COURSE STRUCTURE
AND
DETAILED SYLLABUS

for

M.Tech course

in

Nanotechnology

(with effect from the Academic year 2012-2013)

SREENIDHI INSTITUTE OF SCIENCE AND TECHNOLOGY
(An Autonomous Institution approved by UGC and affiliated to JNTUH)
Yamnampet, Ghatkesar, R.R.District-501 301.

M.Tech. Full-Time (NANOTECHNOLOGY)
Course Structure and Syllabus: Academic Year 2012-2013

I YEAR–I Semester

Code	Subject	L	T	P	Credits	Internal Marks	External Marks
NT101	Introduction to Nanotechnology	4	0	0	3	40	60
NT102	Characterization of Nanomaterials	4	0	0	3	40	60
NT103	Synthesis of Nanomaterials	4	0	0	3	40	60
NT104	Nano Bio-Materials	4	0	0	3	40	60
NT105	Nano Electronics	4	0	0	3	40	60
NT106	Nanotechnology for Energy Systems	4	0	0	3	40	60
NT107	Simulation Lab	0	0	4	2	40	60
NT108	Technical Paper Writing and Seminar	0	0	3	2	40	60
Total		**24**		**7**	**22**	**330**	**420**

I YEAR - II Semester

Code	Subject	L	T	P	Credits	Internal Marks	External Marks
NT201	Manufacturing methods of nanostructures	4	0	0	3	40	60
NT202	Nanocomposites	4	0	0	3	40	60
NT203	Mechanical Processing and properties of nanostructure materials	4	0	0	3	40	60
	Elective – I	4	0	0	3	40	60
NT204	Electronic devices, NEMS/MEMS Carbon based nanostructures and their applications				3 3		
	Elective – II	4	0	0	3	40	60
NT205	Thin film Technology Nanophotonics				3 3		
	Elective – III	4	0	0	3	40	60
NT206	Nanotechnology in Health care Nanotechnology: society and environment						
NT207	Nanomaterials Characterization Lab	0	0	4	2	40	60
NT208	Technical Seminar (Independent review Paper)	0	0	3	2	50	--
Total		**24**		**7**	**22**	**330**	**420**

II YEAR–I Semester

Code	Subject	L	T	P	Credits	Internal Marks	External Marks
NT301	Comprehensive Viva-Voce	--	--	--	2	--	50
NT302	Project Seminar-I	0	0	0	2	50	--
NT303	Project work (Part – I) (Project Status Report)	--	--	--	18	Grading*	--
Total credits					**22**	**50**	**50**

*Grading-----Excellent/Good/Satisfactory/Fail

II YEAR–II Semester

Code	Subject	L	T	P	Credits	Internal Marks	External Marks
NT401	Project Seminar-II	0	0	0	2	50	--
NT402	Project work and Dissertation	--	--	--	20	--	Grading*
Total credits					**22**	**--**	**50**

*Grading-----Excellent/Good/Satisfactory/Fail

M.Tech-NT I Year – I Sem.

NT101 - INTRODUCTION TO NANOTECHNOLOGY

L	T	P/D	C
4	0	0	3

Unit-I: Introduction to Nanotechnology**,** Crystal Structure: Introduction, arrangement of atoms, two dimensional crystal structures

Unit-II: Three dimensional crystal structures, some examples of three dimensional crystals, planes in crystals and crystallographic directions,

Unit-III: Reciprocal lattice Bragg's law, reciprocal lattice vectors, diffraction conditions, Laue and Powder methods; Quasicrystals, Type of bonds – ionic, covalent and metallic bonds

Unit-IV: Why quantum mechanics? Matter waves, Length scales, De-Broglie hypothesis,Wave particle duality, Heisenberg's uncertainty principle, Schrodinger wave equation, Particle in one dimensional box

Unit-V: Finite Potential Wells and barriers: Periodic lattice, Energy gaps, Qualitative Description of the theory of conduction in Solids, Particle in 2-D box, Quantum Fluctuation and Discrete Quantum states, Concepts of Quantum Confinement

Unit-VI: Thermodynamics, phase diagrams and phase transformations

Textbooks:

1. Introduction to Nanotechnology by Charles P.Poole Jr & Frank J. Owens, Wiley India Pvt. Ltd.
2. Nano pahysics and nanotechnology by E.L.Wolf willely VCH
3. A Textbook of Quantum Mechanics by P.M. Mathews and K. Venkatesan, Tata McGraw Hill Publishing Company Ltd.
4. Modern Quantum Mechanics by J.J. Sakurari, Addison Wesley Longman Inc.
5. Solid state Physics by Kittel
6. Nanotechnology:Principles and Practices by S.K. Kulkarni, Capital Publishing Company
7. Quantum mechanics by Pawling and Wilson
8. The Feynman lectures on Physics; Vol I to III

Reference Books:

1. Nanotechnology and Nano Electronics – Materials, devices and measurement techniques by WR Fahrner, Springer
2. Nanotechnology – science, innovation and opportunity by Lynn E Foster, Prentice Hall - Pearson education.
3. Encyclopedia of Nanotechnology by H.S. Nalwa

M.Tech-NT I Year – I Sem.

