DR. HOMI BHABHA STATE UNIVERSITY

Program - M. Sc.

Course -Physics

Syllabus for Semesters - III, IV

(Credit Based Semester and Grading System

With effect from the academic year 2021-2022)

Semester–III

	Course Code: **MSPHCC301T**	Course Title: **Statistical Mechanics**	
	Course Credit: 4	**Total Contact Hours: 60 Hours**	
Sr. No.	**Course Contents (Topics &Subtopics)**		**Reqd. Hours**
1	**Unit I** **Fundamentals of Statistical Mechanics:** A Brief Revision of the Laws of Thermodynamics. Thermodynamical Work for Magnetic, Dielectric, Elastic Systems. Fundamentals of Statistical Mechanics: Microstates of a System- Principle of Equal Apriori Probability, Phase Space, Quantization of Phase Space, Concept of Ensemble, Ensemble Average, Density Distribution Function in Phase Space, Liouville's Theorem, Distributions Theory (One of Maxwell Boltzman (MB), Fermi-Dirac(FD), Bose-Einstein(be) Distributions), Classical Limit , Entropy Probability, Entropy of a two Level System.		**15 Hours**
2	**Unit II** **Ensembles:** Microcanonical Ensemble (MCE), Thermodynamics in MCE, Entropy of an Ideal Gas in MCE, Gibbs Paradox, Sackur Tetrode Equation, Canonical Ensemble (CE): Thermodynamics in Ce, Ideal Gas in CE, Maxwell's Velocity Distribution: Equipartition Energy Theorem, Grand Canonical Ensemble (GCE), Thermodynamics in GCE, Ideal Gas in GCE, Fermi – Dirac Bose-Einstein Distribution Functions from Grand Canonical Partition Function.		**15 Hours**
3	**Unit III** **Bose Systems**: Equation of State for Ideal BE FD Gases, Photons, Planks Distribution Law, Phonons, Specific Heat of Solids, Einstein Debye's Theories, Bose Einstein Condensation, Liquid He-two Fluid Model, Phonons: Rotons – Super Fluidity.		**15 Hours**
4	**Unit IV** **Fermi Systems:** Ideal Fermi Gas – Free Electron Model, Electronic Specific Heat, Thermionic Emission, Pauli Paramagnetism: Lau Diamagnetism, White Dwarfs, Boltzman Transport Equation: Electrical Conductivity, Thermal Conductivity – Wiedermann,– Franz Law , Non-Equilibrium Semiconductors, Electron-Hole Recombination, Classical, Hall Effect, Quantum Hall Effect. Ising Model its 1-D Solution.		**15 Hours**
	Suggested Readings		
	1. Statistical Mechanics, Pathria Beale (Academic Press). 2. Statistical Mechanics Agarwal &Melvin Eisner (New Age International). 3. Statistical Mechanics, Kerson Huang (John Wiley &Sons). 4. Statistical Mechanics – R.K. Srivastava & J. Ashok (Prentice-Hall of India). 5. Statistical Physics of Particles, Kardar (Cambridge University Press). 6. Statistical Thermal Physics, Gould & Tobochnik (Princeton University Press). 7. An Introduction to Statistical Mechanics Thermodynamics, Swendsen (Oxford University Press).		

	8. Thermodynamics Statistical Mechanics, Greiner, Neise, Stocker, Springer, 2010. 9. Statistical Mechanics, Reif. 10. Statistical Physics (Part 1), L.D. Lau E. M. Lifhsitz **(Elsevier).**	
	Course Outcomes:	
	From This Course Students will Learn the Basics of Thermodynamics, its History, Application. Students will Understand Concepts of Ensemble Used for Statistical Application.	

