Revised Scheme of

M. Tech Nano Science & Technology

w.e.f. 2018-19

Department of Bio & Nano Technology
Guru Jambheshwar University of Science & Technology, Hisar-125 001, Haryana

REVISED SCHEME OF M. Tech (NANO SCIENCE & TECHNOLOGY) w.e.f 2018-19 Batch

Program core (PC)	Program Elective (PE)	Open Elective (OE)	Total Credit
68	6	3	77

FIRST SEMESTER

Sr. No.	Course No.	Title	L	T	P	Credits
1	MNL-701	Introduction to Biotechnology & Nanotechnology	4	0	0	4
2	MNL -702	Bionanotechnology-An Introduction	4	0	0	4
3	MNL -703	Physics & Chemistry of Solids	4	0	0	4
4	MNL-704	Quantum & Statistical Mechanics	4	0	0	4
5	MNP-705	(Lab-I Basic Techniques in Bionanotechnology)	0	0	8	4
6.		Audit Course- I	2			NC
		Total	18	0	8	20

SECOND SEMESTER

Sr. No.	Course No.	Title	L	T	P	Credits
1	MNL -711	Carbon based Nanostructures & Thin Films	3	0	0	3
2	MNL -712	Nanomaterials- Synthesis, Properties & Applications	4	0	0	4
3	MNL -713	Instrumentation Techniques for Nanotechnology	4	0	0	4
4	MNL -714	Nanoparticles in Microorganisms & Biosystems	3	0	0	3
5	MNP-715	(Lab-II Nanomaterials/ CNT & Thin Films)	0	0	8	4
6	MNP-716	(Lab-III Advanced Instrumentation Techniques)	0	0	8	4
7		Audit Course- II	2			NC
Total			16	0	16	22

THIRD SEMESTER

Sr. No.	Course No.	Title	L	T	P	Credits
1	MNL – 721 to 724	*Program Elective-I	3	0	0	3
2	MNL – 721 to 724	*Program Elective-II	3	0	0	3
3	MNL -725	MEMS & NEMS – Sensors & Devices	3	0	0	3
4	MNP-726	(Lab-IV Applied Nanotechnology)	0	0	8	4
5	MNS -791	Credit Seminar	1	0	0	1
	OPEN ELECTIVE	Open elective offered by other department	3	0	0	3
Total			13	0	8	17

*For each of the Program Elective courses I and II Student can opt for any two out of the five courses including MOOC

FOURTH SEMESTER

Sr. No.	Course No.	Title	L	P	Credits
1	MND -800	Thesis	0	18	18

Program Elective-I	Program Elective-II
MNL- 721 Bionanostructures-Applications & Perspectives	MNL-723 Nano Composites
MNL-722 Environmental Nanotechnology & IPR	MNL-724 Nanomedicine and Drug Delivery
	MOOC Online Course as per list on SWAYAM

Total # of Credits- 77

Note: *Program Elective courses

1. The minimum credit requirement for the M. Tech. degree in Nano Science & Technology in the Department of Bio & Nano Technology will be 77 credits inclusive of the 6 credits for Program Elective courses including MOOC and 3 credits for open elective.
2. As per MHRD guidelines, all students can opt one online course from list of courses available on SWAYAM in 3rd semester in Program elective II which will be notified by the department.
3. Among the Program Electives Courses I and II Student can opt for any one out of the two/three courses offered in 3rd Semester.
4. For theory courses, one hour per week per semester is assigned as one credit. For practical courses Eight hours per week accounts for 4 credits.
5. Each theory paper examination will be of 3 hours duration and practical examination will be of 4-6 hours duration.
6. Thesis (MND-800) will start in fourth semester and will be of 18 credits in all and the grades of thesis will be submitted as marks.
7. In the third semester, each student has to deliver one credit seminar of 1 credit and it will be evaluated internally by the seminar incharge.
8. Audit Courses Non-credit (2+0+0) will be offered in Sem-1 and Sem-2: Every student has to undertaken one course in each semester out the given below courses:

Semester-I

i) AC01: English for Research Paper Writing
ii) AC02: Disaster Management
iii) AC07: Stress management by YOGA
iv) AC04: Value Education

Semester-II

v) AC03: Sanskrit for Technical Knowledge
vi) AC05: Constitution of India
vii) AC06: Pedagogy studies
viii) AC08: Personality Development through Life Enlightening skills

Open Electives for other departments:

i) MNL-751 Basic Nanotechnology (3+0)
ii) MNL-725 MEMS & NEMS – Sensors & Devices (3+0)

MNL-701 Introduction to Biotechnology & Nanotechnology **MM: 70**
(Credits: 4+0) **Internal: 30**
Time: 3 Hour

Note: Nine questions will be set by the examiner, two from each unit and one compulsory question of short/ objective type questions covering entire syllabus. Students will have to attempt five questions in all selecting at least one question from each unit including the compulsory question.

Unit-1

Biotechnology: An Overview-definition, scope and importance of Biotechnology, Concept of Recombinant DNA technology and Gene Cloning, Tools of Recombinant DNA Technology-Restriction enzymes, vectors etc.

Microbial Biotechnology: Brief history, Important group of microorganisms, Bacterial Growth and culturing of microbes, Control of microorganisms by physical & chemical agents, Antibiotics & chemotherapeutic agents, A brief account of microbes in industry and agriculture.

Unit-2

Nano Science & Technology: An Overview, Insights and intervention into the Nano world, Historical Developments, Societal implications & Ethical issues in Nanotechnology, Applications of Nanotechnology in different areas of Food, Agriculture, Automobiles, IT, Cosmetics & Consumer products, Textile and Medical Sciences.

