MASTER OF TECHNOLOGY(NANOTECHNOLOGY)
REVISED SCHEME OF EXAMINATION (FOUR SEMESTERS)

FIRST SEMESTER

S. No.	Course No.	Subject	Marks			Duration of End Sem. Exam	Schedule of Teaching			Credits
			End Sem Exam	Sessional	Total	Exam. Hours	L	T	P	
1.	PHY531T	Solid State Physics	50	50	100	3	3	-	-	3
2.	PHY532T	Foundations of nanoscale Science & Tech.	50	50	100	3	3	-	-	3
3.	PHY533T	Electronics & Optical Properties of Materials	50	50	100	3	3	-	-	3
4.	PHY534T (Elective)	Material Science	50	50	100	3	3	-	-	3
5.	PHY535T (Elective)	Experimental Methods in Nanotechnology	50	50	100	3	3	-	-	3
6.	PHY536P	Lab 1	40	60	100	4	-	-	-	2
7.	PHY537S	Seminar				2	-	-	-	1
SECOND SEMESTER										
1.	PHY541T	Characterization tools for nanomaterials	50	50	100	3	3	-	-	3
2.	PHY542T	Micro Electro Mechanical Systems(MENS & Nano Electro Mechanical Systems (NEMS)	50	50	100	3	3	-	-	3
3.	PHY543T (Elective)	Nanoelectronics & Devices	50	50	100	3	3	-	-	3
4.	PHY544T (Elective)	Nanoscale magnetic materials and Devices	50	50	100	3	3	-	-	3
5.	PHY545T (Elective)	Computer Technology	50	50	100	3	3	-	-	3
6.	PHY546P	Lab -II	40	60	100	4	-	-	-	2
7	PHY547S	Seminar				2	-	-	-	1
THIRD SEMESTER										
1.	Preparatory Work for Dissertation		-	-	-	-	-	-	20	10
FOURTH SEMESTER										
1.	Dissertation		-	-	-	-	-		32	16

M. TECH 1st SEMESTER NANOTECHNOLOGY

SOLID STATE PHYSICS : PHY531T

L	T			
3	0	Credits	:	03
		Sessional	:	50
Duration of Exam. 3 Hours		End Sem. Exam.	:	50
		Total	:	100

CRYSTAL PHYSICS:

Periodic array of atoms, translation vectors, unit cell, space lattice, Miller indices, simple crystal structures, bonds in solids. nanocrystalline solids, physical properties of nanomaterials, melting points and lattice phonons, constants, mechanical properties.

X-ray diffraction methods and their applications in identification of crystal structures, Geometric factor reciprocal lattice.

LATTICE VIBRATIONS AND THERMAL PROPERTIES OF SOLIDS:

Concept of lattice vibrations and thermal heat capacity, classical, Einstein and Debye theories of molar heat capacity and their limitations, concept of phonons.

BAND THEORY OF SOLIDS:

Origin of bands, band theory of solids, motion of electron in periodic field of crystal, Kronig-Penny model, Brillouin zones, effective mass, concept of holes, Electronic density of states,distinction between metal, insulator and semi-conductor, Fermi level, Hall effect, electronic conduction in nanomaterials, effect of nanometer length scale on the system total energy, size effect on energy gap- quantum confinement, quantum dots, supperlattices.

REFERENCE BOOKS:

1. Introduction to Solid State Physics
   C. Kittel
2. Solid State Physics
   A.J. Dekker
3. Solid State Physics
   S.O. Pillai
4. Nanostructures and Nanomaterials
   Guozhong CaO, Imperial College Press, 2006

M. TECH 1st SEMESTER NANOTECHNOLOGY

FOUNDATIONS OF NANOSCALE SCIENCE AND TECHNOLOGY: PHY532T

L	T				
3	0	Credits	:	03	
		Sessional	:	50	
Duration of Exam. 3 Hours		End Sem. Exam.	:	50	
		Total	:	100	

NANOTECHNOLOGY:

Background, what is nanotechnology, types of nonotechnology and nano-machines, top down and bottom up techniques, atomic manipulation-nanodots, semi-conductor quantum dots, self-assembly monolayers, Simple details of characterization tools- SEM, TEM, STM, AFM.