NT102 - CHARACTERIZATION OF NANOMATERIALS

L	T	P/D	C
4	0	0	3

Unit-I: Compositional and structural Characterization techniques**:** X-ray Photoelectron Spectroscopy (XPS), X-Ray topography, Energy Dispersive X-ray analysis (EDAX), Principles and applications of X-ray diffraction:

Unit-II: Small angle X-ray diffraction and Wide angle X-Ray diffraction; electron diffraction, Electron probe microanalysis (EPMA), Ion beam techniques: SIMS & RBS, 3-D atom probe

Unit-III: Surface characterization Techniques: Scanning electron microscopy (SEM), Transmission electron microscopy, Basic principles and the applications of scanning probe techniques (SPM), Atomic force microscopy, scanning tunneling microscopy

Unit-IV: Spectroscopic techniques: UV-Visible spectroscopy, Infrared (IR) & Fourier Transform infrared (FTIR) spectroscopy, Raman spectroscopy techniques: micro Raman and laser Raman; Photo luminescence spectroscopy

Unit-V: Electrical characterization techniques: Hall measurement, Dynamic and static Current voltage (I-V) characteristics, capacitance, voltage measurements, I-V analysis by AFM and STM (STS), electron beam induced current measurement (EBIC)

Unit-VI: Magnetic & dielectric characterization: SQUID, VSM, MFM, Neutron diffraction, Dielectric measurements, impedance and ferroelectric measurements

Text books:

1. Nano: The Essentials -Understanding Nano Scinece and Nanotechnology by T.Pradeep, Tata Mc.Graw Hill
2. Introduction to Nano Technology by Charles. P. Poole Jr and Frank J. Owens, Wiley India Pvt Ltd.
3. A practical approach to X-Ray diffraction analysis by C.Suryanarayana
4. Electron Microscopy and analysis by P.J. Goodhew and F.J. Humpreys
5. Scanning electron microscopy and x-ray microanalysis by J.I. Goldstein
6. Characterization of nanostructured materials by Z.L. Wang
7. Modern Raman Spectroscopy: A practical approach by E. Smith and G.Dent
8. Principles of Instrumental analysis by D.A. Skoog, F.J. Hollen and T.A. Niemann

Reference Books:

1. Nanotechnology : Principles and Practices – Sulabha K. Kulkarni – Capital Publishing Company
2. Specimen preparation for Transmission Electron microscopy by John & Bravmno et al, published by MRS
3. Photoelectron spectroscopy by JHD Eland, Butterworth & Co. publishers, 2nd education.

M.Tech-NT I Year – I Sem.

NT103 - SYNTHESIS OF NANOMATERIALS

L	T	P/D	C
4	0	0	3

Unit-I: Introduction to synthesis of nanostructure materials, Bottom-up approach and Top-down approach with examples.

Unit-II: Physical methods**:** Inert gas condensation, Arc discharge, RF-plasma, plasma arc technique, electric explosion of wires, laser ablation, laser pyrolysis,

Unit-III: Ball milling, molecular beam epitaxy, electrodeposition, rapid solidification (RSP), consolidation

Unit-IV: Chemical methods**:** Nanocrystals by chemical reduction, photochemical synthesis, electrochemical synthesis, nanocrystals of semiconductors and other materials by arrested precipitation, emulsion synthesis, sonochemical routes

Unit-V: Thermolysis route - spray pyrolysis and solvated metal atom dispersion, sol-gel method, solvothermal and hydrothermal routes, solution combustion synthesis, CVD method and other variants

Unit-VI: Biological methods – use of bacteria, fungi**,** actinomycetes for nano-particle sythesis-magnetotatic bacteria for natural synthesis of magnetic nano-particles, role of plants in nano particle synthesis.

Textbooks:

1. Inorganic Materials Synthesis and Fabrication by J.N. Lalena, D.A. Cleary, E.E. Carpenter, N.F. Dean, John Wiley & Sons Inc.
2. Introduction to Nano Technology by Charles P. Poole Jr and Frank J. Owens. Wiley India Pvt Ltd.
3. The Chemistry of nanomaterials: Synthesis, Properties and Applications, Vol-I by C.N.R. Rao, A. Muller and A.K. Cheetham

Reference books:

1. Encyclopedia of Nanotechnology by M.Balakrishna Rao and K.Krishna Reddy, Vol I to X, Campus books.
2. Encyclopedia of Nanotechnology by H.S. Nalwa
3. Nano: The Essentials – Understanding Nano Scinece and Nanotechnology – by T.Pradeep; Tata Mc.Graw Hill

M.Tech-NT I Year – I Sem.

NT104 - NANO BIO-MATERIALS

L	T	P/D	C
4	0	0	3

Unit-I: Biological building blocks: Sizes of building blocks and Nanostructures, Polypeptide nanowire and protein nanoparticles

Unit-II: Nucleic Acids – DNA Double Nano wire, Genetic code and protein synthesis

Unit-III: Biological Nanostructures: Bio-mimicry with examples, Bio compatible Bio sensors, Examples of proteins, vesicles, bilayers, and Multilayer films, application of bio-nanotechnology: bio nano machines, molecular modeling.

Unit-IV: Applications to NEMS and Nano devices: Nano bio-sensors and biomedical applications involving drug delivery using implantable drug delivery devices with the emphasis on Biochips and nanoencapsulation

Unit-V: organic semiconductors, biological neurons and their functions, modeling of neuron cells by VLSI circuits, bio-chemical and quantum mechanical computers: DNA computers, parallel processing, Bit and 'Q' bit, Quantum parallelism

Unit-VI: Nanoscale processes in the environment, Nano technology for Immune system, clinical imaging, nano robots, Nano Fibres for Tissue Engineering

Text books:

1. Bio Nano Technology by Good Sell, Wiley Liss
2. Introduction to Nanotechnology by Charles. P.Poole Jr and Frank J. Owens, Wiley India Pvt Ltd.
3. Nano Technology, A gentle introduction to the next big idea by Mark Ranter and Daniel Ranter, Pearson education
4. Nanotechnology – science, innovation and opportunity by Lynn E Foster, Prentice Hall - Pearson education

Reference books:

1. Encyclopedia of Nanotechnology by H.S.Nalwa
2. Encyclopaedia of Nanotechnology by M.Balakrishna Rao and K.Krishna Reddy (Vol I to X), Campus books.

