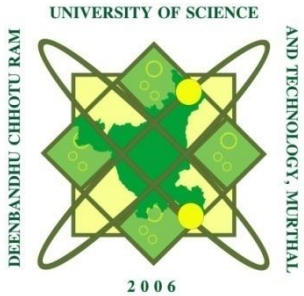
DEPARTMENT OF MATERIALS SCIENCE AND NANOTECHNOLOGY

SCHEME OF STUDIES AND EXAMINATIONS
(ALL SEMESTERS)

M.Tech. in
MATERIALS SCIENCE AND NANOTECHNOLOGY

(Effective from Session 2015-16)



DEENBANDHU CHHOTU RAM UNIVERSITY OF SCIENCE AND TECHNOLOGY,
MURTHAL, SONEPAT - 131039

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

S. No.	Course No.	Course Title	Teaching Schedule			Marks			Credits	Duration of Exam (hr)
			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-613	Polymer and Biomaterials Lab	0	0	2	50	50	100	2	3
7	MSN-615	Simulation and Computation Lab	0	0	2	50	50	100	2	3
	TOTAL		**20**	**0**	**4**	**350**	**600**	**950**	**24**	

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.**
2. **MSN-613 and MSN-615 are applicable from Session 2015-16**

MSN-601: PHYSICS AND CHEMISTRY OF MATERIALS

L	T	P	
4	0	0	**Internal Marks: 50**
			ExternaMarks:100
Credits: 4			**DurationofExam:3hours**

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.

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. Corrosion: Introduction, types, monitoring and prevention,economics of corrosion controle, corrosion auditing and corrosion map of india. **Photochemistry** ï Laws, Frank-Condon Principle Charge transfer spectra and excitations, Fluorescence, Phosphorescence, Chemiluminescence.

UNIT IV: Chemistry of Biological Systems: Cell: structure and function; Bio-molecules ï 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 ï biological energy currency. Hemoglobin and Myoglobin ï 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 ï by A. Ghatak
3. Quantum Mechanics ï by Bransden and Joachen
4. Principles of Quantum Mechanics 2nd ed. - R. Shankar
5. Principals of Physical Chemistry-Marron-Pruton.
6. Physical Chemistry ï Atkins, Peter W. and Paula Julio, OUP.
7. Inorganic Chemistry- by Cotton and Wilkinson.
8. Introduction to Theoretical Chemistry ï Jack Simons.
9. Modern Electrochemistry ï J.O.M. Bockris and A.K. N. Reddy
10. Principles of Biochemistry: A.L. Lehringer, Worth Publishers.
11. Outlines of Biochemistry ï E.E. Conn and Strumpf, John Wiley.

Notes:

1. Eight (8) questions are to be set ï 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

Credits: 4

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

UNIT I: Statistical Mechanics: Statistical distribution functions; Quantum Statistics- Maxwell-Boltzmann Statistics, Molecular energies in an Ideal gas, Rayleigh jeans formula, Plankôs Radiation law, Einsteinôs Approach., Experimental verification of Planckôs radiation law and comparison with other laws.

UNIT II: Basic concepts: Elementary error analysis techniques ï including importance of sampling, Curve-fitting techniques, Introduction to Graphical packages (Origin and Image J), Monte Carlo method: simple simulations of segregation and precipitation phenomena.

UNIT III: Numerical Methods:. Solution of systems of linear equations, Numerical differentiation and integration methods, Numerical methods for Ordinary and Partial differential equations.

UNIT IV: Matrices: Eigen values and Eigen vectors, Tensor notations, Kronecker delta symbol, Tenser of higher rank, tensor in dynamic of particle, tensor treatment of material properties such as elasticity, tensor in rigid body, Basics of Fourier Transforms; Fourier series, Dirichlet Theorem; Dirichlet conditions.

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.

Notes:

1. Eight (8) questions are to be set ï 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

Credits: 4

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

UNIT I: Structure of Metals and Ceramics: Atomic structures and bonding, crystal structures ï lattices, indices etc with examples; Symmetry operations; Order and disorder; Diffusion mechanisms; Deformation mechanisms; Classes of materials; Defects: point defects, line defects, surface and volume defects; strengthening mechanisms.