	Course Code: **MSPHCC302T**	Course Title: **Condensed Matter Physics**	
	Course Credit: **4**	Total Contact Hours: 60 Hours	
Sr. No.	**Course Contents (Topics &Subtopics)**		**Reqd. Hours**
1.	**Unit I**		**15 Hours**
	Structure Factor: Static Structure Factor its Relation with the Pair Correlation Function. Determination of Structure Factor by X-Ray Neutron Scattering. Inelastic Neutron Scattering Dynamic Structure Factor, Space Time Correlation Function its Relation with Dynamic Structure Factor, Properties of Space Time Correlation Function. Langevin's Equation for Brownian Motion its Modifications. Velocity Auto-Correlation Function, Mean Square Displacement, Relation Between Velocity Autocorrelation Function Diffusion Coefficient.		
2.	**Unit II**		**15 Hours**
	Liquid Metals: Metallic Interactions-Kinetic Energy, Electrostatic Exchange Correlation, Pseudopotential Formalism, Diffraction Model, Structure Factor, Form Factor for Local Nonlocal Potentials, Energy Eigen States, Dielectric Screening. Energy Wave Number Characteristics, Calculation of Phonon Dispersion of Liquid Metals. B Structure Energy in Momentum and Direct Space. Zeeman's Resistivity Formula, Green Function Method for Energy Bands in Liquid Metals		
3.	**Unit III**		**15 Hours**
	Quantum Liquids: Distinction Between Classical Quantum Liquids, Criteria for Freezing, Phase Diagram of He4, He I He II Tisza's two Fluid Model, Entropy Filter, Fountain Effect, Super fluid Film Vehicle, Viscosity Specific Heat of He4, First Sound, Second Sound, Third Sound Fourth Sound, Landau Theory: Rotons and Phonons, T-Matrix Theory of Super fluid He. Basic Differences in Superfluidity in He_3 He_4.		
4.	**Unit IV**		**15 Hours**
	Exotic Solids Many and Bodies System: Structure Symmetries of Liquids, Liquid Crystals Amorphous Solids. Aperiodic Solids Quasicrystals; Fibonacci Sequence, Penrose Lattices Their Extension to 3-Dimensions. Schrodinger Time Dependent Independent Equation Review, Born-Oppenheimer Approximation, Spatial- Spin Orbitals, Electron Correlation Overview of Electron Correlation Methods, the Hartree-Fock Method; Exchange Correlation, Density Functional Theory (DFT), Time Dependent DFT, Computations on Simple Atoms.		
	Suggested Readings		
	1. Egelestaff: An Introduction to the Liquid State (Chapters 2, 3, 5, 6, 7,8.). 2. Hansen Mc Donald: Theory of Simple Liquids, (Chapters 3, 5, 7, 9). 3. D. Pines P. Nozier: The Theory of Quantum Liquid. 4. W.A. Harison: Pseudopotentials in the Theory of Metals Benjamin.		

	5. March, Young Sampanthar- Many Body Problems. 6. March Tosi: Atomic Motions in Liquids. 7. March, Tosi Street: Amorphous Solids the Liquid State, Plenum, 1985. 8. Dugdale: Electrical Properties of Metals an Alloys. 9. Quantum Mechanics, Robert Eisberg Robert Resnick, 2nd edn., 2002, Wiley. 10. Quantum Mechanics, Leonard I. Schiff, 3rdedn. 2010, Tata McGraw Hill. 11. Michael P Marder, Condensed Matter Physics, 2nd Ed.; John Wiley Sons, 2010.	
	Course Outcomes:	
	Analyse different types of condensed matter depending upon properties of materials. Analyse the crystal structures by applying crystallographic parameters. Determine crystal structure by analysis Ofxrd data. Analyse electron transport energy related problems by applying quantum mechanical principles. Determine the lattice vibration phenomenon in the solids. determine the concepts, theories, methods for understanding the HF, DFT.	