M.Tech-NT I Year – I Sem.

NT105 - NANOELECTRONICS

L	T	P/D	C
4	0	0	3

Unit-I: basics of nanoelectronics: (I) Structure– crystal structures, lattice vibrations, Energy bands – insulators, semiconductors and conductors, reciprocal space, effective masses, Fermi surfaces, Localized particles – donors, acceptors and deep traps, mobility, excitons, Quantization of Action, Charge and Flux, Electrons in potential wells, Photons interacting with electrons in solids, Diffusion Processes.

Unit-II: quantum electronics: quantum electronic devices (qed): electrons in mesoscopic structures, examples of quantum electronic devices: short-channel mos transistor, split-gate transistor, electron–wave transistor, electron-spin transistor, quantum cellular automata (qca), quantum dot array.

Unit-III: molecular electronics: switches based on fullerenes and nanotubes, polymer electronics (introductory), self-assembling circuits, optical molecular memories (introductory).

Unit-IV: nanoelectronics with tunnelling devices-i : tunnelling element (te) – tunnel effect and tunneling elements, tunelling diode (td), resonant tunnelling diode (rtd), three-terminal resonant tunneling devices,

Unit-V: Nanoelectronics with tunnelling devices-ii: technology of rtd. digital circuit design based on rtds: memory applications, basic logic circuits, dynamic logic circuits, digital circuit design based on rtbt (resonant tunneling bipolar transistor): rtbt mobile, rtbt threshold gate, rtbt multiplexer.

Unit-VI: Single electron transistor (set): principle of the single-electron transistor: the coulomb blockade, performance of the single electron transistor, technology, set circuit design: wiring and drivers, logic and memory circuits, set adder as an example of a distributed circuit, comparison between fet and set circuit designs.

Text books:

1. Nanoelectronics and Nanosystems: From Transistors to Molecular and Quantum Devices, by Karl Goser, K. Glosekotter, J. Dienstuhl, Springer, third reprint 2009.
2. Introduction to Nanotechnology, by Charles Poole and Frank Owens, Wiley India, 2007.

References:

1. Nanotechnology and Nanoelectronics – Materials, Devices and measurement Techniques by W.R. Fahrner; Springer.
2. Nano: The Essentials – Understanding Nano Scinece and Nanotechnology by T.Pradeep; Tata Mc.Graw Hill.
3. W. Ranier, “Nano Electronics and Information Technology”, Wiley, (2003).
4. K.E. Drexler, “Nano Systems”, Wiley, (1992).
5. Encylopedia of Nanotechnology by H.S. Nalwa, American Scientific Publishers

M.Tech-NT I Year – I Sem.

NT106 - NANOTECHNOLOGY FOR ENERGY SYSTEMS

L	T	P/D	C
4	0	0	3

Unit-I: Battery materials and batteries: Lithium Ion based batteries

Unit-II: Renewable energy Technology: Energy challenges, nanomaterials and nanostructures in energy harvesting, developments and implementation of nanotechnology based renewable energy technologies, solar cell structures: quantum well and quantum dot solar cells, photo- thermal cells for solar energy harvesting, Thin film solar cells, CIGS solar cells, Die sensitized solar cells

Unit-III: Hydrogen storage Technology**:** Hydrogen production methods, purification, hydrogen storage methods and materials: metal hydrides and metal-organic framework materials, volumetric and gravimetric storage capacities, hydriding and dehydriding kinetics, high enthalpy formations and thermal management during hydriding reaction, multiple catalytic – degradation of sorption properties, automotive applications

Unit-IV: Fuel cell Technology**:** Fuel cell Principles, types of fuel cells (Alkaline Electrolyte, Phosphoric acid, Molten Carbonate

Unit-V: Solid oxide and direct methanol and Proton exchange fuel cells), Principle and operation of Proton Exchange Membrane (PEM) fuel cell, Materials and fabrication methods for fuel cell technology, micro fuel cell power sources – Biofuels

Unit-VI: Nanofluids, Magnetic fluids, propellants, additives, nanofluid for heat transfer

Reference Books

1. Renewable Energy Resources by J. Twidell and T.Weir, E&FN Spon Ltd.
2. Hydrogen from Renewable Energy Source by D.Infield
3. Fundamentals of Industrial Catalytic Process by C.H. Bartholomew and Robert J. Farraoto, John Wiley & Sons Inc.
4. Fuel storage on Board Hydrogen storage in Carbon Nanostructures by R.A. Shatwell
5. Fuel cell Technology Handbook by Hoogers, CRC Press
6. Hand book of fuel cells: Fuel cell technology and applications by Vielstich, Wiley:CRC Press

M.Tech-NT I Year – I Sem.

NT107 - SIMULATION LAB

L	T	P/D	C
0	0	4	2

I. ARGUS LAB:

1. Construction of fullerene & its energy calculations
2. Construction of bucky balls (C20, C40, C60, C80, C100, C120)
3. Construction of Carbon nanotubes
4. Energy minimization of lysozyme and its mutant
5. Energy minimization of chymotrypsin and its mutant
6. Energy minimization of enzymes involved in Neurological science

II. MOSES 1.2

1. Study single electron transistor using MATLAB programme
2. Simulation of I – V characteristics for a single junction circuit with a single quantum dot using **MOSES 1.2 simulator**

M.Tech-NT I Year – I Sem.
NT108 - TECHNICAL PAPER WRITING & SEMINAR

L	T	P	C
0	0	3	2

There shall be two seminar presentations during I year I semester and I year II Semester. For seminar, a student under the supervision of a faculty member, shall collect the literature on a topic and critically review the literature and submit it to the Department in a report form and shall make an oral presentation before the Departmental Committee, which shall consist of the Head of the Department, a senior Faculty Member and the Supervisor and will jointly evaluate the report and presentation. For each Seminar there will be only internal evaluation of 50 marks. A candidate has to secure a minimum of 50% to be declared successful.