UNIT II: Properties of Metals and Ceramics:
Mechanical properties: Strength, ductility, toughness, creep, fatigue and fracture properties
Electrical properties including semiconductors, dielectrics, ferroelectrics, piezoelectrics and thermistors,
Thermal properties: Thermal expansion, thermal stresses, thermal fatigue
Magnetic properties including ferromagnetic and ferrimagnetic materials.
Optical properties: Atom-photon interaction mechanisms

UNIT III: **Composite Materials**: Metal Matrix Composites, Ceramic Matrix Composites; Composite Strengths; Fibers as reinforcements; Composite Interfaces; Bonding Mechanisms.

UNIT IV: Microstructural Processes: Solid state sintering, densification and coarsening processes, grain boundary mobility, porosity evolution (stability/entrapment), Interfaces ï coherent and incoherent, Precipitates and dispersoids, Ostwald ripening.

TEXT/REFERENCE BOOKS:

1. Introduction to Materials Science and Engineering, William J Callister, John Wiley & Sons, Inc.
2. An Introduction to Materials Science and Engineering, Brian S Mitchell, John Wiley & Sons, Inc.
3. PhysicalMetallurgy Principles Reed-Hill - R. E., and R. Abbaschian, 3rd ed. Boston: PWS-Kent, 1992.
4. *Structure and Properties of Engineering Alloys* - Smith, W. F., McGraw-Hill, 1981.
5. Introduction to Ceramics ï W.D. Kingery, H.K. Bowen, D.R. Ulhmann.
6. Treatise on Inorganic Chemistry, Vol. II: Subgroups of the periodic table and general topics, Preparation of Metals - H. Remy, Elsevier, 1956.
7. Synthesis of Advanced Ceramic Materials ï David Segal.
8. Fundamentals of Polymer Science: An Introductory Text - P. Painter and M. Coleman, Technomic, 1997
9. Composite Materials: Engineering and Science - F. L. Matthews and R. D. Rawlings, Chapman & Hall 1994
10. Ceramic Processing and Sintering - M.N. Rahman, Marcel Dekker, Inc.

11. Handbook of Advanced Ceramics Vol.II, Processing and Their Applications - Shigeyuki Somiya, Elsevier Acadmic press.
12. Mechanical properties of ceramics ï Watchman, J. B., John Wiley New York, 1996
13. Advanced Composite Manufacturing - Gutowski, Wiley.
14. Mechanics of Composite Material - R. M. Jones, McGraw Hill Pub., New York, 1975.
15. Composite Structures, Testing, Analysis and Design - J. N. Reddy and A.V. Krishna Moorty, Narosa Publishing House, New Delhi, 1992.

Notes:

1. Eight (8) questions are to be set ï 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-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, **Raman spectroscopy:** Introduction, principle and applications.

UNIT II: X-ray Diffraction techniques: Crystal structure, 2-D crystals, 3-D crystal, position and orientation of crystal pane: miller indices, Production of X-rays, its properties and hazards effect, X-ray Diffraction and Bragg's law, Laue techniques, Determination of crystal structure of powder sample by Debye-Scherrer techniques, residual stress measurement, introduction to pole figure and texture analysis.

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.

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.

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 ï Eddington
9. Scanning Probe Microscopy and Spectroscopy: Theory, Techniques, and Applications ï 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 ï 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. Nano synthesis: 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: Bulk vs Nano: elementary mechanical, electrical and magnetic properties, Physical, Ferroelectric and dielectric properties, Metal Nano-Clusters, Semi conducting Nano-Particles,

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.

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 issuesô, *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 ï 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-613: POLYMER AND BIO-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 distill and purify Pyrrole and Aniline
2. Functionalization of CNTs
3. Synthesis of Polypyrole conducting polymer
4. Synthesis of Polyaniline conducting polymer
5. Characterization of Polyaniline by FTIR Spectroscopy
6. Characterization of Polypyrole by UV Spectroscopy
7. Synthesis of PPy-CNT composite materials
8. Synthesis of PANI-CNT composite material
9. Synthesis of Ag and Au nanoparticles using biological agents
10. Synthesis of Cu and Zn nanoparticles using bacterial reduction

Note: At least 7 experiments shall be conducted out of the above list.