Applied Electronics- Sem. III-Paper I

	Course Code: **MSPHDE301T**	**Course Title:** **Electronic Communication**	
	Course Credit: 4	**Total Contact Hours: 60 Hours**	
Sr. No.	**Course Contents (Topics &Subtopics)**		**Reqd. Hours**
1	**Unit I** **EM Wave Propagation:** Fundamental of Electromagnetic Waves, Effects of the Environment, Propagation of Waves; Ground Waves, Sky Wave Propagation (Different Layers of Ionospheres, Critical Frequency, Lowest Usable Frequency, Maximum Usable Frequency, Virtual Height, Skip Distance) Space Waves, Tropospheric Scattering Ducting, Extra-Terrestrial Communication		**15 Hours**
2	**Unit II** **Modulation:** Introduction to Signal Modulation-Amplitude, Frequency Phase Modulation, Modulation Index, Evolution Description of SSB, Suppression of Carrier, Suppression of Unwanted Sideband, Extensions of SSB, Frequency Modulation: Theory of Frequency Phase Modulation, Noise Frequency Modulation, Generation of Frequency Modulation. Radio Receivers: Receiver Types, Am Receivers, Communication Receivers, Fm Receivers, Single- Sideband Receivers, Independent-Sideband Receivers.		**15 Hours**
3	**Unit IV** **Digital Modulation:** Introduction, Information Capacity, Bits, Bit Rate, Baud M-Ary Encoding, Ask, FSK, PSK, QAM, Bandwidth Efficiency, Carrier Recovery, Clock Recovery. Digital Transmission: Introduction, Pulse Modulation, PCM Sampling, Signal to Quantization Noise Ratio, Cumming, PCM Line Speed, Delta Modulation PCM, Adaptive Delta Modulation.		**15 Hours**
4	**Unit IV** **Radar:** Basic Principles; Advantages, Limitations Applications of Radar, Block Diagram of Simple Radar, Improved Radar, Classification of Radar-Continuous Wave/Doppler Radar Pulsed Radar, Free Space Radar Range Equation, Maximum Radar Range Factors Affecting Range of Radar. Pulsed Radar Systems-Block Diagram. Radar Displays- a-Scope Display, Plan-Position Indicator. Scanning Tracking with Radars-Horizontal Scan Pattern, Elevation/Vertical/Nodding Scan Pattern, Helical Scanning, Spiral Scanning. Tracking-Lobe Switching, Conical Switching, Mono-pulse Tracking, Display Methods, Pulsed Radar Systems. Moving Target Indication, Radar, CW Doppler Radar.		**15 Hours**
	Suggested Readings:		

	1. Microwave Radar Engineering by M. Kulkarni, Umesh Publications, New Delhi. 2. Microwave Engineering- by Sanjeev Gupta, Khanna Publication, New Delhi. 3. Electronics Communication System–by Kennedy George, McGraw Hill. 4. Antenna Wave Propagation by Das, McGraw Hill Education. **5.** Antennas Wave Propagation by Kraus, R. J. Marhefka A.S. Khan, McGraw Hill Education. **6.** Microwaves Radar by A. K. Maini, Khanna Publishers, New Delhi	
	Course Outcomes:	
	On completion of the course students will have knowledge of important components of electronic communication system along with different types of modulation techniques used in Analog Digital communication. The students will be familiar with radar its importance, different types of radars etc.	

Applied Electronics- Sem. III- Paper II

	Course Code: **MSPHDE302T**	Course Title: **Transmission Lines and Microwave Devices**	
	Course Credit: **4**	Total Contact Hours: 60 Hours	
Sr. No.	**Course Contents (Topics &Subtopics)**		**Reqd. Hours**
1	**Unit I**		**15 Hours**
	Transmission Lines: Microwave Frequency B Designation, Fundamental of Transmission Lines, Different Types of Transmission Lines; Definition of Characteristics Impedance, Losses in Transmission Lines. Microwave Transmission Line Analysis, Reflection Coefficient, Sting Waves, Sing Wave Ratio, VSWR, Quarter Half Wavelength Lines, Reactance Properties of Transmission Lines, Fundamental of the Smith Charts its applications.		
2	**Unit II**		**15 Hours**
	Microwave Components: Comparison of Transmission Lines Waveguides, Types of waveguides-Rectangular, Circular, Ridge. TE TM Modes, Cut-Off Frequency of a Rectangular Waveguide, Relation Between Λ_g, Λ_0, Λ_c, Cavity Resonators, Expression of F_0 in Rectangular Cavity Resonators, Directional Couplers, Microwave Tee Junctions - H Plane, E-Plane, Magic Tee, Rat Race, Waveguide Bend, Corners, Waveguide Iris, Posts Tunning Screws, Coupling Probe Coupling Loops, Microwave Attenuators.		
3	**Unit III**		**15 Hours**
	Microwave Tubes: Klystron- Velocity Modulation, Multicavity Klystrons, Reflex Klystron, Magnetron, Cross Field Amplifier, Travelling Wave Tube, Backward Wave Oscillator, Comparison of Microwave Tubes.		
4	**Unit IV**		**15 Hours**
	Microwave Solid State Devices: Microwave Transistor, Classification of Solid State Microwave Devices, Varactor Diode, PIN Diode, Tunnel Diode, Gunn Diode, IMPATT TRAPATT Diodes, Microwave Field Effect Transistors, Types of Microwave FETS, MESFET, HFET.		
	Suggested Readings		
	1. Microwave Radar Engineering by M. Kulkarni, Umesh Publications, New Delhi. 2. Microwave Devices Circuits- bySamuley Y. Liao, Prentice Hall ofGredia Private Limited, New Delhi. 3. Microwave Circuits Passive Devices-by M.L. Sisodia &G.S. Raghuvanshi, Wiley Eastern Limited, New Delhi. 4. Microwave Engineering- by Sanjeev Gupta, Khanna Publication, New Delhi. 5. Electronics Communication System –by Kennedy George, McGraw Hill		
	Course Outcomes		
	The students will understand the basic EM theory propagation of EM waves through transmission lines microwave components. They will get an		

