DEPARTMENT OF APPLIED PHYSICS

SYLLABUS

M.TECH. NANOTECHNOLOGY
(FULL TIME)

FIRST SEMESTER

SUBJECT : **SOLID STATE PHYSICS** PAPER-**1** SUBJECT CODE: **NT-501**

PERIOD PER WEEK : Lecture –04 ; Tutorial –01 CREDITS : **4.5**
Maximum Marks : End Term –80 , Continuous Evaluation –20

Crystal Bonding and Structure, Crystalline, Polycrystalline & Non- Crystalline Solids, X-ray diffraction procedures. Defects in Solids, Band theory of solids, Free Electron Theory. transport properties of materials, dielectric properties of solids, magnetic materials and its properties. Ferrits & Nano-Magnets**.** optical and thermal properties of semiconductors**.** Structures of Ceramics, Polymers & Composites**.**

REFRENCES :

1. Introduction to Solid State Physics : Kittel
2. Introduction to Theory of Solids : H.M.Rosenberg

DEPARTMENT OF APPLIED PHYSICS

M.TECH. NANOTECHNOLOGY
(FULL TIME)

FIRST SEMESTER

SUBJECT : **INSTRUMENTATION** PAPER-**2** SUBJECT CODE: **NT-502**

PERIOD PER WEEK : Lecture –04 ; Tutorial –01 CREDITS : **4.5**
Maximum Marks : End Term –80 , Continuous Evaluation –20

Characterization of Materials, Resistivity Probing, Hall Mobility, Optical mapping, auto radiography, Electron Micrography. Phase Identification. Chemical assessment, Spectrophotometery, Differential Thermo Analysis. Determination of Physical Structure, Optical Methods of Structure determination, Optical microscopy, Electron Microscopy (SEM,TEM, AFM etc.)

Spectroscopic techniques, NMR, ESR, Photoacousitc spectroscopy. Electron Microprobe Analysis. Surface analytical techniques, electron spectroscopy's , XPS (ESCA), UV- Photoemission and inverse photoemission, Electronics structure determination using synchrotron radiation sources, X-ray absorption techniques.

REFRENCES :

1. Crystal Growth and Characterisation : R. Ueda and J.B. Mullin
2. Solid State Physics : Ibach and Luth
3. Experimental Techniques of Surface Science: Woodruff and Delchar

M.TECH. NANOTECHNOLOGY
(FULL TIME)

FIRST SEMESTER

SUBJECT : **ATOM & PHOTON PHYSICS** PAPER-**3** SUBJECT CODE: **NT-503**

PERIOD PER WEEK : Lecture –04 ; Tutorial –01 CREDITS : **4.5**

DEPARTMENT OF APPLIED PHYSICS

Maximum Marks : End Term –80 , Continuous Evaluation –20

Atomic scale structure of material. Magnetism: moments, environments and interactions, order and magnetic structure. Scattering theory: Excitations of crystalline materials, magnetic excitations, sources of X-rays and neutrons.

Interaction of light with photon: L.A.S.E.R. Chaotic light and coherence. Laser spectroscopy. Multiphoton processes. Light scattering by atoms. Electron scattering by atoms. Coherence and cavity effects in atoms. Trapping and cooling.

REFRENCES :

1. Light & Matter : Yehuda Band
2. NanoPhotonics : Paras N. Prasad

DEPARTMENT OF APPLIED PHYSICS

M.TECH. NANOTECHNOLOGY

(FULL TIME)

FIRST SEMESTER

SUBJECT : **PHYSICS OF NANO MATERIALS** PAPER-**4** SUBJECT CODE: **NT-504**

PERIOD PER WEEK : Lecture –04 ; Tutorial –01 CREDITS : **4.5**

Maximum Marks : End Term –80 , Continuous Evaluation –20

Introduction to Nanotechnology: Characteristic scale for quantum phenomena, nanoparticles, nano-clusters, nanotubes, nanowires and nanodots. Drexler-Smalley debate - realistic projections.

Electronic structure: quantum wells quantum dots, quantum wires. Nano clusters, clusters of rare gases, clusters of alkali metals. The Jellium model. Discovery of C_{60}. Fullerene structure and bonding. Carbon nano tubes. Electronic structure. Transport, optical, thermal and mechanical properties of nano tubes. Synthesis of nanomaterials using chemical techniques. Application of Nano Materials. Micro & Nano electromechanical systems. Fabrication techniques of Nano devices.