Unit-3

Plant Biotechnology: Transgenic Plants, Biotechnology & Genomics, Principles of DNA sequencing, Automated DNA sequencing, DNA Chip Technology and Microarray Technology, Methods and applications of Genomics and Proteomics Research.

Unit-4

Animal Biotechnology: Transgenic Animals, Immuno-technology and Immunoglobulins, Antigens and antigenicity, Cells of Immune system, Active and passive Immunity, Adjuvants, Hybridoma technology and Monoclonal antibodies. Techniques in Immunology-ELISA, RIA, Immuno-Diffusion, Immuno- Electrophoresis.

Medical Biotechnology: Biotechnology in medicine, Nano Medicine & Drug Delivery, Vaccines, Diagnostic, Forensic, Gene therapy, Cell & Tissue Engineering, Stem Cell therapy

Books/ References:

1. Tizard I.R. (2013). Immunology- An introduction, 5th Edition, Philadelphia Saunders College press.
2. Bhushan, Bharat (Ed.) (2012). Encyclopedia of Nanotechnology. Springer.
3. Jain, K. K. (2012). The Handbook of Nanomedicine. Springer
4. Gupta P.K. (2010). Biotechnology & Genomics, 5th Reprint, Rastogi Publications Meerut.
5. Singh B.D. (2010). Biotechnology, 4th edition, Kalyani Publication.
6. Black J.G (2008). Microbiology- Principles and Explorations, 7th edition, John Wiley & Sons.
7. Kuby J. (2006). Immunology, 6th Edition, W.H. Freeman & Co., New York.
8. 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.

MNL -702 Bionanotechnology-An Introduction **MM: 70**
(Credits: 4+0) **Internal: 30**
Time: 3 Hour

Note: Nine questions will be set by the examiner, two from each unit and one compulsory question of short/ objective type questions covering entire syllabus. Students will have to attempt five questions in all selecting at least one question from each unit including the compulsory question.

Unit-1

Bionanotechnology – An Overview: What can engineers learn from biology? From biotechnology to Bionanotechnology, Bionanomachines in action. Molecular recognition.

Biophysics: Bioelectromagnetism, bioenergetics, biomechanics, Neuro transport, Biological Rhythms.

Unit-2

Modern Biomaterials: Proteins, Nucleic acids, Lipids, Polysaccharides; Polymeric, Ceramic & metallic biomaterials- classes, properties and applications; Biological testing of biomaterials; hydrogels, hip joints, bone cement, orthopedic implants, dental implants, tissue adhesives etc.

Unit-3

Biomolecular Design and Biotechnology: Molecular Modeling and Biomolecular structure determination.

Structural Principles of Bionanotechnology: Natural Bionano-machinery, Hierarchical strategy, raw materials, Protein folding, self assembly and self- organization, molecular recognition and flexibility.

Unit-4

Functional Principles of Bionanotechnology: Information driven Nano assembly, Energetics, chemical transformation, regulation. Biomolecular motors, Biomolecular sensing, self replication and machine - phase bionanotechnology.

Bionanotechnology Today and Future: Basic capabilities, Nanomedicine today, DNA computers, hybrid materials, artificial life and biosensors.

Books/ References:

1. Jain, K. K. (2012). The Handbook of Nanomedicine. Springer
2. Bhushan, Bharat (Ed.) (2012). Encyclopedia of Nanotechnology. Springer.
3. Sharon, M. & Sharon, M (2012) Bio-Nanotechnology- Concepts and Applications, CRC Press.
4. David E. Reisner (2011) Bionanotechnology II- Global Prospects, CRC Press.
5. Endo, Isao; Nagamune, Teruyuki (Eds.) (2010). Nano/Micro Biotechnology. Springer.
6. David E. Reisner (2008) Bionanotechnology- Global Prospects, CRC Press.
7. Niemeyer C.M. & Mirkin, C.A. (2004). Nanobiotechnology- Concepts, Applications and Perspectives, Wiley-VCH Verlag.
8. Goodsell, David S. (2004). Bionanotechnology- Lessons from Nature. John Wiley & Sons, INC., Publication.

9. Avouris, P., Klitzing, K. Von, Sakaki H. & Wiesendanger, R. (2003). Nano Science and Technology Series. Springer.
10. Pattabhi,V & Gautham, N. (2002). Biophysics. Narosa Publications.
11. Hench L.L, Ethridge, E.C. (2007) Biomaterials- An Interfacial Approach, Academic Press.

MNL-703 Physics and Chemistry of Solids **MM: 70**
(Credits: 4+0) **Internal: 30**
Time: 3 Hour

Note: Nine questions will be set by the examiner, two from each unit and one compulsory question of short/ objective type questions covering entire syllabus. Students will have to attempt five questions in all selecting at least one question from each unit including the compulsory question.

Unit-1

Chemical Bonding and PN Junctions: Amorphous and crystalline materials, polycrystals, symmetry, Unit Cells, Crystal Structures. Atomic Bonding in solids, Types of bond: Metallic, Ionic, Covalent and Van der Waals bond; Hybridisation; H- bonding, Molecular orbital theory for simple molecules, Physics of Semiconductor materials, Drift velocity, Mobility, Scattering, Diffusion current, Band model, Fabrication of pn junctions, Step junction, linearly graded junction, Use of Junction diode as a rectifier, Zener Diode, Tunnel Diode, Varactor Diode, MOSFETs

Unit-2

Types of Material: Different types of materials: Metals, Semiconductors, Composite materials, Ceramics, Polymers, polymer applications, frontiers of polymer materials (biogradable polymers, biomedical polymers, conducting polymers, magnetic polymers, polymers for space, nonlinear optical polymers), problems of polymer (thermoxidative degradation, fire hazards, toxicity, effluent disposal, feedstock scarcity), Superconductors, meissner effect, origin of superconductivity BCS theory of superconductivity, Type –I and Type II superconductors, Josephson effect, High Temperature Superconductors.