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

MSN-615: SIMULATION AND COMPUTATION LABORATORY

			Sessional	**:**	**50 Marks**
			Exam	**:**	**50 Marks**
L	**T**	**P**	**Total**	**:**	**100 Marks**
-	**-**	**4**	**Duration of exam**	**:**	**6 hrs**

List of Experiments:

1. Excel calculations for Materials
2. Origin calculations for Materials
3. Monte Carlo calculations
    a. Pi calculation
    b. Precipitation simulation in alloy solutions
4. ImageJ analysis of SEM images
5. ImageJ analysis of HRTEM images in Materials Science
6. ImageJ analysis of area calculations in Materials Science
7. Curve-fitting techniques for Materials Science
8. SciLab calculations for Materials Science
9. Phase diagram simulation for completely miscible elements
10. Crystal structure simulation for pure and compound materials
11. Crystal (single and powder) X-ray diffraction simulation and analysis

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. Programme in Materials Science and Nanotechnology

SCHEME OF STUDIES & EXAMINATIONS

SEMESTER-II

S. No.	Course No.	Course Title	Teaching Schedule			Marks			Credits	Duration of Exam (hr)
			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-	ELECTIVE-I	4	0	-	50	100	150	4	3
6	MSN-610	Presentation and Communication Skills	0	0	0	0	0	0	0*	1
7	MSN-614	Mechanical and Electrical Materials Lab	0	0	2	50	50	100	2	3
8	MSN-616	Characterization Techniques Lab	0	0	2	50	50	100	2	3
	Total		**20**	**0**	**4**	**350**	**600**	**950**	**24**	

ELECTIVES:

1. MSN-624 Transport phenomena in materials
2. MSN-626 Study of novel and smart materials
3. MSN-628 Physics of Amorphous Material
4. **MSN-630 Materials for Energy and Environment**

*Audit Pass / Audit Fail – Qualifying Examination

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.**
2. **MSN-614, MSN-616 and MSN-630 are applicable from Session 2015-16**
3. The electives shall be offered by the department according to the expertise available.

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:
Extraction of Metals ï Fe, Al, Au and Cu; Techniques of extraction of metals from ores
Synthesis of Ceramics: Metal oxides/nitrides/ferrites, Glasses, Semiconductors, Aluminosilicates
Synthesis of Polymers: Chain Reaction Polymerization, Coordination Polymerization,
Step Reaction Polymerization; *Fabrication Techniques*: Foam Processing, Film-Forming Processes, Composites, Extrusion, Molding and Coatings.

UNIT II: General Synthesis Techniques:
Solid State Synthesis Methods; Melting and solidification; Microwave Synthesis; Sol-Gel Methods; Precursor Methods; Hydrothermal Methods; PVD; CVD (chemical vapor deposition); Chemical Vapour Transport; Lithography

UNIT III: High Strength Materialsô Synthesis:- Diamond thin films, Carbon fibers, high-strength steels, Ni and Ti alloys.
Electronic Materialsô Synthesis: Elemental, doped and compound semiconductors; MOSFET.
Catalysts in the Synthesis of Materials

UNIT IV: Materials for Environmental Monitoring and Control; Synthesis of Biomaterials; Synthesis of Nanomaterials; Synthesis of Materials for Optical Applications; Synthesis of Single Crystals

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 ï 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 ï A Practical Guide, U. Schubert, N. Husing and R.M. Laine, Springer Verlag.

Notes:

1. Eight (8) questions are to be set ï 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 ï 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 ï 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 ï 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, Nernsts heat theorem, Phase rule, Phase diagram calculations, single phase system and binary systems using example of Lead-silver system.

UNIT II: Importance of thermodynamics in materials science: Laws of thermodynamics; Second law of thermodynamics, Entropy of second law of thermodynamics, Entropy and disorder, thermodynamics potentials and the reciprocity relations, Chemical potential, Joule Thomson effect, carnotôs theorem, Clapeyron-Clausius equation.

UNIT III: Thermodynamics of Surfaces and Interfaces: Surface energy, surface tension, mean free path, viscosity, heat conduction, Wiedemann and Franz law, Brownian motion, Radiation and Thermodynamics, Radiation pressure, Kirchoffôs law.