REFRENCES :

1. D.Bimberg, M.Grundman, N.N. Ledenstov : Quantum Dot Heterostructures
2. Sharma Ashutosh, Jayesh : Adv. In Nano Science & Tech.
3. Dresselhaus M.S. & Avouris : CNT Synthesis, Structure, Properties & Application

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M.TECH. NANOTECHNOLOGY

(FULL TIME)

FIRST SEMESTER

ELECTIVE-I

SUBJECT : PAPER-**Physics of Nano Fluids and Surfaces 5(i)** SUBJECT CODE: **NT-511**

PERIOD PER WEEK : Lecture –04 ; Tutorial –01 CREDITS : **4.5**

Maximum Marks : End Term –80 , Continuous Evaluation –20

Nanofluidics and surfaces: liquid structure near solid-liquid interfaces (simple liquids; layering electrolytes: Poisson-Boltzmann equation; Debye Hückel approx.) Hydrodynamic boundary condition: slip vs. non-slip, electro kinetic effects (electrophoresis, electro osmotic effect, electro viscous effect), surface reconstruction, dangling bonds and surface states

Band theory of solids, transport properties of materials, dielectric properties of solids, magnetic properties of materials. Vacuum technology.

X-ray diffraction procedures. Electrical, optical and thermal properties of semiconductors.

REFERENCES:

1. Introduction to Solid State Physics : Kittel

2. Introduction to Theory of Solids : H.M. Rosenberg

DEPARTMENT OF APPLIED PHYSICS

M.TECH. NANOTECHNOLOGY

(FULL TIME)

FIRST SEMESTER

ELECTIVE-I

SUBJECT : **PHYSICS OF AMORPHOUS MATERIALS** PAPER- **5(ii)** SUBJECT CODE: **NT-512** CREDITS : **4.5**

PERIOD PER WEEK : Lecture –04 ; Tutorial –01

Maximum Marks : End Term –80 , Continuous Evaluation –20

Physics of Amorphous Material: preparation of amorphous materials, metallic glass, thermal evaporation techniques such as sputtering, CVD Techniques, quenching. Glasses, theory for glass transition, glass transition temperature. Chalcogenide glasses. Structure of disordered materials. Experimental techniques, electronic density of states. Localization phenomenon, transport , optical and dielectric properties.

REFRENCES :

1. Amorphous Materials : S.R. Elliot
2. Physics of Amorphous Solids : Richard Xylen
3. Electronic process in Non-Crystalline Materials : Davis & Mott.
4. Disordered Material an Introduction : Paolo M. Ossi

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M.TECH. NANOTECHNOLOGY

(FULL TIME)

FIRST SEMESTER

ELECTIVE-I

SUBJECT : **LASER TECHNOLOGY** PAPER-5**(iii)** SUBJECT CODE: **NT-513**

PERIOD PER WEEK : Lecture –04 ; Tutorial –01 CREDITS : **4.5**

Maximum Marks : End Term –80 , Continuous Evaluation –20

Interaction of radiation with matter, absorption and stimulated emission, absorption and gain coefficient, spontaneous emission, homogeneous and inhomogeneous broadening, Doppler width. basic principles of lasers , properties of laser beams, population inversion in three and four level lasers, resonance frequencies, modifications of the laser output, single mode operation, Q- switching. laser materials and types of lasers, solid state lasers, characteristics of dye lasers, semiconductor lasers. Laser applications. Material processing metrology and Remote sensing. Laser induced controlled thermonuclear fusion. Laser applications in spectroscopy.

REFRENCES :

1. Introduction to Laser Physics : K. Shimoda
2. Laser Spectroscopy A Basic Concepts and Instrumentation : W. Demtr der
3. Atomic and Laser Spectroscopy : A. Corney

DEPARTMENT OF APPLIED PHYSICS

M.TECH. NANOTECHNOLOGY

(FULL TIME)

FIRST SEMESTER

ELECTIVE-I

SUBJECT : **SEMICONDUCTOR DEVICES** PAPER-**5(iv)**

SUBJECT CODE: **NT-514** CREDITS : **4.5**

PERIOD PER WEEK : Lecture –04 ; Tutorial –01

Maximum Marks : End Term –80 , Continuous Evaluation –20

Semi conducting materials, p-n junction, space charge and electric field distribution at junctions, forward & reversed biased condition, minority & majority carrier currents, Zener and avalanche break downs, Schottky barrier, Shockley diode & silicon control rectifier, Zener diodes, tunnel diodes, photo diodes. Two port network analysis, H,Y & Z parameters, BJT in CE configuration, Constants of CB & CE amplifier, FET, MOSFET, Equivalent circuit of FET. Source amplifier. Idea of transistor biasing and amplifiers.