Unit-3

Imperfections in solids and Electrochemistry: Imperfections of crystal structure: point defects, Grain boundaries, phase boundaries, Dislocations Screw, Edge and Mixed Dislocations. Electrochemical cell, Electrolysis, Fundamental equations: Nernst equation, Fick's law of diffusion, Faraday's Law, Cyclic Voltammetry, Solid Electrode Materials, Ultramicroelectrodes, Chemically modified electrodes.

Unit-4

Green Synthesis Strategies: Basic principles of green chemistry, High-yield and zero-waste chemical processes: Microwave synthesis, electro-organic synthesis, the design and development of environmentally friendly chemical pathways: challenges and opportunities. Materials for green chemistry and technology: Catalysis, environmental friendly catalysts, Bio-catalysis, biodegradable polymers, alternative solvents, ionic liquids. Applications of green chemistry.

Books/ References:

1. Schlaad, H (2013). Bio-synthetic Polymer Conjugates, Springer.
2. Gazit, E, Nussinov, R. (Eds.) (2008). Nanostructure Design Methods and Protocols. Springer.

3. Kalia, S; Kaith, B. S. & Kaur Inderjeet (Eds.) (2011). Cellulose Fibers: Bio- and Nano-Polymer Composites, Green Chemistry and Technology, Springer.
4. William D. C. (Jr). (2007). Materials Science & Engineering: An Introduction, 7th edition, Wiley.
5. McKelvey, J.P. (1966). Introduction to Solid State and Semiconductor Physics, Harper and Row and John Weathe Hill.
6. Sze, S.M. 1981. Physics of Semiconductor Devices, 2nd edition, John Wiley.
7. Green Reaction Media in Organic Synthesis by Mikami Koichi Wiley-Blackwell, 2005
8. Koichi Tanaka Solvent-free Organic Synthesis Green chemistry Wiley-VCH; 2003
9. Stanley E. M. (2005) Green Chemistry and the Ten Commandments of Sustainability, ChemChar
10. R. A. Sheldon, Isabel Arends, and Ulf Hanefeld. (2007) Green Chemistry and Catalysis.Wiley VCH.
11. C. P. Pool, Jr., H. A. Farach and R. J. Creswick (1995) Superconductivity, Academic Press.
12. J. Kahovec, I.Meisel, C.S.Kniep (2001) Polymers in Medicine Wiley VCH.
13. K. Holmberg, B. Jonsson, B. Kronberg, B. Lindman,(2004) Surfactants and Polymers in Aqueous Solution, Wiley.
14. C.G. Zoski (2007) Handbook of Electrochemistry, Elsevier.

MNL-704 Quantum & Statistical Mechanics **MM: 70**
(Credits: 4+0) **Internal: 30**
Time: 3 Hour

Note: Nine questions will be set by the examiner, two from each unit and one compulsory question of short/ objective type questions covering entire syllabus. Students will have to attempt five questions in all selecting at least one question from each unit including the compulsory question.

Unit-1

Introduction to Quantum Mechanics: Failures of Classical Mechanics; Brief discussion of general ideas such as "Wave particle duality", uncertainty principle, superposition principle etc.; solutions to Schrödinger Equation for 1-D and 3-D square wells and potential barriers, H-atom.

Unit-2

Matrix Mechanics: Operators, change of basis, Eigen values and Eigen vectors; Simultaneous Eigenvectors, Harmonic oscillator in matrix mechanics; Exchange operator and identical particles.

Angular Momentum: Introduction to angular momentum operators; Eigen values and eigenvectors of L^2, L_2 Spin and J^2 and J_2

Unit-3

Scattering Theory: Scattering Cross-section and scattering amplitude, partial wave analysis, born approximation and its application to simple potentials. Introduction to Non-Degenerate and degenerate perturbations theory.

Unit-4

Ensembles Theory and Quantum Statistics: Concept of microstate and macrostate**,** Different types of ensembles**,** The microcanonical ensemble theory and its application to ideal gas of monatomic particles; The canonical ensemble and its thermodynamics; Partition function, energy fluctuations, equipartition; A system of harmonic oscillators as canonical ensemble; The grand canonical ensemble and significance of statistical quantities. Basic concepts and thermodynamic behavior of an ideal Bose gas, Bose-Einstein condensation, Pauli paramagnetism, heat capacity of a free-electron gas at low temperatures.

Suggested readings:

1. Khanna, M.P. 1966.Quantum Mechanics. Har Anand, New Delhi.
2. Sakurai, J.J. & Jim Napolitano (2011) Modern Quantum Mechanics, Addison Wesley.
3. Schiff, L.I. (1968) Quantum Mechanics, 3rd Edition, McGraw Hill, NY.
4. Loknathan, S & Ghatak, A.(2004) Quantum Mechanics, Kluwer Academic.
5. Merzbacher, E.(1998) Introduction to Quantum Mechanics, 3rd edition, John Wiley, NY.
9. Pathria, R.K. & P.D. Beale (2011). Statistical Mechanics, Reprint Elseivier.
10. Davidson, N (2003) Statistical Mechanics, Dover Publications, NY.

MNL-711 Carbon based Nanostructures & Thin Films **MM: 70**
(Credits: 3+0) **Internal: 30**
Time: 3 Hour

Note: Nine questions will be set by the examiner, two from each unit and one compulsory question of short/ objective type questions covering entire syllabus. Students will have to attempt five questions in all selecting at least one question from each unit including the compulsory question.