NANOMATERIALS:

What are nanomaterials? Preparation of nanomaterials- solid state reaction method, Chemical Vapor Deposition, Sol-gels techniques, Electrodeposition, Ball Milling, Introduction to lithography, pulse laser deposition (PLD), Applications of nanomaterials

CARBON TUBES:

New forms of carbon, Carbon tubes-types of nanotubes, formation of nanotubes, Assemblies, purification of Carbon nanotubes, Properties of nanotubes, applications of nanotubes.

OPTICS, PHOTONICS AND SOLAR ENERGY:

Light and nanotechnology, Interaction of light and nanotechnology, Nanoholes and photons, Solar cells, Optically useful nanostructured polymers, Photonic Crystals.

FUTURE APPLICATIONS:

MEMs, Nanomachines, Nanodevices, quantum computers, Opto-electronic devices, quantum electronic devices, Environmental and Biological applications.

REFERENCE BOOKS:

1. Nanotechnology-Basic Science and Emerging Technologies
   Mick Wilson, Kamali Kannangra Geoff Smith, Michelle Simons and Burkhard Raguse, Overseas Press.
2. Nanotechnology-A Gentle Introduction to the Next Big Idea
   Mark Ratner and Daniel Ratner, Prentice Hall
3. Nanotechnology
   Rebecca L Johnson, Lerner Publications.
4. Introduction to Nanotechnogy
   Charles P. Poole Jr., Chapman and Hall/CRS

M. TECH 1st SEMESTER NANOTECHNOLOGY

ELECTRONIC AND OPTICAL PROPERTIES OF MATERIALS: PHY533T

L	T			
3	0	Credits	:	03
		Sessional	:	50
Duration of Exam. 3 Hours		End Sem. Exam.	:	50
		Total	:	100

Electronic Properties of Materials:

Introduction - An overview of quantum mechanical concepts related to low-dimensional systems.

Concepts related to Electronic Structure - Energy bands, Direct-and Indirect-gap semiconductors, Variation of energy bands with alloy composition and its exploitation for devices, Lattice matching.

Interacting Quantum Wells - Coupling between Quantum wells, Superlattices, Wavefunctions and Density of States for superlattices, Unit cell for quantum well, for quantum wire and for quantum dot.

Quantum confined systems - Classification of Quantum confined systems, Electrons and holes in Quantum wells. Surface to volume ratio in quantum confined systems, Spherical cluster approximation, Exterior surface area, Interior surface area.
Electronic conduction, Systems confined to one, two or three dimension and their effect on property.
Single Electron Effects: Coulomb Blockade, Coulomb Staircase, Coulomb Oscillations
Quantum Phenomena: Tunneling, Quantum Confinement, Quantum confinement, quantum dots, colloidal quantum dots.

Optical Properties - Luminescence in nanomaterials, Excitons: Weekly bound excitons, tightly bound excitons, excitons in molecular crystals and in nanostructures.

Non-Linear Optics: Non-linear optical susceptibility second and third order optical susceptibilities. Harmonic Generation. Multiple photon excitation. Stimulated Raman Scattering. Stimulated Brillouin Scattering. Non-linear optical properties of nano structures

Novel properties of nanomaterials-size and shape dependent optical, emission, electronic, transport, photonic, refractive index, mechanical, magnetic catalytic/photocatalytice properties.

REFERENCE BOOKS:

M. TECH 1st SEMESTER NANOTECHNOLOGY

MATERIAL SCIENCE: PHY534T

L	T			
3	0	Credits	:	03
		Sessional	:	50
Duration of Exam. 3 Hours		End Sem. Exam.	:	50
		Total	:	100

INTRODUCTION:

Classification of materials, Structure property relationship in material, multiphase materials, Modern materials – polymers, ceramics, composites, nanomaterials.