	idea about the electronics at low frequency at microwave frequency. They also will get acquainted with various microwave components; various tubes used to generate microwaves microwave solid state devices.	

Sem. III Applied Electronics Lab-1

	Course Code: **MSPHLB301P**	Course Title: **Applied Electronics Lab-1** Minimum Number of Experiments to be Performed Reported in the Journal **= 10**	
	Course Credit: **4**	Total Contact Hours: **120** Hours	
Sr. No.	**List of Experiments**		
	GROUP-A (Minimum 05)		
1	Amplitude Modulator Demodulator		
2	Balanced Modulator Demodulator - Study of Suppressed Carrier Am Generation Using IC 1496/1596.		
3	Characteristics of PLL IC 565/4046.		
4	FM Modulator Demodulator		
5	To Study Implement Pulse Position Modulator (PPM)		
6	To Construct Pulse Amplitude Modulation Demodulation Circuit		
7	To Study Implement Pulse Width Modulation (PWM)		
8	To Implement Study Frequency Shift Keying (FSK) Modulator Demodulator		
9	To Implement Study Amplitude Shift Keying (FSK) Modulator Demodulator		
10	To Study Implement Pulse Position Modulation (PPM)		
	GROUP-B (Minimum 05)		
11	Microwave Bench Components Setup Study.		
12	Study of Reflex Klystron Modes Using X-B Set Up		
13	Study of Propagation Characteristics in a Waveguide.		
14	To Determine the Frequency & Wavelength ina Rectangular Wave Guide		
15	To Study Function of Microwave Directional Coupler. Compute (I) Coupling Factor (II) Directivity		
16	To Study Properties of Microwave E-Plane Tee.		
17	To Study Properties of Microwave H-Plane Tee		

Sem. III Applied Electronics - Project-01

	Course Code: **MSPHPR301P**	Course Title: **Project-01**	
	Course Credit: **4**	Total Contact Hours: **120** Hours	
Sr. No.	**List of Experiments**		
	Research Level Project		