Unit-1

Introduction: Different Allotropes of carbon, Introduction to CNTs, Historical developments, Structure Of CNTs, Types of CNTs- SWNTs, MWNTs, Buckyballs, Graphene.

Applications of Carbon Nanotubes and Graphene: Field emission, Fuel Cells, Display devices, CNTs- Role in Healthcare, CNT based chemical & biological sensors, Graphene as sensing material, Automobile, composite materials, space elevators, Electron and Probe microscopy, Nanotweezers, nanogears etc.

Unit-2

Synthesis of Carbon Nano-Tubes and Graphene: Different methods of synthesis of CNTs: laser ablation, carbon arc method, Chemical vapor deposition, Electrodeposition, Flame synthesis etc, fullerenes its synthesis and applications. Properties of Carbon Nanotubes: Physical, Thermal, Electrical, Optical, Mechanical, Vibrational properties etc. Synthesis strategies for graphene, Improved Hummer's method, Properties of graphene..

Unit-3

Functionalization and characterization of Carbon Nanotubes and Graphene: Functionalization of Carbon Nanotubes and graphene, Covalent Functionalization & Purification methods: Oxidation, Acid treatment, Annealing, Ultrasonication, Micro filtration, Ferromagnetic separation, Cutting, Functionalisation, and Chromatography techniques. Characterization Techniques.

Unit-4

Thin Films: Introduction to Thin Films, History, Types of Thin Films, Basic Concepts of deposition, Methods of deposition/ Methods of Preparation of Thin Films: CVD, Langmuir Blodgett Film deposition system, Spin coating, Dip coating, RF plasma, Electron Beam, Sputtering, Vacuum Deposition (Thermal Evaporation)system etc, Magnetic Thin Films, Applications of Thin Films.

Books/ References:

1. Ren, Zhifeng, Lan, Yucheng, Wang, Yang (2013) Aligned Carbon Nanotubes: Physics, Concepts, Fabrication and Devices. Springer.
2. Wonbong Choi, Jo Won Lee (2012) Graphene: Synthesis and Applications, CRC Press.
3. Lüth, Hans (2010) Solid Surfaces, Interfaces and Thin Films. Springer.
4. Gazit, Ehud; Nussinov, Ruth (Eds.) (2008). Nanostructure Design Methods and Protocols. Springer.
5. Anke Krueger (2010) Carbon Materials and Nanotechnology, Wiley – VCH Verlag, GmbH & Co. K GaA.
6. Kannan Balasubramanian and Marko Burghard (2010) Carbon nanotubes-Methods and protocol, Humana Press.
7. Dirk M. Guldi and Nazario Martín (2010) Carbon Nanotubes and Related Structures, Wiley – VCH Verlag, GmbH & Co. K GaA.
8. Kazuyoshi Tanaka, Tokio Yamabe and Kenichi Fukui (1999) The Science and Technology of Carbon Nanotubes, Elsevier Science Ltd.

9. Sie Chin Tjong(2009), Carbon Nanotube Reinforced Composites *Wiley – VCH Verlag, GmbH & Co*
10. Y. Gogotsi (2006) Nanotubes and Nanofibers , Taylor and Francis.
11. S. Carrarra (2011) Nano-Bio-Sensing, Springer.
12. D. Smith (1995) Thin Film Deposition: Principles and Practices, Mcgraw Hill.

MNL-712 Nanomaterials-Synthesis, Properties and Applications **MM: 70**
(Credits: 4+0) **Internal: 30**
Time: 3 Hour

Note: Nine questions will be set by the examiner, two from each unit and one compulsory question of short/ objective type questions covering entire syllabus. Students will have to attempt five questions in all selecting at least one question from each unit including the compulsory question.

Unit-1
Nanomaterials: Various classes, properties & applications, Semiconductor Nano particles – types, properties and applications

Unit-2
Physical Methods: Inert gas condensation, Arc discharge, RF-plasma, Plasma arc technique, Ion sputtering, Laser ablation, Laser pyrolysis, Ball Milling, Molecular beam epitaxy, Chemical vapour deposition method and other variants, Electrodeposition.

Unit-3
Chemical Methods: Metal nanocrystals by reduction, Solvothermal synthesis, Photochemical synthesis, Electrochemical synthesis, Nanocrystals of semiconductors and other materials by arrested precipitation, Thermolysis routes, Sonochemical routes, Liquid-liquid interface, Hybrid methods, Solvated metal atom dispersion, Post-synthetic size-selective processing. Sol- gel, Micelles and microemulsions, Cluster compounds. operational principle and application for analysis of nanomaterials, Principle of operation and application for band gap measurements, Magnetic and electrical measurements.

Unit-4
Biological Methods of Synthesis: Use of bacteria, fungi, Actinomycetes for nanoparticle synthesis, Magnetotactic bacteria for natural synthesis of magnetic nanoparticles; Mechanism of formation; Viruses as components for the formation of nanostructured materials; Synthesis process and application, Role of plants in nanoparticle synthesis

Lithographic Techniques: AFM based nanolithography and nanomanipulation, E beam lithography and SEM based nanolithography and nanomanipulation, Ion beam lithography, oxidation and metallization. Mask and its application. Deep UV lithography.

Books/ References:

1. Hari Singh Nalwa (2011) Encyclopedia of Nano Science &Nanotechnology, American Scientific Publishers.
2. Gazit, Ehud; Nussinov, Ruth (Eds.) 2008. Nanostructure Design Methods and Protocols. Springer.
3. Sakka, S. (Ed.) 2005. Handbook of Sol-Gel Science and Technology: Processing, Characterization and Applications, V. I - Sol-Gel Processing/Hiromitsu Kozuka, Editor, V. II - Characterization of Sol-Gel Materials and Products/Rui M. Almeida, Editor, V. III - Applications of Sol-Gel Technology/Sumio Sakka, Editor. Springer.
4. Lüth, Hans 2010 Solid Surfaces, Interfaces and Thin Films. Springer.
5. Vajtai, R 2013. Springer Handbook of nanomaterials, Springer.