REFRENCES :

1. Electronic Devices & Circuits : Millman & Halkins
2. Solid State Electronic Devices : Ben G Streetman
3. Microwave Principle : W.J. Reich
4. Electronics : S. Bhadran

DEPARTMENT OF APPLIED PHYSICS

M.TECH. NANOTECHNOLOGY

(FULL TIME)

FIRST SEMESTER

SUBJECT : **LAB PRACTICE-I**

SUBJECT CODE: **NT-541** CREDITS : **2.5**

PERIOD PER WEEK : Practical - 05

Maximum Marks : End Term –60 , Continuous Evaluation –40

List of Experiments:

1. G.M. Tube Characteristics
2. Absorption Coefficient using GM counter
3. Design & Study of CE amplifier
4. Study of operational amplifier IC – 741
5. Study of Emitter follower
6. I/V characteristics of FET
7. I/V characteristics of MOSFET

DEPARTMENT OF APPLIED PHYSICS

M.TECH. NANOTECHNOLOGY
(FULL TIME)

SECOND SEMESTER

SUBJECT: **PROCESSING AND FABRICATION OF NANOSTRUCTURES** PAPER-**1** SUBJECT CODE: **NT-551** CREDITS : **4.5**

PERIOD PER WEEK : Lecture –04 ; Tutorial –01
Maximum Marks : End Term –80 , Continuous Evaluation –20

Si processing methods: Cleaning /etching, oxidation-oxides, Gettering, doping, epitaxy. Top-down techniques: Photolithography, other optical lithography's (EUV, X-ray, LIL), particle beam lithography's (e-beam, FIB, shadow mask evaporation), probe lithography's. Processing of III-V semiconductors including nitrides. Molecular-beam epitaxy, chemical beam epitaxy, metal-organic CVD (MOCVD). Bottom-up techniques: self-assembly, self-assembled monolayer, directed assembly, layer-by-layer assembly. Combinations of top-down and bottom-up techniques: current state of the art

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REFRENCES :

1. Nanostructures : Tsakalakos, Ovidko & Vasudevan
2. Physics of Amorphous Solids : Richard Xylen
3. Nanostructured Films & Coatings : Gang Moog Chow

DEPARTMENT OF APPLIED PHYSICS

M.TECH. NANOTECHNOLOGY

(FULL TIME)

SECOND SEMESTER

SUBJECT: **PROPERTIES OF LOW DIMENSIONAL SYSTEM** PAPER-**2**
SUBJECT CODE: **NT-552** CREDITS : **4.5**

PERIOD PER WEEK : Lecture –04 ; Tutorial –01
Maximum Marks : End Term –80 , Continuous Evaluation –20

Transport properties: quantization of conductance, density of states, Coulomb blockade, Kondo effect. Hall, quantum Hall, fractional quantum hall effects

Vibrational and thermal properties: phonons, quantization of phonon modes, heat capacity and thermal transport

Optical properties: Collective oscillation (Gustav-Mie explanation), surface plasmon resonance, interactions between Nanoparticles, coupled-dipole approximation, Linear and nonlinear optical properties. Optical quantum well & particle.

REFRENCES :

1. Handbook of nanotechnology : Bhushan
2. Nano optoelectronics : M.Grundman
3. Nanophotonics : Paras N.Prasad

DEPARTMENT OF APPLIED PHYSICS

M.TECH. NANOTECHNOLOGY

(FULL TIME)

SECOND SEMESTER

SUBJECT: **MOLECULAR PHYSICS** PAPER-**3**

SUBJECT CODE: **NT-553** CREDITS : **4.5**

PERIOD PER WEEK : Lecture –04 ; Tutorial –01

Maximum Marks : End Term –80 , Continuous Evaluation –20

Molecular structure: Born-Oppenheimer approximation; Electronic structure ionic and covalent bonding, H_2, H_2^+; Vibrational and rotational structure.

Molecular spectra: Microwave, infrared and optical spectra of molecules; selection rules, experimental set-ups and examples; Raman spectroscopy. ortho-para states.

Molecular processes: Collisions with electrons and heavy particles; Experimental techniques.

REFERENCES

1. Physics of Molecules : Wolf Gang Demtroder
2. Hand Book of Molecular Physics & Quantum Chemistry : Stephen Wilson

DEPARTMENT OF APPLIED PHYSICS

M.TECH. NANOTECHNOLOGY

(FULL TIME)

SECOND SEMESTER

SUBJECT: **NANO ELECTRONICS** PAPER-**4**

SUBJECT CODE: **NT-554** CREDITS : **4.5**

PERIOD PER WEEK : Lecture –04 ; Tutorial –01

Maximum Marks : End Term –80 , Continuous Evaluation –20

Spintronic: Spin injection, spin valve effect, spin valves and MRAM devices

Solid state devices: quantum dots, quantum wires, microwave induced transport Josephson junctions

Photonic bandgap materials, nanoscale photonic devices, Special phenomena in 2D and 3D structures.