Solid State Physics – Sem. III- Paper I

	Course Code: **MSPHDE303T**	Course Title**: Thin Film Physics**	
	Course Credit: **4**	Total Contact Hours: 60 Hours	
Sr. No.	**Course Contents (Topics &Subtopics)**		**Reqd. Hours**
1	**Unit I**		**15 Hours**
	Physics of Surfaces, Interfaces and Thin Films: Definition of Thin Film, Mechanism of Thin Film Formation: Condensation Nucleation, Growth Coalescence of ISLS, Crystallographic Structure of Films, Factors Affecting Structure Properties of Thin Films; Applications of Thin Films.		
2	**Unit II**		**15 Hours**
	Thin Films: **Physical Methods:** Vacuum Deposition Apparatus: Vacuum Systems, Substrate Deposition Technology, Substrate Materials, Thermal Evaporation Methods, Laser Evaporation, Sputtering: Introduction to Sputtering Process Sputtering Variants, Glow Discharge Sputtering, Ion Beam Sputtering. **Chemical Methods:** Chemical Vapor Deposition, Electrodeposition, Sol-Gel, Hydrothermal Method Etc. **Langmuir-Blodgett Method.**		
3	**Unit III**		**15 Hours**
	Thin Film Thickness Measurements and Properties: **Thickness Measurements:** Stylus Method, Electrical Method, Quartz Crystal Method, Optical Methods, Mass Measurements (Microbalance) **Properties**: Introduction to Elasticity, Plasticity Mechanical Behaviour, Introduction to Electrical Properties of Thin Films, Optical Properties of Thin Films.		
4	**Unit IV**		**15 Hours**
	I-V Characterization of Thin Films (Structural Morphological): X-Ray Diffraction, Scanning Electron Microscopy, Chemical Characterization. Introduction, Electron Spectroscopy, X-Ray Energy Dispersive Analysis (EDX), X-Ray Photoelectron Spectroscopy (XPS)		
	Suggested Readings		
	1. Thin Film Phenomena by K L Chopra McGraw-Hill Book Company, NY 1969. 2. The Materials Science of Thin Films by Milton Oaring, Academic Press, (1992). 3. Properties of Thin Films by Joy George, Marcel Decker, (1992). **4.** Physics of Thin Films by Ludmila Eckertová, Springer (1986). **5.** Thin Film Technology by O S Heavens, Methuen Young Books (1970).		
	Course Outcomes:		
	Students will come to know the thin film, its different formation stages. They will learn different physical chemical methods of thin film deposition along with various characterization techniques of thin films.		

Solid State Physics – Sem. III- Paper II

	Course Code: **MSPHDE304T**	Course Title: **Semiconductor Physics**	
	Course Credit**: 4**	Total Contact Hours: 60 Hours	
Sr. No.	**Course Contents (Topics &Subtopics)**		**Reqd. Hours**
1	**Unit I**		**15 Hours**
	Energy Bands and Charge Carriers in Semiconductors: Bonding Forces Energy Bs in Solids, Direct Indirect Semiconductors, Variation of Energy Bs with Alloy Composition, Charge Carriers in Semiconductors: Electrons Holes, Effective Mass, Intrinsic Extrinsic Materials, Electrons Holes in Quantum Wells, The Fermi Level, Carrier Concentration at Equilibrium, Temperature Dependence, Space Charge Neutrality, Conductivity Mobility, Drift Resistance, Effects of Temperature Doping on Mobility, High Field Effects.		
2	**Unit II**		**15 Hours**
	Excess Carriers in Semiconductors: Optical Absorption, Luminescence, Direct Recombination of Electrons Holes, Indirect Recombination Trapping, Steady State Carrier Generation Quasi Fermi Levels, Diffusion Processes, Diffusion Drift of Carriers, Built-in Fields, The Continuity Equation, Steady State Carrier Injection, Diffusion Length, The Haynes-Shockley Experiment.		
3	**Unit III**		**15 Hours**
	Semiconductor Junctions Formation: Fabrication of P-N Junctions; Thermal Oxidation, Diffusion, Rapid Thermal Processing, Ion Implantation, CVD, Photolithography, Etching, Metallization, The Contact Potential, Space Charge at a Junction, Qualitative Description of Current Flow at a Junction, Reverse-Bias Breakdown, Zener Avalanche Breakdown.		
4	**Unit IV**		**15 Hours**
	Junction Properties: Capacitance of P-N Junctions, The Varactor Diode, Recombination Generation in the Transition Region, Ohmic Losses, Graded Junctions, Schottky Barriers, Rectifying Contacts, Ohmic Contacts, Heterojunctions, Algaas-Gaas Heterojunction.		
	Suggested Readings		
	1. Solid State Electronic Devices by B. G. Streetman. 2. Physics of Semiconductor Devices by S. M. Sze. 3. Solid State Semiconductor Physics by Mckelvey. 4. Principles of Electronic Materials Devicesby S.O. Kasap. 5. Fundamentals of Semiconductor, Physics of Materials Properties, Yu, Peter, Cardona, Manuel, Springer.		
	Course Outcomes:		
	Students will be able to understand the basics of semiconductor, b theory. They will able to understands the semiconductor junction it properties.		