MNL-713 Instrumentation Techniques for Nanotechnology MM: 70
(Credits: 4+0) Internal: 30
Time: 3 Hour

Note: Nine questions will be set by the examiner, two from each unit and one compulsory question of short/ objective type questions covering entire syllabus. Students will have to attempt five questions in all selecting at least one question from each unit including the compulsory question.

Unit-1

Introduction to electron microscopy, principle and operation of SEM and TEM. Different detectors as attachment with electron microscopes. Sample preparation for SEM and TEM. High resolution imaging, safety measures in electron microscopy. Introduction to scanning probe microscopes. Principle and operation of STM, AFM, MFM, EFM, LFM, SCM, SThM. Principle and operation of confocal microscopy.

Unit-2

Principle, operation and applications of X ray Diffraction (XRD), small angle X ray scattering (SAXS), X ray Fluorescence (XRF): WD-XRF and EXRF, X ray photoelectron spectroscopy (XPS), X-ray absorption spectroscopy (XAS).

Unit-3

Principle, operation and applications of Fluorescence spectroscopy, UV-Visible spectroscopy, Ultraviolet photoelectron spectroscopy (UPS), Fourier Transform Infra-red spectroscopy (FTIR), Raman Spectroscopy, Auger electron spectroscopy (AES), Nuclear magnetic resonance (NMR) spectroscopy, Mass spectroscopy, atomic absorption spectroscopy, atomic emission spectroscopy.

Unit-4

Principle, operation and applications of Differential Scanning Calorimetry (DSC), Differential Thermal Analysis (DTA), Thermogravimetric analysis (TGA), Dynamic Light Scattering (DLS) based particle size analyzer, Zeta Potential, Optical Tweezers, High-performance liquid chromatography (HPLC).

Books/ References:

1. Bhushan, Bharat 2004. Handbook of Nanotechnology. Springer.
2. Papkovsky, D., Zhdanov, A.V., Fercher, A., Dmitriev, R.I., Hynes, J. 2012 Phosphorescent Oxygen-Sensitive Probes. Springer.
3. Ye, Bang-Ce, Zhang, Min, Yin, Bin-Cheng 2012 Nano-Bio Probe Design and Its Application for Biochemical Analysis. Springer
4. Carrara, Sandro (Ed.) 2011 Nano-Bio-Sensing. Springer.
5. Bhushan, Bharat (Ed.) 2013 Scanning Probe Microscopy in Nanoscience and Nanotechnology Springer.
6. Schultz, J.; Mrksich, M.; Bhatia, S.N.; Brady, D.J.; Ricco, A.J.; Walt, D.R.; Wilkins, C.L. (Eds.) 2006 Biosensing: International Research and Development. Springer.
7. Avouris, P., Klitzing, K. Von, Sakaki, H. & Wiesendanger,R .2003. NanoScience and Technology Series. Scanning Probe Microscopy- Analytical Methods (R. Wiesendanger eds), Springer.
8. Avouris, P. Klitzing, K. von H. Sakaki & Wiesendanger, R,.2003. NanoScience and Technology Series. Noncontact Atomic Force Microscopy (S.Morita & R. Wiesendanger eds), Springer.

MNL-714 Nanoparticles in Microorganisms & Biosystems MM: 70
(Credits: 3+0) Internal: 30
Time: 3 Hour

Note: Nine questions will be set by the examiner, two from each unit and one compulsory question of short/ objective type questions covering entire syllabus. Students will have to attempt five questions in all selecting at least one question from each unit including the compulsory question.

Unit-1

Microorganisms for synthesis of Nano materials and for toxicity detection: Natural and artificial synthesis of Nano particles in microorganisms; Use of microorganisms for nanostructure formation, Testing of environmental toxic effect of Nano particles using microorganisms.

Unit-2

Nano composite biomaterials, teeth and bone substitution: Natural nanocomposite systems as spider silk, bones, shells; organic-inorganic nanocomposite formation through self-assembly. Biomimetic synthesis of nanocomposite material; Use of synthetic nano composites for bone, teeth replacement, Nanophase Materials Coatings, Advantages of Nanomaterials Used as Implants, Nanophase Materials in Tissue Engineering Applications.

Unit-3

Nano bio Systems: Nano particle-biomaterial hybrid systems for bioelectronic devices, Bioelectronic systems based on nanoparticle-enzyme hybrids; nano particle based bioelectronic biorecognition events. Biomaterial based metallic nanowires, networks and circuitry. DNA as functional template for nano circuitry; Protein based nanocircuitry; Neurons for network formation. DNA nanostructures for mechanics and computing and DNA based computation; DNA based nanomechanical devices.

Unit-4

Tissue Engineering: The status of tissue engineering of specific organs, including bone marrow, skeletal muscle, and cartilage. Cell biological fundamentals of tissue engineering. Nano-regenerative medicine towards clinical outcome of stem cell and tissue engineering in humans.