In the First semester the report must be in the form of the review paper with a format used by IEEE / ASME etc. In the Second semester Technical Seminar in the form of Independent Review Paper must be of high quality fit for publication in a reputed conference / journal.

The evaluation format for seminar is as follows:

- Day to day evaluation by the Supervisor : 10 marks
- Final Report : 10 marks
- Presentation : 30 marks

A Student has to concentrate on the following sections while writing technical paper or presenting seminar.

Contents:

- Identification of specific topic
- Analysis
- Organization of modules
- Naming Conventions
- Writing style
- Figures
- Feedback
- Writing style
- Rejection
- Miscellaneous

References:

Teach Technical Writing in Two Hours per Week by Norman Ramsey

For Technical Seminar the student must learn few tips from sample seminars and correcting himself, which is continues learning process

Reference Links:

http://www.cs.dartmouth.edu/~scot/givingTalks/sld001.htm
http://www.cse.psu.edu/~yuanxie/advice.htm
http://www.eng.unt.edu/ian/guides/postscript/speaker.pdf

Note: A student can use any references for this process, but must be shared in classroom.

The evaluation format for seminar is as follows:

- Day to day evaluation by the Supervisor : 10 marks
- Final Report : 10 marks
- Presentation : 30 marks

M.Tech-NT I Year – II Sem.

NT201 - MANUFACTURING METHODS OF NANOSTRUCUTRE

L	T	P/D	C
4	0	0	3

Unit-I: introduction: introduction to micro fabrication and moore's law – importance of lithographic techniques- different types of lithographic techniques -optical projection lithography- photomask- binary mask- phase shift mask -optical immersion lithography- maskless optical projection lithography- zone plate array lithography- extreme ultraviolet lithography.

Unit-II: e-beam and ion beam lithography: principle and instrumentation - scanning electron-beam lithography- mask less (ml2) ebl-parallel direct-write e-beam systems-e-beam projection lithography - prevail x-ray lithography - focused ion beam lithography - ion projection lithography - masked ion beam direct structuring-nanoimprint lithography and soft lithography- nanoimprint lithography - soft lithography- dip-pen lithography.

Unit-III: etching techniques:reactive ion etching- rie reactive ion etching- magnetically enhanced rie- ion beam etching - wet etching of silicon - isotropic etching - anisotropic etching - electrochemical etching - vapor phase etching - dry etching- other etching techniques.

Unit-IV: epitaxial film deposition methods:epitaxy, different kinds of epitaxy- influence of substrate and substrate orientation, mismatch, mocvd metal organic chemical vapor deposition - ccvd combustion chemical vapor deposition - ald atomic layer deposition - lpe liquid phase epitaxy -mbe molecular beam epitaxy.

Unit-V: chemical methods: sol-gel synthesis –different types of coatings -spin coating- self assembly- (periodic) starting points for self-assembly- directed self-assembly using conventional lithography- template self-assembly-vapor liquid solid growth- langmuir-blodgett films – dna self assembly.

Unit-VI: printing technologies: screen printing- inkjet printing- gravure printing and flexographic printing- flex graphic printing- gravure printing- roll-to-roll techniques.

Reference Books:

1. M. J. Jackson, "Micro fabrication and Nanomanufacturing", CRC Press, 2005.
2. P.Rai-Choudhury, "Handbook of Micro lithography, Micro machining, and Micro fabrication", Vol. 2, SPIE Press, 1997.
3. M. Madou, "Fundamentals of Microfabrication," CRC Press, 1997.
4. G.Timp, "Nanotechnology", AIP press, Springer-Verlag, New York, 1999.
5. G. Cao, "Nanostructures & Nanomaterials: Synthesis, Properties &Applications" Imperial College Press, 2004.
6. W.T.S. Huck, "Nanoscale Assembly: Chemical Techniques (Nanostructure Science and Technology)"
7. "Handbook of Nanoscience, Engineering and Technology", Kluwer publishers, 2002.

M.Tech-NT I Year – II Sem.

NT202 - NANOCOMPOSITES

L	T	P/D	C
4	0	0	3

Unit-I: Introduction to composites

Unit-II: Introduction to nanocomposites

Unit-III: Ceramic-Metal Nanocomposites, Ceramic based nanoporous composite, metal matrix nanocomposites, Polymer-based nanocomposites Carbon nanotube based nanocomposites

Unit-IV: Natural nanobiocomposites, Biomimetic nanocomposites and biologically inspired nanocomposites; Nano composites for hard coatings; DLC coatings; thin film nanocomposites; Modeling of nanocomposites

Unit-V: Synthesis methods for various nanocomposite materials: sputtering, mechanical alloying, sol-gel synthesis, thermal sprays synthesis etc.

Unit-VI: Processing of polymer nanocomposites, properties of nanocomposites, Salt infiltration, Powder mixing, Intrusion method, Exfoliation & interaction, Gel-casting impregnation techniques: Hot melt impregnation, solution impregnation.

Text books:

1. Nanocomposite Science & Technology by P.M. Ajayan, L.S. Schadler and P.V. Braun, Wiley-VCH GmbH Co.
2. Introduction to Nano Technology by Charles. P.Poole Jr and Frank J. Owens; Wiley India Pvt Ltd.
3. Nanotechnology, A gentle introduction to the next big idea by Mark Ranter, Danie Ranter Pearson education

Reference books:

1. Encyclopedia of Nanotechnology by H.S.Nalwa
2. Encyclopaedia of Nano Technology by M.Balakrishna rao and K.Krishna Reddy, Vol I to X Campus books.

M.Tech-NT I Year – II Sem.