The basic properties of liquid crystals and their display and non-display applications at the nanoscale

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REFERENCES

1. Nano Electronics and Information Technology : Rainer Waser

DEPARTMENT OF APPLIED PHYSICS

M.TECH. NANOTECHNOLOGY

(FULL TIME)

SECOND SEMESTER

ELECTIVE-II

SUBJECT : **OPTO ELECTRONICS** PAPER-**5(i)**

SUBJECT CODE: **NT-561** CREDITS : **4.5**

PERIOD PER WEEK : Lecture –04 ; Tutorial –01

Maximum Marks : End Term –80 , Continuous Evaluation –20

Applied Optics, Holography, Fourier-Transform Optics, Spatial Filtering, Speckle Interferometry, Birefringence, Electro-optics, Magneto-optics and Acousto-optics, Kerr Effect, Optical Integrated Circuits. Fiber Optics, The optical fiber, comparison of optical fiber with other interconnectors, concept of an optical waveguide, rays and modes, principle of light guidance in optical wave guides, Application of fiber optics. nonlinear optics, nonlinear optical susceptibility, second and third order optical susceptibilities, harmonic generation, phase matching, optical mixing, parametric generation of light, self-focusing of light, optical bistability, optical phase conjugation.

REFRENCES :

1. Optical Electronics : A. Ghatak & K. Thyagarajan
2. Quantum Electronics : A. Yariv
3. An Introduction to Optical Fibers : A.H. Cherin

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M.TECH. NANOTECHNOLOGY

(FULL TIME)

SECOND SEMESTER

ELECTIVE-II

SUBJECT : **COMPUTAIONAL PHYSICS** PAPER-**5(ii)**

SUBJECT CODE: **NT-562** CREDITS : **4.5**

PERIOD PER WEEK : Lecture –04 ; Tutorial –01

Maximum Marks : End Term –80 , Continuous Evaluation –20

Differential equation, special functions Bessel's, Hermite's. Laguerre polynomials. Eigen value , Eigen functions. Perturbation theory. Numerical analysis. Idea of visual basic, c++ and c-sharp.

REFERENCES

1. Matehmatical Physics : S.S. Rajput
2. Visual Basic & C ++ : Shyaum Series

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M.TECH. NANOTECHNOLOGY

(FULL TIME)

SECOND SEMESTER

ELECTIVE-II

SUBJECT : ADVANCED TOPICS IN PHYSICS **PAPER-5(iii)**

SUBJECT CODE: **NT-563** CREDITS : **4.5**

PERIOD PER WEEK : Lecture –04 ; Tutorial –01

Maximum Marks : End Term –80 , Continuous Evaluation –20

Electrets physics: various types of electrets, methods of preparation, various studies on electrets, uses of electrets

Luminescence: various kinds of luminescence, theory of luminescence, paramagnetic behavior, activators and co-activators, Clustering, color centers. Preparation techniques and application.

Amorphous semiconductor materials. Preparation techniques in bulk form & in thin form. Rocking and quenching of materials. Characterization of amorphous materials.

REFRENCES :

1. Amorphous Materials : S.R. Elliot
2. Physics of Amorphous Solids : Richard Xylen

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M.TECH. NANOTECHNOLOGY

(FULL TIME)

SECOND SEMESTER

Lab Practice - II SUBJECT CODE: **NT-591**

CREDITS : **2.5**

PERIOD PER WEEK : Practical - 05

Maximum Marks : End Term –60 , Continuous Evaluation –40

List of Experiments:

1. To grow single crystal of NaCl from solution and take its Laue photograph. Index the same photograph using Gnomonic projection.
2. To take Debye Scherrer pattern of a given poly-crystalline material and determination of third "d" values from powder lines.
3. Determination of energy gap of a semiconductor by four probe method.
4. Study of Hall effect in semiconductors: a) Hall Voltage & Hall Coefficient, b) Mobility of charge carriers and the carrier concentration.
5. To determine the response of silicon solar cells and the effect of prolonged irradiations, and to calculate the efficiency and fill factors of a variety of solar cells.
6. Study of ESR spectrum of a paramagnetic substance.
7. To determine

   (a) The velocity of ultrasonic waves in a liquid and,

   (b) The compressibility of the liquid.