Books/ References:

1. David S. Goodsell (2004) Bionanotechnology: Lessons from Nature, Wiley-Liss Inc.
2. Rai, Mahendra; Duran, Nelson (Eds.) (2011) Metal Nanoparticles in Microbiology. Springer.
3. Cioffi, Nicola; Rai, Mahendra (Eds.) (2012) Nano-Antimicrobials. Springer
4. R. A. Freitas (2003) Nanomedicine, Vol. IIA: Biocompatibility, Landes Bioscience.
5. Hari Singh Nalwa (2005) Handbook of Nanostructured Biomaterials and Their Applications in Nanobiotechnology, American Scientific Publishers.
6. Nanobiotechnology; ed. C.M.Niemeyer, C.A. Mirkin.
7. Introduction to Nanoscale Science and Technology (Nanostructure Science and Technology) -Massimiliano Di Ventra
8. Seeram Ramakrishna, Ramalingam Murugan, T .S. Sampath Kuma (2010) Biomaterials: a nano approach, CRC Press/Taylor & Francis.

MNL-721 Bionanostructures -Applications and Perspectives MM: 70
(Credits: 3+0) Internal: 30
Time: 3 Hour

Note: Nine questions will be set by the examiner, two from each unit and one compulsory question of short/ objective type questions covering entire syllabus. Students will have to attempt five questions in all selecting at least one question from each unit including the compulsory question.

Unit-1

Protein Based Nanostructures: S- layers- structures, self assembly, Recrystallization, Diagnostics, lipids chips; Engineered Nanopores- potential applications, methods of production, protein engineering, supported Bilayers, Membrane arrays; protein microarrays; Magnetosomes- Nanoscale magnetic iron minerals in bacteria; Bacteriorhodopsin and its potential in technical applications & preparation of Bacteriorhodopsin films.

Unit-2

DNA based Nanostructures: DNA-Protein Nanostructures- overview, conjugation, supra-molecular Assembly, DNA directed immobilization, Microarray Technologies; DNA-template electronics, DNA Gold Nanoparticles conjugates- Chip Based DNA detection assays; DNA Nanostructures for mechanics and Computing; Nanoparticles as Non-Viral Transfection Agents, Real Time PCR based methods in Diagnosis of Infectious Diseases.

Unit-3

Biodegradable Polymers- Polymers derived from Renewable resources, Petroleum resources, Bacterial polymers, Applications of Biodegradable polymers, Biodegradable polymers in controlled drug delivery.

Analysis of Biomolecular Structures: Luminescent quantum dots for Biological Labeling, Nanoparticle molecular labels, Role of AFM and Force spectroscopy in Nanoanalytics and molecular pulling, Biocojugated Silica Nanoparticles for Bioanalytical Applications.

Unit-4

Nano Structured Fluids and Nanoformulations: Properties, Characterization, design & formulation;– Applications in drug solubilization and delivery, Novel approaches for enhancing of Drug bioavailability, Nanotechnology as emerging tool for enhancing solubility for poorly water soluble drugs; antimicrobial and cosmetic nano-emulsions, nano-emulsions for foods and nutraceuticals, smart materials.

Books/ References:

1. Fan, Chunhai (Ed.) (2013) DNA Nano Technology: From structure to function. Springer.
2. Schlaad, Helmut (Ed.) 2013 Bio-synthetic Polymer Conjugates Springer
3. Rahman, M., Laurent, S., Tawil, N., Yahia, L., Mahmoudi, M. 2013 Protein-Nanoparticle Interactions - The Bio-Nano Interface. Springer.
4. Gracheva, Maria E. (Ed.) 2012 Nanopore-Based Technology. Springer
5. Kalia, Susheel; Kaith, B. S.; Kaur, Inderjeet (Eds.) 2011 Cellulose Fibers: Bio- and Nano-Polymer Composites. Green Chemistry and Technology. Springer
6. Zvelindovsky, A.V. (Ed.) 2007 Nanostructured Soft Matter. Experiment, Theory, Simulation and Perspectives. Springer.
7. Niemeyer C.M. & Mirkin, C.A., 2004. Nanobiotechnology- Concepts, Applications and Prespectives. Wiley-VCH Verlag.
8. Bauerlein, E. 2000. Biomineralization- From Biology to Biotechnology and Medical Applications. Wiley-VCH Verlag.

MNL-722 Environmental Nanotechnology & IPR MM: 70
(Credits: 3+0) Internal: 30
Time: 3 Hour

Note: Nine questions will be set by the examiner, two from each unit and one compulsory question of short/ objective type questions covering entire syllabus. Students will have to attempt five questions in all selecting at least one question from each unit including the compulsory question.

Unit-1

Environmental Nanotechnology- An introduction, Concept of Nano pollution, Nanotechnology for Reduced waste and improved energy efficiency, Nanotechnology based water treatment strategies, Nanomaterials for sensing of pollutants, Nanomaterials for cleaner energy

Unit-2

Waste remediation: Nanoporous polymers and their applications in water purification, Photo-catalytic fluid purification. Energy conversion; Hierarchical self-assembled nano-structures for adsorption of heavy metals, Nano-pesticide formulations, Nanoparticles for dye removal and water filtration.

Unit-3

Pollution by Nano-particles- Health impact, Safety and Toxicological effects.

Societal impact & Ethical issues in Nanoscience and Nanotechnology, Problems and possible solutions, Regulation, Green Nanotechnology.

Unit-4

Intellectual Property Rights and Protection (IPP)- GATT & TRIP, Concept of Patents, Copyrights, Trademarks; Patenting – need for patents, Patenting of Biological materials and nanomaterials, Regulatory issues and Challenges to Nanotechnology Patent process, protection of knowledge, knowledge consortia and databases, Protectable Intellectual Property in nanotechnology, Legal Issues related to nanotechnology-lessons from experiences worldwide. Monitoring systems for nanotechnology patents.