Sem. III - Solid State Physics Lab - 1

	Course Code: **MSPHLB302P**	Course Title: **Solid State Physics Lab - 1** Minimum number of experiments to be performed and reported in the journal **= 10**	
	Course Credit: **4**	Total contact hours: 120 Hours	
Sr. No.	**List of Experiments**		
	GROUP-A (Minimum 05)		
1	Structure determination of powder polycrystalline sample by X-ray powder diffraction.		
2	Intensity analysis of XRD peaks.		
3	Strain analysis and Particle size determination by XRD.		
4	Calibration of unknown magnetic field using a Hall Probe.		
5	Study of AC Hall effect in given semiconducting sample.		
6	Measurement of thermo-emf of Iron-Copper (Fe-Cu) or chromel-alumel thermocouple as a function of temperature.		
7	Study of Ionic conductivity of solids.		
8	Determination dielectric constant of given ferroelectric material.		
9	Determination of Transition Temperature of a Ferroelectric Material.		
10	Study of frequency response of dielectric materials.		
11	ResistivityofGesamplebyvanderPauwmethodatdifferenttempanddeterminationofba ndgap.		
12	Optical transmission and absorption studies of elemental/ compound semiconductors.		
	GROUP-B (Minimum 05)		
13	Band gap of semiconductors by photoconductivity.		
14	Band gap measurements of thin films using UV-Vis Spectroscopy.		
15	I-V measurements of Ge, Si, Ga As diodes at room temp, identification of different regions, determination of Ideality factor.		
16	Carrier life time by light pulse method.		
17	Determination dcelectricalconductivityofSemiconductingthinfilmsatroomtemperatureanditstemper ature dependence.		
18	Thermo-electric power measurement of semiconducting thin films.		
19	Least squares fit/curve-fitting.		
20	Thin film thickness measurement by Gravimetric method.		
21	Thin film deposition by electrodepostion method.		
22	Synthesis of given material in required stoichiometry by chemical method.		
23	Synthesis of composite material in given composition.		
24	Study of cyclic voltammetry (CV).		
25	Study of phase diagram of given component system.		

Sem. III Solid State Physics Project-1

	Course Code **MSPHPR302P**	Course Title: **Project-1**	
	Course Credit: **4**	Total Contact Hours: 120 Hours	
Sr. No.	**List of Experiments**		
	Research Level Project		

Solid State Electronics – Sem. III- Paper I

	Course Code: **MSPHDE305T**	Course Title: **Semiconductor Devices**	
	Course Credit: **4**	Total Contact Hours: 60 Hours	
Sr. No.	**Course Contents (Topics &Subtopics)**		**Reqd. Hours**
1.	**Unit I**		**15 Hours**
	Metal-Insulator-Semiconductor (MIS) Devices: Review of Ideal Mis Device, Si-Sio2 Practical Mos Diode, Oxide Charges, Defects, Surface Interface States, C-V G-V Measurement Techniques Characterization of Mos Devices. Review of MOSFET Basic Device Characteristics, Types of MOSFETs, Non- Uniform Doping Buried-Channel Devices, Short-Channel Effects, Mos Transistor Scaling. MOSFET Structures- HMOS, DMOS, SOI, VMOS, HEXFET. Charge Coupled Devices (CCDS), Non-volatile Memory Devices, Simulation.		
2.	**Unit II**		**15 Hours**
	Microwave, Power & Hot Electron Devices: Microwave Devices-Different Types of Tunnel Diodes, Tunnel Transistor, IMPATT Diode, Baritt Diode, Dovett Diode, Transferred Electron Device, Gunn Diode, Microwave Transistor, Thyristors, Bipolar Power Transistor, Hot Electron Transistor; Mos Power Transistor, Hemt.		
3.	**Unit III**		**15 Hours**
	Optoelectronic Devices: Light-Emitting Diodes, Liquid Crystal Displays, Photo Detectors, Photodiode Materials, Phototransistor, Solar Cells, Materials Design Considerations, Thin Film Solar Cells, Amorphous Silicon Solar Cells, Semiconductor Lasers, Optical Processes in Semiconductor Lasers (Js-Art.15.8), Heterojunction Lasers. Exciton (Js-Art16.1), Quantum Confined Stark Effect (Js. Art16.6), Quantum Well IR Photodetector, Application of Laser in Materials Processing, Fiber Optical Waveguides, Losses Dispersion in Fibers, Measurement of Fiber Characteristics, Fiber Materials Fabrication, Fiber Optics Simulation.		
4.	**Unit IV**		**15 Hours**
	Quantum Well & Nano Structures: Quantum Wells: B Structure Modifications by Heterostructures; B Structure in Quantum Wells, Quantum Wires, Quantum Dots; Modulation Doping; Mobility in a MODFET Quantum Well (Js-6.2, 6.3, 8.6, 14.2) Nanotechnology: Nanomaterials, Nanostructures, Synthesis of Nanoparticles, Semiconductor Nanocrystals, Metallic Nanoclusters, Carbon Nanostructures, Bulk Nanostructured Materials, Microelectromechanical Systems (Mems).		
	Suggested Readings:		
	1. S.M. Sze, Physics of Semiconductor Devices, John Wiley, N.Y., 1981. 2. Jasprit Singh, Semiconductor Devices-Basic Principles, Wiley Student Edition, New Delhi, 2009. 3. Bhattacharya, Semiconductor Optoelectronics Devices, Prentice Hall, India, 1995.		