UNIT IV: Statistical distribution functions; Classical Statistics, Fermi-Dirac statistics, Bose-Einstein statistics; Properties of Materials: Specific heat - Debye and Einstein models, heat capacity, free electrons in a metal, thermal expansion, thermal conduction.

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 Eastern Pvt. Ltd., N. Delhi.
2. Introduction to Metallurgical Thermodynamics ï Gaskell, David R, McGraw Hill.
3. Introduction to Materials Science and Engineering - Kenneth M. Ralls, Thomas H. Courtney and John Wulff, Wiley Eastern Ltd.
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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 ï C.H.P Lupis, Elsevier Science Ltd.
13. Chemical and Metallurgical Thermodynamics ï K.K. Prasad, New Age Publishers.

Notes:

1. Eight (8) questions are to be set ï 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 -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: Polymers: Types of polymeric materials and their structures, Classification and mechanism of polymerization reactions. preparation, properties and uses of PVC, PVA, PMMA, Nylon, PET, Bakelite, and urea formaldehyde resin. Average molecular weight concept; Elastomers ï structure of natural rubber, vulcanization, synthetic rubber (Buna-s, Butyl rubber and Neoprene).

UNIT II: Thermoplastic and thermosetting polymers. Strengthening mechanism; Properties of textile Fibres with example of nylon-6 and nylon -66. Glass transition temperature and its importance, Conducting polymers- introduction, classification, preparation and properties, carbon substrate-conducting polymer nanocomposite.

UNIT III: 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. **Properties in Service Environments :** Effects of vapours and solvents on polymeric materials. Oxidation and thermal degradation of polymers. Biodegrable plastics.

TEXT/REFERENCE BOOKS:

1. The Plastic Engineer's Data Book ï 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 ï 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.

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 614: MECHANICAL AND ELECTRICAL PROPERTIES 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. Powder compaction and porosity reduction by Pellet press
2. Synthesis of metallic alloys / composites using induction melting
3. Hardness vs heat treatment of metals and Alloys
4. Tensile and Compression tests for stress and strain behavior of materials
5. Ball milling of metal oxide powders
6. Ball milling of composite powders
7. AC impedance measurements of materials ï Rare Earth doped oxides (Nd and Y)
8. DC resistivity measurements of materials ï Rare Earth doped oxides (Nd and Y)
9. AC impedance measurement Noble metals doped silica
10. Metallographic etching of Aluminum / other metals and alloys
11. Generation of Hydrophobic surfaces by coating technique
12. Generation of Hydrophilic surfaces by coating technique

Note:

At least 7 experiments shall be conducted out of the list.

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

MSN 616: CHARACTERIZATION TECHNIQUES LABORATORY

L	T	P
0	0	4

Internal	**:**	**50 Marks**
Final Exam	**:**	**50 Marks**
Total	**:**	**100 Marks**
Duration of exam	**:**	**6 Hrs.**

List of Experiments:

1. X-Ray Diffraction ï powder diffraction analysis
2. FTIR Spectroscopyï functional group determination
3. The application of UV-Visible Spectroscopy to Oxides/polymeric materials
4. To measure thermal behavior of nanoparticles by DTA
5. To measure thermal behavior of PANI and PANI composites by TGA
6. To measure thermal behavior of phase change materials by DSC
7. AC impedance analysis of doped silica
8. AC impedance analysis of nanoferrites
9. AC impedance analysis of amorphous materials
10. DC Resistivity analysis of nanocomposite materials
11. SEM/TEM/AFM characterization of Nanomaterials

Note:

At least 7 experiments shall be conducted out of the list.

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.

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 ï 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.

UNIT II: Superconductivity and Superconducting Materials: Superconductivity Phenomenona, properties of superconductors, Meissner effect, Critical magnetic field & critical temperature. Types of superconductors Type I & II superconductors, Silsbee rule.BCS theory, Debye temperature. London's & Glag theories, High temperature superconductors and its application.

UNIT III: Fabrication: Novel synthesis 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 ï 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 ï 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-630: MATERIALS FOR ENERGY AND ENVIRONMENT

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

Unit I:

Energy and the environment; Nonrenewable energy sources; Renewable energy sources; Waste to energy.