Books/ References:

1. Schlaad, Helmut (Ed.) (2013) Bio-synthetic Polymer Conjugates, Springer
2. Hambleton, P.; Salusbury, T. (Eds.) (1994) Biosafety in Industrial Biotechnology. Springer.
3. 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.
4. 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.
5. Roco, M.C.; Bainbridge, W.S. (eds.): (2001) *Societal implications of nanoscience and nanotechnology*, (Proceedings of a workshop organized by the National Science Foundation, September 28-29, 2000), Kluwer, Dordrecht.
6. Mark Wiesner, Jean-Yves Bottero (2007) Environmental Nanotechnology : Applications and Impacts of Nanomaterials: Applications and Impacts of Nanomaterials, McGraw Hill Professional.

MNL-723 Nano Composites **MM: 70**
(Credits: 3+0) **Internal: 30**
Time: 3 Hour

Note: Nine questions will be set by the examiner, two from each unit and one compulsory question of short/ objective type questions covering entire syllabus. Students will have to attempt five questions in all selecting at least one question from each unit including the compulsory question.

Unit-1

Metal based Nano composites: Metal-Oxide or Metal-Ceramic composites, Different aspects of their preparation techniques and their final properties and functionality. Applications in various fields.

Unit-2

Metal-metal nanocomposites: some simple preparation techniques and their new electrical and magnetic properties.

Design of Super hard materials: Super hard Nano composites, its designing and improvements of mechanical properties.

Unit-3

New kind of Nano composites: Fractal based glass-metal Nano composites, its designing and fractal dimension analysis. Electrical property of fractal based Nano composites. Core-Shell structured Nano composites.

Unit-4

Polymer based Nano composites: Preparation and characterization of diblock Copolymer based nanocomposites; Polymer-carbon Nanotubes based composites, their mechanical properties, and industrial possibilities.

Books/ References:

1. P. M. Ajayan, L.S. Schadler, P. V. Braun.(2003) Nano composites Science and Technology, Wiley-VCH.
2. V. Mittal (2011) Nanocomposites with Biodegradable Polymers: Synthesis, Properties, and Future perspectives., Oxford University Press.
3. Schlaad, Helmut (Ed.) 2013 Bio-synthetic Polymer Conjugates Springer
4. Kalia, Susheel; Kaith, B. S.; Kaur, Inderjeet (Eds.) 2011 Cellulose Fibers: Bio- and Nano-Polymer Composites. Green Chemistry and Technology. Springer
5. Christian Brosseau, Jamal Ben, Youssef, Philippe Talbot, Anne-Marie Konn (2003) Nanometer versus micrometer-sized particles, (Review Article) J. Appl. Phys, Vol 93, 2003.
6. R. K. Gupta, E. Kennel, Kwang-Jea Kim(2010) Polymer Nanocomposites Handbook, CRC Press.
7. S C Tjong, Y.-W. Mai (2010) Physical Properties and Applications of Polymer Nanocomposites, Woodhead Publishing Limited, UK.

MNL-724 Nanomedicine and Drug Delivery **MM: 70**
(Credits: 3+0) **Internal: 30**
Time: 3 Hour

Note: Nine questions will be set by the examiner, two from each unit and one compulsory question of short/ objective type questions covering entire syllabus. Students will have to attempt five questions in all selecting at least one question from each unit including the compulsory question.

Unit-1

Nanomedicine: Concept and applications.

Gene Therapy and Nanotechnology: An Introduction, gene therapy using nanoparticles; stem cell therapy, Medical applications of molecular nanotechnology, Nanobiopharmaceutics.

Unit-2

Nanotechnology for Imaging - Detection and Therapy: Fluorophores and Quantum dots, Labeling and functionalization, Image analysis, Imaging facilitating surgical approaches. Diagnostics using nanomaterial, Nanoparticles for bioanalytical applications**,** Nanodevices for sensing and therapy. Use of nanoparticles for MRI, X Ray, Ultrasonography, Gamma ray imaging. Nanoparticles as molecular labels, nanotechnology in surgery, Photodynamic therapy (PDT), Impalefection.

Unit-3

Drug Delivery, Therapeutic action of nano particles and nano devices

Nanotechnology for Drug Targeting, Targeted, non-targeted delivery; controlled drug release; exploiting novel delivery routes using nanoparticles; Nanostructures for use as antibiotics; Diseased tissue destruction using nanoparticles

Unit-4

Nanotechnology for Cancer Therapy : Cancer biology – Fundamentals, Physiology of Tumourgenesis, clinical aspects & current approaches, Challenges in cancer therapy, Role of nanotechnology in cancer therapy, Nanotechnology platforms, Properties of nanoplatforms, Passive versus active targeting, Tumor-targeted drug delivery systems (DNA, siRNA, etc), Nanoparticles: silica, vesicles, dendrimers, etc., Drug encapsulation strategies, Multifunctional nanotherapeutics, Radiosensitization and tumor ablation with nanoparticles.

Nanotechnology in Cancer Research: Genome and proteome perturbations: overview, Protein and nucleic acid markers: handle for early detection, Current methodology and instrumentation, Cantilevers, Limitations.

Books/ References:

1) Jenkins, Gareth; Mansfield, Colin D. (Eds.) (2013). Microfluidic Diagnostics: Methods and Protocols. Springer.
2) Pavlovic, Mirjana, Balint, Bela. (2013) Stem Cells and Tissue Engineering. Springer
3) Taxman, Debra J. (Ed.) (2013) siRNA Design Methods and Protocols. Springer
4) Baharvand, Hossein; Aghdami, Nasser (Eds.) (2013) Regenerative Medicine and Cell Therapy. Springer.
5) Jain, Kewal K. (2012) The Handbook of Nanomedicine. Springer.
6) Kunugi, Shigeru; Yamaoka, Tetsuji (Eds.) (2012) Polymers in Nanomedicine. Springer.
7) Zahavy, E.; Ordentlich, A.; Yitzhaki, S.; Shafferman, A. (Eds.) (2012) Nano-Biotechnology for Biomedical and Diagnostic Research. Springer.
8) Baharvand, Hossein; Aghdami, Nasser (Eds.) (2012) Advances in Stem Cell Research. Springer.