NT203 – MECHANICAL PROCESING AND PROPERTIES OF NANOSTRUCTURE MATERIALS

L	T	P/D	C
4	0	0	3

Unit-I: Introduction to mechanical behavior of nanostructured materials

Unit-II: Mechanical properties of nanocomposite material: stress - strain relationship, toughness, strength, plasticity

Unit-III: Structure-property correlations: Hall-Petch relation, microstructure – dislocation interactions at low and high temperatures; effects of diffusion on strength and flow of materials

UNIT-IV: Properties slightly dependent on temperature and grain size; properties strongly dependent on temperature and grain size; strengthening mechanisms; enhancement of available plasticity; grain size evolution and grain size control

UNIT-V: methods of enhancing or retarding diffusion; grain boundary sliding and grain boundary migration; current limitations on approaches based on dislocation theory; possibilities for predictive design.

Unit-VI: Mechanical Characterization: Nano Indentation, Types of indentation: Oliver & Pharr, Joslin-Oliver, Vickers, Indenter process, Nanoindentation, Nanotribology.

References Books:

1. A. H. Cottrell “The Mechanical Properties of Matter”, John Wiley, New York- London, 1964.
2. P. Haasen, “Physical Metallurgy”, Cambridge University Press, Cambridge, UK, 1978.
3. G. E. Dieter, adapted by D Bacon, “Mechanical Metallurgy”, SI Metric edition, MaGraw-Hill, Singapore, 1988.
4. K. A. Padmanabhan, “Mechanical Properties of Nanostructured Materials”, Materials Science and Engineering, A 304-306 (2001) 200-205.
5. C. C. Koch, “Nanostructured Materials: Processing, Properties and Applications”, 2nd Edition, Ed.: 2007

M.Tech-NT I Year – II Sem.

NT204 - ELECTRONIC DEVICES, MEMS AND NEMS (Elective-I)

L	T	P/D	C
4	0	0	3

Unit-I: **Introduction:** MEMS and NEMS – multidisciplinary nature of MEMS/NEMS – working principles: as microsensors (acoustic wave sensor, biomedical and biosensor, chemical sensor, optical sensor, pressure sensor and thermal sensor), microactuation (thermal actuation, shape-memory alloys, piezoelectric actuation and electrostatic actuation) – microgripers – micromotors – microvalues – micropumps – accelerometers – microfluidics.

Unit-II: Engineering aspects-I: Mechanics for Microsystems: static bending, mechanical vibration, thermomechanics, Fracture mechanism, fatigue, Thin Film mechanics and stress

Unit-III: Engineering aspects-II: fluid mechanics and dynamics for MEMS – materials for MEMS: substrate materials, silicon on insulator (SOI), SiO_2, SiN, SiC, GaAs and hybrid materials-scaling laws in miniaturization.

Unit-IV: Design and Processing: Introduction – design considerations – process design – mechanical design – design microfluidic and capillary electrophoresis – computer aided design – Process layout

Unit-V: Packaging: Introduction – package design – selection of packaging materials – mechanical packaging – microsystem packaging: device & systems level – Die preparation – interconnects – surface bonding – wafer bonding – wire bonding & scaling – 3D packaging & assembly – signal mapping & transductions.

Unit-VI: Applications: Applications in automotive industry – health care – aerospace – industrial product consumer products – lab on chip – molecular machines – storage devices – microreactor - telecommunications

Text Books & References

Text books:

1. Tai-Ran Hsu "MEMS and Microsystems: Design and Manufacture" Tata McGrew-Hill, New Delhi.
2. Marc Madou "Fundamentals of Microfabrications" CRC Press, 1997.
3. Julian W. Gardner "Microsensors: Principles and applications" Wiley 1994
4. Sergey Edward Lyshevski "Nano – and Microelectromechanical systems" CRC Press, 2000

M.Tech-NT I Year – II Sem.

NT204 - CARBON BASED NANOSTRUCTURES AND THEIR APPLICATIONS
(Elective-I)

L	T	P/D	C
4	0	0	3

Unit-I: Carbon Nano structures and types of Carbon Nano tubes, growth mechanisms Mechanical reinforcements

Unit-II: Solid Disordered carbon Nanostructures, Nano structured crystals.

Unit-III: Electrical, Vibrational, Mechanical Properties of CNTs, optical properties & Raman Spectroscopy of CNTs

Unit-IV: Carbon clusters and Fullerenes, Synthesis of CNTs by Flame, CVD, Laser & Arc procenes

Unit-V: Lithium & Hydrogen adsorption & storages, Fuel cell applications and energy storage, Chemical Sensors applications of CNTs,

Unit-VI: Computer applications (Nano chip), optical and telecommunication applications Nano composites, silicon Nanowires, aerospace applications

Text books & References

Text books:

1. Introduction to Nanotechnology by Charles P. Poole Jr and Frank J.Owens Wiley India Pvt Ltd.
2. Nanotechnology and Nano Electronics – Materials, devices and measurement techniques by WR Fahrner, Springer publications

Reference books:

1. Encyclopaedia of Nanotechnology by M.Balakrishna rao and K.Krishna Reddy, Vol I to X Campus books.
2. Encyclopedia of Nanotechnology by HS Nalwa
3. Nanotechnology – science, innovation and opportunity by Lynn E.Foster. Prentice Hall Pearson education.
4. Nano:The Essentials – Understanding Nano Scinece and Nanotechnology by T.Pradeep; Tata Mc.Graw Hill

M.Tech-NT I Year – II Sem.

NT205 - THIN FILM TECHNOLOGY (Elective-II)

L	T	P/D	C
4	0	0	3

Unit-I: Vacuum technology: Concept of different vacuum pumps: rotary, diffusion, turbo molecular pump, cryogenic-pump, Ti-sub limitation pump; Concept of different gauges: pirani, penning, pressure control.