Environmental sensing and monitoring; Environmental remediation - Carbon capture and reduction, water purification.

Unit II:

Energy Generation and Storage: Electrochemical methods ï batteries, fuel cells and ultracapacitors; Solar fuel - Photovoltaic and solar thermal methods; Physico-chemical methods - Hydrogen storage; Nuclear fuels

Energy Efficiency: Lighting, Energy efficient buildings, Insulation science, Green processing ï catalysis, Recycling of materials

Unit III:

Structure of Ion Exchangers, Ion Conductors, Catalysts, and Permeable Materials

Synthesis Methods of Catalyst Adsorbents, Ion Exchangers, and Permeable Materials

Unit IV:

Case studies in Adsorption in Nanoporous Materials, Membranes, and Ion Exchange.

Basics of Solid-State Electrochemistry, Heterogeneous Catalysis and Surface Reactions.

References:

1. Fundamentals of Materials for Energy and Environmental Sustainability, Eds. David S. Ginley and David Cahen, Cambridge University Press and MRS, 2012, ISBN 978-1-107-00023-0.
2. The physical chemistry of materials: energy and environmental applications, by Rolando M.A. Roque-Malherbe., CRC Press, Taylor and Francis, 2010, ISBN 978-1-4200-8272-2.
3. Green Materials for Energy, Products and Depollution, Series: Environmental Chemistry for a Sustainable World, Vol. 3, Lichtfouse, Eric, Schwarzbauer, Jan, Robert, Didier (Eds.) 2014, ISBN 978-94-007-6836-9
4. Nanoporous Materials for Energy and the Environment, Ed. Gilbert Rios, Gabriele Centi and Nick Kanellopoulos, Pan Stanford Publishing Pte. Ltd., 2012, ISBN 978-981-4267-17-5.

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 (hr)
			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
5	MSN-707	Seminar	0	0	2	50	50	100	2	1
6	MSN-709	Minor Dissertation	0	0	4	-	100	100	4	1
3	MSN-711	Electronic and Optical Materials Lab	0	0	2	50	50	100	2	3
4	MSN-713	Thin Films Lab	0	0	2	50	50	100	2	3
7	MSN-	ELECTIVE-I	4	0	0	50	100	150	4	3
	Total		**12**	**0**	**10**	**300**	**550**	**850**	**22**	

ELECTIVES:

1. MSN-721 Degradation of materials
2. MSN-723 Thin film technologies
3. MSN-725 Advanced Materials Science – II
4. **MSN-727 Advanced Electronics**
5. **MSN-729 Mechanical Behaviour of Materials**

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.**
2. **MSN-711, MSN-713, MSN-727 and MSN-729 are applicable from Session 2015-16**
3. The electives shall be offered by the department according to the expertise available

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, Semiconductor devices to Single electron Transistors, Micro fluidics and their Applications, Materials for Micro fluidic devices, active and smart passive Micro fluidics devices,.

UNIT-II Micro/Nanofabrication Techniques: Thin films and lithography, Stamping techniques for Micro and Nanofabrication**, Assembly** and characterization of sensors; Packaging & Reliability.

UNIT-III Micro and Nano-sensors: Fundamentals of sensors, Temperature Sensors, Smoke Sensors, humidity sensor, 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, DNA and its potential applications in molecular electronics, Lab-on-a-chip for Biochemical analysis.

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. ñIntroduction to Nanotechnologyò, 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 ï uniformly distributed over the entire content of the course syllabus. Students shall have to attempt any five (5) of those questions.

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, dielectric polarization, dielectric constant and displacement vector, atomic and molecular polarization, Clausius -Mosotti equation, dipolar Polarizability, mechanism of polarization, factors affecting polarization, ionic polarizability, electronic polarizability, ferroelectricity.

UNIT II: Introduction to magnetic materials: Laws of magnetic materials. Domain theory, diamagnetism classical theory, diamagnetism quantum theory, Magnetic anisotropy. Paramagnetism, ferromagnetism-quantum theory, antiferromagnetic susceptibility above neel temperature, 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 ï 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 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)

L	T	P
4	0	0

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.