	4. Gerd Kelser, Optical Fiber Communication, Mc Graw Hill-1980. 5. Jasprit Singh, Physics ofSemiconductors Their Heterostructures, Mcgraw-Hill, New York, 1993. 6. C. P. Poole F.J. Owens, Introduction to Nanotechnology, Wiley Interscience, Hoboken, New Jersey, 2003. 7. E.H. Nicollianan J.R. Brews, Mos Physics Technology, John Wiley, 1982. 8. J. Wilson J.F.B.Hawkes, Optoelectronics, an Introduction, Prentice Hall, 1983. 9. Jasprit Singh, Semiconductor Optoelectronics, Mc-Graw Hill.	
	Course Outcomes:	
	On successful completion of the course, the students will be able to describe the properties of materials application of semiconductor electronics. Apply the knowledge of semiconductors to illustrate the functioning of basic electronic devices. Demonstrate the switching amplification application of the semiconductor devices. Demonstrate the control applications using semiconductor devices. Identify the fabrication methods of integrated circuits. Classify describe the semiconductor devices for special applications.	

Solid State Electronics – Sem. III- Paper II

	Course Code: **MSPHDE306T**	Course Title: **Thin Film: Properties and Techniques**	
	Course Credit: **4**	Total Contact Hours: 60 Hours	
Sr. No.	**Course Contents (Topics &Subtopics)**		**Reqd. Hours**
1.	**Unit I** **Thin Films Preparation & Thickness Measurement:** Methods of Preparation/Synthesis of Thin Films: Vacuum Evaporation, Cathode Sputtering, Anodic Oxidation, Plasma Anodization, Chemical Vapour Deposition (CVD), Ion-Assisted Deposition (LAD), Laser Ablation, Longmuir Blochet Film, Sol-Gel Film Deposition. Thickness Measurements: Resistance, Capacitance, Microbalance, Quartz Crystal Thickness Monitor, Optical Absorption, Multiple Beam Interference, Interference Colour, Ellipsometry Methods.		**15 Hours**
2.	**Unit II** **Thin Film Physics:** Mechanism of Thin Film Formation: Formation Stages of Thin Films, Condensation Nucleation, Thermodynamic Theory of Nucleation, Growth Coalescence of ISLS, Influence of Various Factors on Final Structure of Thin Films, Crystallographic Structure of Thin Films. Properties of Thin Films: Conductivity of Metal Films, Electrical Properties of Semiconductor Thin Films, Transport in Dielectric Thin Films, Dielectric Properties of Thin Films, Optical Properties of Thin Films. Thin Films of High Temperature Superconductors, Diamond Like Carbon Thin Films.		**15 Hours**
3.	**Unit III** **Thin Films for Devices & Other Applications:** Thin Film Capacitors: Materials, Capacitor Structures, Thin Film Field Effect Transistors: Fabrication Characteristics, Thin Film Solar Cells – Antireflection Coatings, Interference Filters, Electrophotography-Electrical Dielectric Behaviour of Thin Films, Components, Strain Gauges Gas Sensors. Anisotropy in Magnetic Films, Domains in Films, Computer Memories -Superconducting Thin Films Squid.		**15 Hours**
4.	**Unit IV** **Characterization/Analysis of Materials Devices:** X-Ray Diffraction(XRD), Electron Diffraction, Transmission Electron Microscopy (TEM), Scanning Electron Microscopy(Sem), Energy Dispersive Analysis of X-Rays (EDAX), Low Energy Electron Diffraction (LEED), UV-VIS Spectroscopy, ATR, Fourier Transform Infrared (FTIR) Spectroscopy, Raman Spectroscopy, Electron Spin Resonance (ESR), X-Ray Fluorescence (XRF), Auger Electron Spectroscopy (AES), Xray Photoelectron Spectroscopy (XPS), Scanning Tunnelling Microscopy (STM), Atomic Force Microscopy (AFM). Ion Beam Analysis Techniques: Rutherford Backscattering (RBS), Channelling, Elastic Recoil Detection Analysis (ERDA), Secondary Ion Mass Spectroscopy (SIMS).		**15 Hours**
	Suggested Readings:		
	1. Ludmila Eckertova, Physics of Thin Films, 2nd Revised Edition, Plenum Press, New York, 1986 (Reprinted 1990),		

