles, Taylor and Francis, 2001.
3. Introduction to Magnetism and Magnetic Materials, D.C. Jiles, Springer, 1990.
4. Optoelectronic Materials and Device Concepts - Manijeh Razeghi, SPIE-International Society for Optical Engine, 1991.
5. Structure and Properties of Materials - Rose R.M., Shepard L.A., Wulff J., Volume IV, 'Electronic Properties', 4th Edition, 1984.
6. Electrical Engineering Materials - K.M. Gupta, 3rd Edition, Umesh Publication, Delhi, 2005.


**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**

| S. No. | Course No. | Course Title | Teaching Schedule | | | Marks | | | Credits | Duration of Exam |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | Sessional | Exam | Total | | |
| **1** | MSN-702 | Major Project / Dissertation | - | - | 20 | 50 | 100 | 150 | 20 | |
| | | **Total** | **-** | **-** | **20** | **50** | **100** | **150** | **20** | |

**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** **Session: 2011-12**

| S. No. | Course No. | Course Title | Teaching Schedule | | | Marks | | | Credits | Duration of Exam Sessional |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | Sessional | Exam | Total | | |
| 1 | *MSN-901 | Introduction to Materials | 4 | 0 | - | 50 | 100 | 150 | 4 | 3 |
| 2 | *MSN-902 | Experimental Techniques in Materials | 4 | 0 | - | 50 | 100 | 150 | 4 | 3 |
| 3 | RM-900 | Research Methodology | 4 | 0 | 0 | 50 | 100 | 150 | 4 | 3 |
| | **Total** | | **12** | **0** | **0** | **150** | **300** | **450** | **12** | |

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

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

Duration of exam: 3 hrs.

**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**

Solidification and Crystalline Imperfections: Mechanism of nucleation and growth of crystals, Defects in crystals: Point, Line, Surface and Volume defects. Thermally activated mechanisms: Diffusion (Fick's Laws), Creep and Grain growth.

**UNIT -III**

Mechanical Properties: Yield strength, Fracture strength, ductility, elastic and shear moduli, and advantages of composite structures. Phase Diagrams: Binary phase diagrams and basic calculations of compositions. Engineering Alloys: Commercial alloys and their microstructures. Common examples of Polymeric Materials, Ceramics and Composites.

**UNIT IV**

Other properties: Electrical Properties (electrical, semiconducting, dielectric), Optical Properties (refraction, reflection, transmission), Magnetic Properties (Origins of and Types of magnetic behaviors). Structure and Properties of common Natural and Biomaterials.

**TEXT/REFERENCE BOOKS:**


15. Introduction to Materials Science and Engineering, William J Callister, John Wiley & Sons, Inc.
16. PhysicalMetallurgy Principles Reed-Hill - R. E., and R. Abbaschian, 3rd ed. Boston: PWS-Kent, 1992.
17. *Structure and Properties of Engineering Alloys* - Smith, W. F., McGraw-Hill, 1981.
18. Introduction to Ceramics –W.D. Kingery, H.K. Bowen, D.R. Ulhmann.
19. Treatise on Inorganic Chemistry, Vol. II: Subgroups of the periodic table and general topics, Preparation of Metals - H. Remy, Elsevier, 1956.
20. Synthesis of Advanced Ceramic Materials – David Segal.

21. Fundamentals of Polymer Science: An Introductory Text - P. Painter and M. Coleman, Technomic, 1997
22. Composite Materials: Engineering and Science - F. L. Matthews and R. D. Rawlings, Chapman & Hall 1994

## 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:
Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Internal Reflection Spectroscopy, X-ray fluorescence, Photoluminescence, Auger Electron microscopy (AES).

### 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:**


13. Solid state chemistry and its Applications - Antony R. West, Wiley Student Edition
14. Electron Microscopy and Analysis - P.J. Goodhew, F.J. Humphreys, Taylor & francis, 2nd edition, 1997
15. Fundamentals of Molecular spectroscopy - Colin N. Banwell and Elaine M. McCash, Tata McGraw-Hill Publishing Co. Ltd., Fourth edition
16. Modern Physical Metallurgy - Smallman R. E., 4th Edition, Butterworths, 1985

17. Modern Metallographic Techniques and their Applications - Philips V. A., Wiley Interscience, 1971
18. Elements of X-ray Diffraction - Cullity B. D., 4th Edition, Addison Wiley, 1978
19. Electron Beam Analysis of Materials - Loretto M. H., Chapman and Hall, 1984
20. Scanning Probe Microscopy and Spectroscopy: Theory, Techniques, and Applications – Dawn Bonnell, Wiley-VCH.
21. Handbook of Spectroscopy, 2 Volumes, Günter Gauglitz (Editor), Tuan Vo-Dinh (Editor), John Wiley, ISBN: 978-3-527-29782-5