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

MSN 711: ELECTRONIC AND OPTICAL MATERIALS LABORATORY

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

List of Experiments:

1. Synthesis and characterization of Nanoferrites ($FeFe_2O_4$) by Chemical co-precipitation method.
2. Synthesis and characterization of Nanoferrites ($CoFe_2O_4$) by hydrothermal method
3. Synthesis and characterization of Doped Nanoferrites by Sol-Gel method
4. Synthesis and characterization of nano-TiO_2 /ZnO for photocatalytic applications
5. Synthesis and characterization of $BaTiO_3$ by Sol-gel method
6. Synthesis and characterization of Rare-Earth doped silica (Eu)
7. Synthesis and characterization of Rare-Earth doped silica (Ce)
8. Synthesis and characterization of Noble metal doped silica (Cu)
9. Synthesis and characterization of Noble metal doped silica (Ag)
10. Synthesis and Characterization of PPy-CO-PANI-CNT hybrid composite material

Note:

At least 7 experiments shall be conducted out of the list.

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

MSN 713: THIN FILMS LABORATORY

L	T	P
0	0	4

Credits: 4

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

List of Experiments:

1. Spin coating of polymer thin film (Polyaniline)
2. Spin coating of polymer thin film (Polypyrole)
3. Spin coating of metal-oxide thin film (Silica sol / gel)
4. Spin coating of metal-oxide thin film (Nanoferrites sol / gel)
5. Dip coating of polymer thin film (Polypyrole)
6. Dip coating of polymer thin film (Polyaniline)
7. Dip coating of metal-oxide thin film (Doped Silica)
8. Dip coating of metal-oxide thin film (Nanoferrites)
9. Single layer thin film deposition of stearic acid by LB Method
10. Single layer thin film deposition of Cobalt stearate by LB Method
11. Hydrophobic thin films of nano-silica

Note:

At least 7 experiments shall be conducted out of the list.

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

MSN-723: THIN FILM TECHNOLOGIES

L	T	P
4	0	0

Credits: 4

Internal Marks: 50
External Marks: 100
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 ï 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 ï 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

Credits: 4

Internal Marks: 50
External Marks: 100
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, Pockelôs 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 ï 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-727: Advanced Electronics

L	T	P
4	0	0

Credits: 4

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

UNIT-1

Basics of Nano-electronics

Silicon Electronics: Historical development- Silicon era, Mooreôs Law-Limit of smallness, Limitation of Silicon based Technology, Semiconductors, Transistors, Integrated circuits, and their fabrications, Bipolar Junction transistor (BJT), Types of Field effect transistor-Junction field effect transistor (JFET)-working principle and importance of JFET, Metal oxide semiconductor field effect transistor (MOSFET), Power (Large scale low frequency) Amplifiers, Binary Counters.

UNIT-2

Nanostructures and Nanomaterials for Electronics Devices:

Resonant Tunneling Diode**;** Operating Principle and Technology; Modulation and demodulation, Multivibrators; Switching action of a transistor, Single Electron Transistor; Operating Principle and Technology with its Applications, Carbon based electronics; DeMorganôs theorems-operator precedence, logic gates, Nano-MOSFET and Nano-FET

UNIT-3

Application of Nanoelectronics

Sensors- fundamentals and their types, Issues with traditional materials in sensing technology, Novel functional nanomaterials (Metal oxides and mesoporous materials) for advanced Chemical/Gas/VOC/Humidity sensors.
Data storage:- principles, hard disk drives and magneto-optical disks. Nano-ferroelectrics.

Unit-4

Organic Electronic Materials and Devices- Super conducting and conducting organic materials like Polyaniline, polyacetylene and polypyrrol and its applications viz: energy storage, sensor and actuators, EMI shielding, Photovoltaics etc. Organic-Inorganic Hybrid Materials, Fluorescent dyes (Preliminary treatment), Organic Light emitting diodes (OLEDs)

References

1. Electronic Materials Science, Eugene A. Irene, Wiley
2. Electronics Technology Handbook, Neil Sclater, Mcgraw-Hill
3. Handbook Of Nanoscale Optics And Electronics, Gary P. Wiederrecht, Elsevier
4. Molecular Electronics Materials, Devices And Applications, Antoine Jalabert, Springer