MNL-725 MEMS & NEMS – Sensors & Devices MM: 70
(Credits: 3+0) Internal: 30
Time: 3 Hour

Note: Nine questions will be set by the examiner, two from each unit and one compulsory question of short/ objective type questions covering entire syllabus. Students will have to attempt five questions in all selecting at least one question from each unit including the compulsory question.

Unit-1

Micro and Nano-sensors: Fundamentals of sensors, biosensor, MEMS and NEMS, Overview of MEMS & NEMS devices.

Sensors: Therapeutic Nanodevices and Non-therapeutic Nanodevices: Sensors for aerospace and defense: Accelerometer, Pressure Sensor, Sensor for bio-medical and food applications: Cardiology, Cancer and as diagnostic tool in food and medical sciences, for other civil applications: metrology, bridges etc. Nanoscale devices for veterinary technology

Unit-2

Micro/Nanofabrication Techniques: Stamping/Fabrication techniques for Micro and Nanofabrication**,** Material aspects of MEMS and NEMS, Bulk & Surface micromachining, Dry & wet Etching, fabrication techniques for Silicon, polymers and Glass.

Packaging and characterization of sensors: Packaging & Reliability. Method of packaging.

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-3

Biosensors: History, Clinical Diagnostics, generation of biosensors, Biological elements, Performance factors of Biosensors, immobilization of Biological components, Screen Printing Electrode, applications of Biosensors, Types of transducer technology, conducting Polymer based sensor, DNA Biosensors, Biochips and biosensors for detection of pathogens and allergens, Electronic Nose & Tongue, Nanobiosensors.

Unit-4

Quantum Structures and Devices: Quantum dots and wires, Nanowires- Synthesis Methods, physical properties, characterization methods and applications. Engineered multifunctional nanowires as novel biosensing tools.

Books/ References:

1. Jenkins, Gareth; Mansfield, Colin D. (Eds.) (2013). Microfluidic Diagnostics: Methods and Protocols. Springer.
2. Ye, Bang-Ce, Zhang, Min, Yin, Bin-Cheng (2012) Nano-Bio Probe Design and Its Application for Biochemical Analysis. Springer.
3. Carrara, Sandro (Ed.) (2011) Nano-Bio-Sensing. Springer.
4. H. Meixner (1995) Sensors: Micro & Nanosensors, Sensor Market trends (Part 1&2**),**Vch Verlagsgesellschaft Mbh.
5. Michael Rieth (2003) Nano Engineering in Science & Technology: An Introduction to the world of Nano Design. World Scientific.
6. Baltes, H. Brand, O. Fedder, G.K. Hierold, C. Korvink, J.C. Tabata, O (2004) Enabling Technology for MEMS and Nanodevices, Wiley-VCH.
7. Ananthasuresh, G.K. (2003) Optimal Synthesis Methods for MEMS, Kluwer International Series.
8. Choudhury, P. Rai (2000) MEMS & MOEMS Technology and Applications, SPIE publications.
9. Tay, F.E.H (2003) Microfluidics & Bio MEMS applications. Kluwer International Series.

Open Elective Course for M.Tech students of other Departments

MNL-751 Basic Nanotechnology (3+0)
MM: 70 TIME: 3 h

Note: Nine questions will be set by the examiner, two from each unit and one compulsory question of short/ objective type questions covering entire syllabus. Students will have to attempt five questions in all selecting at least one question from each unit including the compulsory question.

Unit-I

Introduction & Background: Introduction to Nanotechnology, Insights and intervention into the Nanoworld, Historical Background, recent advances and future aspects, Applications of Nanotechnology in different fields- Agriculture, medical applications, Environmental applications, Space, Defence, Food processing, consumer durables, textiles, cosmetics etc, Safety, Health & environmental issues, Societal implications of Nanotechnology.

Unit-II

Instrumentation Techniques for Nanotechnology: FTIR, DSC, Scanning Probe Microscopy (SPM), AFM, Scanning Tunneling Microscopy (STM), SEM, TEM, XRD (Powder/Single crystal), Particle size analyzer and Zeta Sizer.

Unit-III

Nanomaterials- Types, Properties and applications; Synthesis methods- Physical, Chemical and Biological methods of synthesis; Carbon Nanotubes – Synthesis methods, characterization and applications; Nanowires- synthesis methods, physical properties, applications; Smart materials.

Unit-IV

Micro and Nanofabrication Techniques- Concept of MEMS and NEMS, Fabrication techniques- A brief account, applications of Micro and Nanodevices, Micro fluidic devices and their Applications; Material aspects for Micro fluidic devices, active and smart passive Micro fluidics devices, Lab-on-a-chip.

Books/ References:

1. Kulkarni, S, K. 2014. Nanotechnology- Principles and Practices. 3rd Edition, Capital Publishing Company.
2. Vajtai, R 2013. Handbook of Nanomaterials, Springer.
3. Hari Singh Nalwa 2011. Encyclopedia of Nano Science & Nanotechnology. American Scientific Publishers.
4. Balzani, V., Credi, A. & Verturi, M. 2003. Molecular Devices and Machines- A Journey into Nanoworld. Wiley-VCH Verlag.
5. Albert Folch (2013) "Introduction to BioMEMS", CRC Press.
6. 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.
7. Bhushan, Bharat. 2004. Handbook of Nanotechnology. Springer.