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M.TECH. NANOTECHNOLOGY

(FULL TIME)

THIRD SEMESTER

SUBJECT : **NANOSTRUCTURE CHARACHTERIZATION TECHNIQUES** PAPER-**1**
SUBJECT CODE: **NT-601** CREDITS : **4.5**

PERIOD PER WEEK : Lecture –04 ; Tutorial –01
Maximum Marks : End Term –80 , Continuous Evaluation –20

Compositional surface analysis: Ultraviolet (UV) and X-ray photoelectron spectroscopy (XPS), Secondary ion mass spectrometry (SIMS), Contact angles

Microscopies: Optical microscopy, fluorescence & confocal microscopy, Cathodoluminescence (CL) and photoluminescence (PL) ,TEM, SEM.

Probe techniques: Atomic force microscopy (AFM), scanning tunneling microscopy (STM), scanning nearfield optical microscopy (SNOM), Deep level transient spectroscopy (DLTS) ,Kelvin-probe measurements. Nanoscale current-voltage (I-V), capacitance-voltage (C-V) relationships

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REFRENCES

1. Nanostructures & Nano Materials : Ghuzang Cao

2. Hand Book of Nanophase & Nanomaterials (Vol. I&II) :Zhong Lin Wang (Springer)

M.TECH. NANOTECHNOLOGY

(FULL TIME)

THIRD SEMESTER

SUBJECT **: MEASUREMENT TECHNIQUES**

DEPARTMENT OF APPLIED PHYSICS

PAPER-**2** SUBJECT CODE: **NT-602** CREDITS : **4.5**

PERIOD PER WEEK : Lecture –04 ; Tutorial –01
Maximum Marks : End Term –80 , Continuous Evaluation –20

Theory of errors & measurement of magnetic and electrical susceptibility by various methods. conductivity measurement, dielectric measurement. use of electrometer, thermo-electric power. high field conduction. **MBE/SEM/TEM/ESR. TSDC.TSL,P**. photoemission, charge storage and decay. Measurement of low pressure penning-pirani gauge. film thickness monitoring & measurement

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REFRENCES

1. Amorphous Materials : S.R. Elliot
2. Thin Film Technology : Brodsky
3. Electrets : G.M. Sessler

M.TECH. NANOTECHNOLOGY

(FULL TIME)

THIRD SEMESTER

ELECTIVE-III

SUBJECT : **ADVANCE LOW TEMPERATURE PHYSICS**

PAPER-**3(i)** SUBJECT CODE: **NT-611** CREDITS : **4.5**

PERIOD PER WEEK : Lecture –04 ; Tutorial –01
Maximum Marks : End Term –80 , Continuous Evaluation –20

Thermodynamics & liquefaction of gases, Cryostat design , Transport Phenomenon, Fermi surface, Magnetism. Conductivity of solids, Technique of measurement, Paramagnetic & Nuclear adiabatic demagnetization. Superconductivity. fundamental phenomena of super conductivity, Meissner effect, London equation, Type I and Type II superconductors, qualitative idea of Cooper pairing and BCS theory. Ginsburg-Landau theory, coherence length, Green's functions of electrons and phonons, isotope effect, The

BCS Hamiltonian, the gap parameter, Superconductor in a field, flux quantization effect, SQUIDS, High-T_c materials.

REFRENCES

1.	Superconductivity	:	Werner Buckel & Reinhold
2.	Thermodynamics	:	M.S.Yadav
3.	Treatise on Heat	:	V.K. Shrivastava

DEPARTMENT OF APPLIED PHYSICS

M.TECH. NANOTECHNOLOGY

(FULL TIME)

THIRD SEMESTER

ELECTIVE-III

SUBJECT **: MOLECULAR ELECTRONICS AND BIOMOLECULES**

PAPER-**3(ii)** SUBJECT CODE: **NT-612** CREDITS : **4.5**

PERIOD PER WEEK : Lecture –04 ; Tutorial –01

Maximum Marks : End Term –80 , Continuous Evaluation –20

Organic semiconductors, Organic molecules as switches, motor-molecules and biomimetic components .conducting polymers, light emitting polymers,

The self-assembly of complex organic molecules, Molecular connections and the integration of molecular components into functional devices**,** Contact issues,

Structure of biomolecules; Biotechnology, recombinant DNA technology, molecular biology

Structural and functional principles of bionanomachines, Interfacing bio with non-bio materials, Porous silicon

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REFERENCES

1. Molecular Electronics : T. Helgakar
2. **Semiconductor Quantum Dots : Masumota Takaga**