CRYSTAL IMPERFECTIONS:

Point and line imperfections, Frankel Defects, Schottky defects, dislocations, Burger Vectors, Surface Imperfections, Stacking faults.

DIFFUSION IN SOLIDS:

Fick's law of diffusion, Temperature dependence of diffusion coefficients, The Kirkendall effect, the atomic model of diffusion.

MAGNETIC MATERIALS:

Magnetic behaviour of materials, classification of magnetic materials, Ferromagnetism and Antiferromagnetism, The soft and hard magnetic materials, magnetic bubbles and magnetic bubble memory.

DIELECTRICS:

Polarization and dielectric constant, Basic relationships, Frequency and temperature dependent dielectric constant, Claussius Mossotti equation, dielectric loss factor, basic considerations, relaxation time and activation energy, tangent of dielectric loss angle, displacement and complex dielectric constant and basic equations, ferrites.

SUPERCONDUCTORS:

Zero resistivity, critical magnetic field and critical current density, Meissner effect, Type I & II Superconductors, Josephson effect, High Tc superconductors, BCS theory of superconductivity.

REFERENCE BOOKS:

1. **Material Science and Engineering**
   V.Raghavan
2. **Introduction to Materials Science for Engineers**
   James F.Shackelford
3. **Electrical Properties of Materials**
   G.C.Jain
4. **Material Science**
   A.J.Dekker

M.TECH. 1st SEMESTER NANOTECHNOLOGY

EXPERIMENTAL METHODS IN NANOTECHNOLOGY: PHY535T

L	T				
3	0	Credits	:	03	
		Sessional	:	50	
Duration of Exam.	3 Hours	End Sem. Exam.	:	50	
		Total	:	100	

EXPERIMENTAL METHODS FOR FABRICATION:

Semiconductor processing techniques- Cleaning, etching, oxidation, Gettering, Doping, Epitaxy; Lithography-Photolithography, Electron beam lithography, X-Ray lithography, Focused Ion Beam Lithography (FIB); Soft Lithography- Micro-contact Printing, Molding, Nanoimprint, Dip-Pen Nanolithography, AFM based Nanolithography ;Experimental techniques used in synthesis of Carbon nanotubes-Arc Discharge, Laser Furnace, Chemical Vapor Deposition(CVD);Template Synthesis.; Self Assembly and Bio/Chemical Methods

EXPERIMENTAL TECHNIQUES FOR CHARACTERIZATION:

Structural Characterization- X-Ray Diffraction (XRD), X-Ray Filter, Ewald construction, Small Angle X-Ray Scattering (SAXS), Scanning Electron Microscopy, Raman Spectrometery.

REFERENCE BOOKS:

1. **Nanostructures and Nanomaterials-Synthesis, Properties and Applications**
   Guozhong Cao,Imperial College Press
2. **Nanotechnology-An Introduction to Nanostructuring Techniques**
   Michael Kohler,Wolfgang Fritzsche,Wiley-VCH
3. **Microfabrication and Nanomanufacturing**
   Mark J (ed)Jackson,Taylor and Francis
4. **Carbon Nanotubes:Science and Applications**
   Laurie Kelly, Meyyappan Meyyappen,CRC Press

M.TECH. 2nd SEMESTER NANOTECHNOLOGY

CHARACTERIZATION TOOLS FOR NANOMATERIALS: PHY541T

L	T			
3	0	Credits	:	03
		Sessional	:	50
Duration of Exam. 3 Hours		End Sem. Exam.	:	50
		Total	:	100

INTRODUCTION:

Need for characterization, Challenges, Brief review of various Characterization tools.

STRUCTURAL CHARACTERIZATION TECHNIQUES:

Raman spectroscopy : Instrumentation, Quantum mechanical explanation of Raman effect, Selection rules, Raman spectroscopy of nanomaterials, Resonance Raman Spectroscopy, Surface Enhanced Raman Spectroscopy(SERS) : Principle, instrumentation and applications for nanomaterials.