Unit-II: Conditions for the formation of thin films: Environment (Gas Phase and Plasma) for thin film deposition, deposition parameters and their effects on film growth, nanocrystalline thin film; structure of thin films: formation of thin films (sticking coefficient, formation of thermodynamically stable cluster – nucleation),

Unit-III: Microstructure, surface roughness, density, stress in thin films, adhesion, stoichiometry, metastable structures; physical parameters for the evaluation of thin films: Mechanical, electrical, thermal, chemical and optical properties of thin films

Unit-IV: Physical Vapor Depostion techniques: Thermal evaporation, resistance evaporation, Electron beam evaporation, Laser ablation, Ion vapour evaporation and Cathodic arc deposition

Unit-V: Chemical vapor deposition techniques: Advantages and disadvantages of Chemical Vapor deposition (CVD) techniques over PVD techniques, reaction types, boundaries and flow, Different kinds of CVD techniques: Metallorganic CVD (MOCVD), Thermally activated CVD, plasma enhanced (RF-Wave) CVD, Low Pressure (LP) CVD, Atmospheric pressure (AP) CVD etc.

Unit-VI: Electrical discharges used in thin film deposition: Sputtering, Glow discharge sputtering, Magnetron sputtering, Ion beam sputtering, Ion plating, Oxidizing and Nitriding, Atomic layer deposition (ALD)**,** Importance of ALD technique, Atomic layer growth: Physics and technology

Text Books & References

Reference books:

1. Thin Film Phenomenon by K.L. Chopra, McGraw-Hill
2. Methods of Experimental Physics (Vol 14) by G.L.Weissler and R.W. Carlson “Vacuum Physics and Technology”
3. A User’s Guide to vacuum Technology by J.F.O’Hanlon, John Wiley and Sons
4. Vacuum Physics and Techniques by T.A. Delchar, Chapman and Hall
5. Evaporation: Nucleation and Growth Kinetics” by J.P. Hirth and G.M.Pound, Pergamon Press

M.Tech-NT I Year – II Sem.

NT205 - NANOPHOTONICS (Elective-II)

L	T	P/D	C
4	0	0	3

Unit-I: Quantum confined materials: quantum dots – optical transitions – absorption-inter-band transitions-quantum confinement intraband transitions-fluorescence/ luminescence– photoluminescence /fluorescence optically excited emission – electroluminescence emission

Unit-II: Plasmonics:internal reflection and evanescent waves- plasmons and surface plasmon resonance (spr)- attenuated total reflection- grating spr coupling- optical waveguide spr coupling- spr dependencies and materials- plasmonics and nanoparticles.

Unit-III: New approaches in nanophotonics: near-field optics- aperture near-field optics- apertureless near-field optics- near-field scanning optical microscopy (nsom or snom)- snom based detection of plasmonic energy transport- snom based visualization of waveguide structures- snom in nanolithography- snom based optical data storage and recovery.

Unit-IV: Photonic molecular materials-i: electroluminescent organic materials - laser diodes - quantum well lasers:- quantum cascade lasers- cascade surface-emitting photonic crystal laser- quantum dot lasers- quantum wire lasers:-

Unit-V: Photonic molecular materials-ii: white leds - leds based on nanowires - leds based on nanotubes- leds based on nanorods high efficiency materials for oleds- high efficiency materials for oleds - quantum well infrared photo detectors.

Unit-VI: Photonic crystals: important features of photonic crystals- presence of photonic bandgap- anomalous group velocity dispersion- microcavity-effects in photonic crystals- fabrication of photonic crystals- dielectric mirrors and interference filters- photonic crystal laser- pc based leds- photonic crystal fibers (pcfs)- photonic crystal sensing.

References Books:

1. V.M. Shalaev and S.Kawata, Nanophotonics with Surface Plasmons (Advances in Nano-Optics and Nano-Photonics), 2007.
2. B.E.A. Saleh and A.C.Teich, Fundamentals of Photonics, John-Weiley & Sons, New York, 1993.
3. W. Ranier, “Nano Electronics and Information Technology”, Wiley, (2003).
4. K.E. Drexler, “Nano systems”, Wiley, (1992).
5. M.C. Pettey, “Introduction to Molecular Electronics”.
6. H.Masuhara, S.Kawata and F.Tokunaga, Nano Biophotonics, Elsevier Science, 2007.
7. M.Ohtsu, K.Kobayashi, T.Kawazoe, and T.Yatsui, Principles of Nanophotonics (Optics and Optoelectronics), University of Tokyo, Japan, 2003.
8. P.N. Prasad, Introduction to Biophotonics, John Wiley & Sons, 2003.
9. J.D.Joannopoulos, R.D.Meade and J.N.Winn, Photonic Crystals, Princeton University Press, Princeton, 1995.

M.Tech-NT I Year – II Sem.

NT206 - NANOTECHNOLOGY IN HEALTH CARE (Elective-II)

L	T	P/D	C
4	0	0	3

Unit-I: Nanotechnology in pharmaceutical applications: overview – developmental prolog - principle of development – neurophysiology – sensory physiology and muscle physiology - trends in nanobiotechnology - protein- and peptide-based compounds for cancer, diabetes, infectious diseases and organ transplant- therapeutic classes- focused pharmaceutical delivery systems.

Unit-II: Immunoassay techniques: understanding of antibody-based diagnostic techniques (immunoassay) - micro- and nano-immunosensors- bio-barcode assay- use of magnets, gold, DNA and antibodies- therapies and diagnostics for cancer and central nervous system disorders

Unit-III: Improved Medical Diagnostics-I: improved diagnostic products and techniques- i*n vivo* imaging capabilities by enabling the detection of tumors, plaque, genetic defects and other disease states-ability to control

Unit-IV: Improved Medical Diagnostics-II: Manipulations on the atomic scale- nanobot medical devices- logic and intelligence embedded into medical devices- stand alone sensing and computing devices.