5. Nanoelectronics: Nanowires, Molecular Electronics And Nanodevices, Krzysztof Iniewski, Mcgraw-Hill
6. Nanophysics And Nanotechnology, Edward L. Wolf, Wiley-Vchverlag
7. Introduction to Optoelectronic Materials, *N. Peyghambarian and M. Fallahi*
8. Molecular Semiconductors for Organic Field-Effect Transistors, *A. Facchetti* Polymer Field-Effect Transistors, *H.G.O. Sandberg*
9. Organic Molecular Light-Emitting Materials and Devices, *F. So and J. Shi*
10. Organic and Polymeric Photovoltaic Materials and Devices, *S.-S. Sun and C. Zhang*

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

MSN – 729: MECHANICAL BEHAVIOUR OF MATERIALS

L	T	P
4	0	0

Credits: 4

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

UNIT I: Mechanical Characterization
Definitions: Elastic Behaviour, Plastic Behaviour
Anelastic and Visco-elastic behaviour;
Stress-Strain Tensors;
Hardness Testing; Creep Testing, Tensile Testing, Fatigue Testing, Fracture Testing, Impact Testing
Microstructural Characterization: X-Ray Diffraction, SEM, Transmission Electron Microscopy, NDT

UNIT II: Mechanical Response Strength, Tensile Ductility; Work Hardening; Strain Rate Sensitivity; Localized Deformation; Cryogenic Behaviour; Creep and Superplasticity; Fatigue and Fracture Behaviour; Corrosion Behaviour

UNIT III: Mechanical Deformation Mechanisms
Plastic deformation: Dislocation and Diffusion Mechanisms, Twinning Mechanism
Fracture: Ductile and Brittle Fracture, Fracture Mechanics, Ductile to Brittle Transition
Fatigue: Analytical methods, Crack initiation and propagation
Creep: Analytical methods
Corrosion: Corrosion of metals, Galvanic Series, Classes of Corrosion Mechanisms, Corrosion of Ceramics, Degradation of Polymers

UNIT IV: Strengthening Mechanisms
Grain boundary strengthening; Yield-point phenomenon; Strain ageing; Solid-solution strengthening; Strengthening from second phase particles; Martensitic strengthening; Strain hardening or cold working; Bauschinger effect; Preferred orientation (texture)
Selection of Corrosion Resistant Alloys; Prevention of Galvanic Corrosion; Prevention of Deposition Corrosion; Prevention of Crevice Corrosion; Prevention of Stress Corrosion; Stress Corrosion Resistant Tempers; Corrosion Inhibitors; Cathodic Protection

TEXT/REFERENCE BOOKS:

1. Mechanical Behaviour of Material - Englewood Cliffs, Prentice Hall, New Jersey, 1993
2. N.E. Dowling: Mechanical Behavior of Materials, 2nd Edition, Prentice Hall, 1999.
3. K. Bowman, Mechanical Behavior of Materials, John Wiley, 2003
4. M.F. Ashby Materials Selection in Mechanical Design, Butterworth-Heinemann, 1999

5. I M Ward : ñMechanical properties of solid polymersò, Wiley Interscience, 2nd Edition
6. Mechanical Behaviour of Material - Courtney Browne, McGraw Hill, 1990
7. Introduction to Fracture Mechanics - Kare Hellan, McGraw Hill.
8. Introduction to Fracture Mechanics - David Brookes.
9. The Nature and Properties of Engineering Materials - Binges D.Jastrzebski, 3rd ed. John Wiley & Sons.
10. Theory of Dislocations, McGraw Hill - J. P. Hirth and J. Lothe.
11. *Mechanical Behavior of Materials* ï Courtney, 2nd ed. Long Grove, IL: Waveland Press Inc., 2005.
12. *Mechanical Metallurgy* - Dieter, G. E. . New York, NY: McGraw-Hill, 1986.
13. *A Treatise on the Mathematical Theory of Elasticity* - Love, A. E. H.New York, NY: Dover Publications, 1927.
14. *Physical Properties of Crystals: Their Representation by Tensors and Matrices* - Nye, J. F., New York, NY: Oxford University Press, 1985.
15. *Introduction to Dislocations* - Bacon, D. J., and D. Hull, New York, NY: Pergamon Press, 1984.
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 ï 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