Fourier Transform Infrared Spectroscopy: Instrumentation, Advantages, Interferrogram, Apodization, Generation of spectra from interferrogram, FTIR spectra of nanomaterials.

Flame spectro-photometry.

CHEMICAL CHARACTERIZATION:

Introduction, Optical Spectroscopy-Absorption and Transmission Spectroscopy; Photoluminescence (PL); Electron Spectroscopy; Ionic Spectroscopy,
Thermogrvimetric analysis, Differential thermal ananlysis

CAPABILITIES AND LIMITATIONS OF TECHNIQUES:

Elemental sensitivity, Detection Limit, Lateral Resolution, Effective probing depth

REFERENCE BOOKS:

1. **Nanostructures and Nanomaterials-Synthesis, Properties and Applications**
   Guozhong Cao,Imperial College Press
2. **Handbook of Nanophase and Nanomaterials(Vol 1 and II)**
   Zhong Lin Wang,Springer
3. **Encyclopedia of Materials Characterization**
   C.R.Brundle,C.A.Evans Jr.,and S.Wilson(eds),Butterworth-Heinemann,Stoneham,Ma
4. **Surface Analysis:The Principal Techniques**
   J.C.Vickerman,John Wiley and Sons
5. **Introductory Raman spectroscopy(Academic Press)** J R Ferraro and K Nakamoto

M. TECH 2nd SEMESTER NANOTECHNOLOGY

MICRO-ELECTRO MECHANICAL SYSTEM (MEMS) & NANO-ELECTRO MECHANICAL SYSTEMS (NEMS): PHY542T

L	T			
3	0	Credits	:	03
		Sessional	:	50
Duration of Exam. 3 Hours		End Sem. Exam.	:	50
		Total	:	100

NANO-AND MICROSCIENCE, ENGINEERING AND TECHNOLOGY:

Introduction and overview, MEMS and NEMS definitions, Taxonamy of Nano-and Microsystems, Materials used for synthesis and Design of MEMS and NEMS.

NANO-AND MICRO SYSTEMS:

Classification and considerations, Biomimetics, Biological analogies, and design–Biomimetics Fundamentals, Biomimetics for NEMS and MEMS, Nano-ICs and Nanocomputer architectures, Biomimetics and nervous systems.

MODELING OF MICRO-AND NANOSCALE ELECTROMECHANICAL SYSTEMS:

Introduction to modeling, analysis and simulation, basic electro-magnetic with application to MEMS and NEMS, modeling developments of micro-and nanoactuators, energy conversion in NEMS and MEMS.

SYNTHESIS, DESIGN AND FABRICATION OF MEMS:

Introduction, Deposition of multilayers, Microfabrication of microcoils / windings of copper, nickel and aluminium through electro deposition method, micromachined polymer magnets, axial electromagnetic micromotors, micromachined polycrystalline SiC microimotors.

REFERENCE BOOKS:

1.Micro-Electro Mechanical and Nano-Electro Mechanical Systems, Fundamental of Nano-and Micro-Engineering

Sergey Edward Lyshevski, Lyshevski Edward Lyshevski,CRC Press

2.Nanomaterials:Synthesis,Properties and Applications
A.S.Edelstein and R.C.Cammarata(edits),Institute of Physics
3.Micro-Electro Mechanical and Nano-Electro Mechanical Systems
Sergy Edward Lyshevski,CRC Press

M.TECH. 2nd SEMESTER NANOTECHNOLOGY

NANOELECTRONICS AND DEVICES: PHY543T

Duration of Exam. 3 Hours	Credits	:	03
	Sessional	:	50
	End Sem. Exam.	:	50
L T	Total	:	100
3 0			

INTRODUCTION:

Moore's Law and its significance; Quantun Effects as limitation to the Miniaturization; Nanoelectronics and its development; Strategies for fabrication of nano devices; Development of Electronics-Semiconductor Transistors; Some tools of Micro-and Nanofabrication.