Unit-V: Prosthetic and medical implants: New generation of prosthetic and medical implants- artificial organs and implants- artificial scaffolds or biosynthetic coatings- biocompatibility and reduced rejection ratio- retinal, cochlear, and neural implants, repair of damaged nerve cells, and replacements of damaged skin, tissue, or bone.

Unit-VI: Methods for diagnosis: Animation of the PCR-DNA profiling-cantilever sensors - targeted drug delivery-magnetic nanoparticles-cancer cell targeting-stem cell scaffolds - electrochemical impedance spectroscopy (ESI) - tethered lipid membranes

Reference Books:

1. Chemical Sensors and Biosensors; Brian, R Eggins; Wiley; New York, Chichester: 2002.
2. Biosensors and modern biospecific analytical techniques, Wilson & Wilson's Comprehensive Analytical Chemistry; Ed. L Gorton; Elsevier, Amsterdam, London; 2005.
3. The Immunoassay Handbook; Ed. David Wild; 3rd ed.; Amsterdam: Elsevier; 2005.
4. Electrochemical Methods: Fundamentals and Applications; Allen J Bard and Larry R Faulkner; Wiley, New York, Chichester: 2nd ed.; 2001.
5. Ultrathin Electrochemical Chemo- and Biosensors: Technology and Performance in Springer Series on Chemical Sensors and Biosensors; Volume Two; Ed. Vladimir M. Mirsky; Springer, Berlin; 2004

M.Tech-NT I Year – II Sem.

NT206 - NANOTECHNOLOGY: SOCIETY AND ENVIRONMENT

L	T	P/D	C
4	0	0	3

Unit-I: Introduction: Concept of Toxicology, dose-response curve, nanotoxicology laboratory models: cells, fish, rodent studies – Ecotoxicologic studies and nanotoxicology testing

Unit-II: Mechanisms of toxicity: Mechanism of nanosize particle toxicity - reactive oxygen species, role of oxidative stress - mechanisms and health effects - interactions of nanoparticles with cells and their impact on cells-cytotoxicity, apoptosis and necrosis.

Unit-III: Fate of nanomaterials in the environment: Sources, fate and environmental transport of nanomaterials in air, water and soil

Unit-IV: Human exposure to nanosized materials: Toxicology of airborne – manufactured nanomaterials in the environment, biological activities of nanomaterials - respiratory tract – efficient deposition of inhaled NSPS- cytotoxicity of ultrafine particles

Unit-V: Translocation of nanosized materials: Deposition of nsps in the respiratory - epithelium translocation – translocation to the circulatory system - neuronal uptake and translocation -translocation of nsps in the blood circulation to bone marrow in mice - studies of neuronal translocation of ufps from respiratory tract -exposure via GI tract and skin

Unit-VI: Risk assessment: Portals of entry and target tissue – risk assessment – ethical – legal and social implications–development of test protocols for nanomaterials – regulation of engineered nanomaterials in Europe and USA

Text books

1. Yuliang Zhao and Hari Singh Nalwa, 'Nanotoxicology: interactions of nanomaterials with biological systems, American Scientific Publishers, 2007
2. "Nanotoxicology - interactions of nanomaterials with biological systems", ED. Yuliang Zhao and Hari Singh Nalwa, June 2006

Reference books

1. E. P. Widmaier, H. Raff, K.T. Strang, vander, sherman and luciano, 'Human physiology: the mechanisms of body. functions', 9th edition, mcgraw hill, new york, 2004
2. Gunter oberdörster, eva oberdorster and jan oberdorster, *Environmental health perspectives*, volume 113 number 7 , july 2005
3. D. Drobne, 'Nanotoxicology for safe and sustainable nanotechnology', 58, pp. 471-478, december 2007
4. Monteiro-Riv, 'Nanotoxicology: characterization, dosing and health effects', Informa healthcare publishers, 2007
5. A Reference handbook of Nanotoxicology by M.Zafar Nyamadzi

M.Tech-NT I Year – II Sem.

NT207 NANOMATERIALS CHARACTERIZATION LAB

L	T	P/D	C
0	0	4	2

LAB - I

Unit I: Two methods for the synthesis of CNTs
(CVD method and Flame Synthesis)

Unit II: Nano – Catalyst Preparation by Chemical methods

Unit III: Synthesis of oxide Nanostructures / nano composites by Sol-gel process

LAB - II

Unit IV: Preparation of any two types of Ceramic Powders, $BaTiO_3$ (ball milling) & Al2O3 (flame)

Unit V: a) Composite preparation (Ball Milling)
b) X-ray Diffraction measurements of Nano Crystallites

Unit VI: Nano Particle Size Analysis

Reference books:

1. Advanced catalysis and Nano structured material by WR Moser.
2. Introduction to Nano Technology by Charles. P.Poole Jr and Frank J. Owens Wiley India Pvt Ltd.
3. Encyclopedia of Nanotechnology by H.S. Nalwa
4. Nano: The Essentials – Understanding Nano Scinece and Nanotechnology – by T.Pradeep; Tata Mc.Graw Hill

M.Tech-NT I Year – II Sem.
NT208 –TECHNICAL SEMINAR
(INDEPENDENT REVIEW PAPER)

L	T	P	C
0	**0**	**3**	**2**

There shall be two seminar presentations during I year I semester and I year II Semester. For seminar, a student under the supervision of a faculty member, shall collect the literature on a topic and critically review the literature and submit it to the Department in a report form and shall make an oral presentation before the Departmental Committee, which shall consist of the Head of the Department, a senior Faculty Member and the Supervisor and will jointly evaluate the report and presentation. For each Seminar there will be only internal evaluation of 50 marks. A candidate has to secure a minimum of 50% to be declared successful.