QUANTUM ELECTRONIC DEVICES:

High Electron Mobility Transistors; Quantum Interference Transistors; Carbon Nanotube Transistors; Quantum Corrals in Electronics

MOLECULAR ELECTRONICS:

Quantum Information and Quantum Computers;Difference between Quantum Computer and Classical Computer; Working of a Quantum Computer; Decoherence; Experimental Implementation of Quantum Computers.

SPECIAL DEVICES:

Quantum Dot Devices; Resonant Tunneling Devices (RTDs); Electron Wavefunction Effect Devices; Carbon Nanotube Sensors

REFERENCE BOOKS:

1. Nanotechnology-Basic Science and Emerging Technologies
   Mick Wilson et al,Overseas Press
2. Carbon Nanotubes:Science and Applications
   Laurie Kelly, Meyyappan Meyyappen,CRC Press
3. Nanomaterials:Synthesis,Properties and Applications
   A.S.Edelstein and R.C.Cammarata(edits),Institute of Physics
4. Molecular Electronic Devices
   F.L.Carter et al (Ed); New York: North Holland

M.TECH. 2nd SEMESTER NANOTECHNOLOGY

NANOSCALE MAGNETIC MATERIALS AND DEVICES:PHY544T

L T	Credits	:	03
3 0	Sessional	:	50
Duration of Exam. 3 Hours	End Sem. Exam.	:	50
	Total	:	100

MAGNETISM

Magnetostatics; Para-,dia and ferromagnetism; Magnetic anisotropy; Domains and domain walls; Nanomagnetic materials-Particulate nanomagnets; Geometrical Magnets; Magnetoresistance- Giant Magneto Resistance(GMR); Spin Valves; Tunneling Magnetoresistance.

FERROMAGNETIC PROPERTIES

Fundamental Magnetic Properties; Nanocomposite Soft Magnetic Materials; Hard Magnetic Materials; Effects of Particle size and Surface Chemistry on Magnetic Properties.

PROCESSING AND PROPERTIES OF NANOMATERIALS

Introduction; Classification; The thermodynamics and Kinetics of Phase Transformations; Synthesis Methods-Rapid Solidification Processing from the Liquid State, Inert Gas Condensation, Electrodeposition and Mechanical Methods.

DEVICES

Magnetic data Storage Devices, Nanosensors, Sensing Mechanisms of different sensors, Fabrication of sensors, Solar cells and their fabrication.

REFERENCE BOOKS:

1. Nanoscale Science and Technology
   Robert Kelsall, Ian Hamley, and Mark Geoghegan (Editors)
   John-Wiley
2. Nanomaterials:Synthesis,Properties and Applications
   A.S.Edelstein and R.C.Cammarata(edits),Institute of Physics
3. Nanostructures and Nanomaterials-Synthesis, Properties and Applications
   Cao,Imperial College Press
4. Nanotechnology-Basic Science and Emerging Technologies

MASTER OF TECHNOLOGY NANOTECHNOLOGY

2nd - SEMESTER

L	T				
3	0	Credits	:		03
		Sessional	:		50
Duration of Exam. 3 Hours		End Sem. Exam.	:	50	
		Total	:		100

COMPUTER TECHNOLOGY- PHY545T

Part A: Computer Architecture:

Introduction to Operation System, Programme Loops, Programming Arithmetic and Logic Operations, Subroutines, Input and Output Programming, Multiprogramming, time-sharing, distributed systems, real time system; overview of pipelining, array processing, multiprocessing, SISD, SIMD, MISD, MIMD architecture.

Part B: C Programming:

Constants, variables, data types; simple input-output statements like, scanf, printf, getch, getche, getchar, gets, putch, puts; loops; if-else; case structure; I-d and 2-d arrays; functions; programming using above statements.

1. Operating System Concepts –Silberschatz & Galvin, Addison Wesley.
2. Programming with C – B.S Gottfried, Schaum Series, TMH
3. Computer Architecture & Parallel Processing – Hwang & Briggs.
4. Computer system architecture, M. Morris Mano- PHI.