In the First semester the report must be in the form of the review paper with a format used by IEEE / ASME etc. In the Second semester Technical Seminar in the form of Independent Review Paper must be of high quality fit for publication in a reputed conference / journal.

The evaluation format for seminar is as follows:

- Day to day evaluation by the Supervisor : 10 marks
- Final Report : 10 marks
- Presentation : 30 marks

M.Tech-NT II Year – I Sem.

NT301 - COMPREHENSIVE VIVA-VOCE

L	T	P	C
-	-	-	2

There shall be a Comprehensive Viva-Voce in II year I Semester. The Comprehensive Viva-Voce will be conducted by a Committee consisting of Head of the Department and two Senior Faculty members of the Department. The Comprehensive Viva-Voce is aimed to assess the students' understanding in various subjects he/she studied during the M.Tech course of study. The Comprehensive Viva-Voce is valued for 50 marks by the Committee. There are no internal marks for the Comprehensive Viva-Voce. A candidate has to secure a minimum of 50% to be declared successful.

M.Tech-NT II Year – I Sem.
NT302- PROJECT SEMINAR-I

L	T	P	C
0	0	0	2

In II year I semester, a project seminar shall be conducted for 50 marks and for 2 credits (there is no external evaluation). The evaluation for the project seminar shall be done in two stages, i.e. in the middle of the semester and at the end of the semester. The mid-semester seminar evaluation shall carry 20 marks and the end semester seminar evaluation shall carry 30 marks. The report for the mid-semester project seminar will carry 5 marks and remaining marks shall be for presentation and discussion. The report for end semester project seminar shall be for 10 marks and the remaining marks shall be for presentation and discussion. A candidate shall secure a minimum of 50% to be declared successful.

M.Tech-NT II Year – I Sem.
NT303 - PROJECT WORK (PART- I)

L	T	P	C
-	-	-	**18**

Every candidate shall be required to submit thesis or dissertation after taking up a topic approved by the Project Review Committee.

A Project Review Committee (PRC) shall be constituted comprising of Heads of all the Departments which are offering the M.Tech programs and three other senior faculty members concerned with the M.Tech. programme.

Registration of Project Work: A candidate is permitted to register for the project work after satisfying the attendance requirement of all the previous semesters and after obtaining the approval of the PRC.

After satisfying 6.2, a candidate has to submit, in consultation with his project supervisor, the title, objective and plan of action of his project work to the PRC for its approval. Only after obtaining the approval of PRC the student can initiate the Project work. This process is to be completed within four weeks of commencement of II year I semester.

The student shall submit a project report at the end of II year I semester, and the same shall be evaluated at the end of that semester by the PRC as SATISFACTORY or UNSATISFACTORY. In the case of unsatisfactory declaration, the student shall re-submit the Project report after carrying out the necessary modifications / additions in the Project work, within the specified time as suggested by the PRC.

M.Tech-NT II Year – II Sem.
NT401 - PROJECT SEMINAR-II

L	T	P	C
0	0	0	2

A project seminar shall be conducted for 50 marks and for 2 credits (there is no external evaluation). The evaluation for the project seminar shall be done in two stages, i.e. in the middle of the semester and at the end of the semester. The mid-semester seminar evaluation shall carry 20 marks and the end semester seminar evaluation shall carry 30 marks. The report for the mid-semester project seminar will carry 5 marks and remaining marks shall be for presentation and discussion. The report for end semester project seminar shall be for 10 marks and the remaining marks shall be for presentation and discussion. A candidate shall secure a minimum of 50% to be declared successful.

M.Tech-NT II Year – II Sem.

NT402 - PROJECT WORK AND DISSERTATION

L	T	P	C
-	-	-	20

A candidate is permitted to submit Project Dissertation only after successful completion of PG subjects (theory and practical), seminars, Comprehensive viva-voce, PG Project Part–I, and after the approval of PRC, not earlier than 40 weeks from the date of registration of the project work. For the approval of PRC the candidate shall submit the draft copy of thesis to the Head of the Department and shall make an oral presentation before the PRC. Along with the draft thesis the candidate shall submit draft copy of a paper in standard format fit for publication in Journal / Conference, based on the project thesis, to the Head of the Department with due recommendation of the supervisor.

- Five copies of the Project Dissertation certified by the Supervisor and Head of the Department shall be submitted to the College.

- The dissertation shall be adjudicated by one examiner selected by the College. For this, Head of Department shall submit a panel of 3 examiners, who are eminent in that field, with the help of the PRC. The Chief Superintendent of the college in consultation with the college academic committee shall nominate the examiner.

- If the report of the examiner is not favorable, the candidate shall revise and resubmit the Dissertation, in the time frame as prescribed by PRC. If the report of the examiner is unfavorable again, the thesis shall be summarily rejected. The candidate can re-register only once for conduct of project and evaluation of Dissertation, and will go through the entire process as mentioned above. The total duration for the M.Tech program is limited to four years.

- If the report of the examiner is favorable, viva-voce examination shall be conducted by a Board consisting of the Head of the Department, Supervisor and the Examiner who adjudicated the Dissertation. The Board shall jointly report the student's performance in the project work as – (a) Excellent, or (b) Good, or (c) Satisfactory, or (d) Unsatisfactory, as the case may be. In case, the student fails in the viva-voce examination, or gets the Unsatisfactory grade, he can re-appear only once for the viva-voce examination, as per the recommendations of the Board. If he fails at the second viva-voce examination, the candidate can re-register only once for conduct of project and evaluation of Dissertation, and will go through the entire process as mentioned above. The total duration for the M.Tech program is limited to four years.