	2. K.L. Chopra, Thin Film Phenomena, McGraw Hill, New York, 1969. 3. L. C. Feldman J. W. Mayer, Fundamentals of Surface Thin Films Analysis, North Holl, Amsterdam, 1986. 4. S.M. Sze, Semiconductor Devices-Physics Technology, John Wiley,1985. 5. Milton Ohring, the Materials Science of Thin Films, Academic Press, 2001. 6. C.C. Koch, ‘Nano Structured Materials’, Vol. 2, 1993. 7. a. Roth, ‘Vacuum Technology’, North – Hol Pub., II Edition, 1982. 8. C.N.R. Rao, a. Muller, a. K. Cheetham (Eds.), ‘the Chemistry of 9. Nanomaterials: Synthesis, Properties Applications’, Wiley-Vch Verlag Gmbh & Co., Weinheim, 2004. 10. H. Gleiter, ‘Progress in Materials Science’, Vol. 33 (1989). 11. Donald L. Smith, ‘Thin Film Deposition: Principles Practice’, Mcgraw-Hill,1995. 12. George Hass, ‘Physics of Thin Films’ Volumes 1-12, Academic Press, 1963. 13. Surface Physics of Materials, Vol. I II (Academic Press). 14. Additional References: 15. R.W. Berry, P. M.Hall M.T. Harris, Thin Film Technology, Van Nostrand, New Jersey, 1970, K. L. Chopra L. k. Malhotra (Ed), 16. Thin Film Technology Applications, T. M. H. Publishing Co., New Delhi (1984).	
	Course Outcomes:	
	Acquire the knowledge of thin film preparation by various techniques. Analyse the behaviour of the thin films by different characterization methods apply the knowledge to develop a device.	

Sem. III Solid State Electronics Lab-1

	Course Code: **MSPHLB303P**	Course Title: **Solid State Electronics Lab-1** Minimum number of experiments to be performed and reported in the journal =**10**	
	Course Credit: **4**	Total contact hours: 120 Hours	
Sr. No.	**List of Experiments**		
	GROUP-A (Minimum 05)		
1	Structure determination of powder polycrystalline sample by X-ray powder diffraction.		
2	Intensity analysis of XRD peaks.		
3	Strain analysis and Particle size determination by XRD.		
4	Thermo-electric power measurement of semiconducting thin films.		
5	Study of AC Hall effect in given semiconducting sample.		
6	Measurement of thermo-emf of Iron-Copper(Fe-Cu) or chromel-alumel thermocouple as a function of temperature.		
7	Resistivity of Ge sample by vander Pauw method at different temp and determination of band gap.		
8	Optical transmission and absorption studies of elemental/ compound semiconductors.		
9	Synthesis of composite material in given composition		
10	I-V measurements of Ge, Si,Ga As diodes at room temp, identification of different regions, determination of ideality factor.		
11	Carrier life time by light pulse method.		
12	Fabrication of FET and its characterization		
	GROUP-B (Minimum 05)		
13	Band gap of semiconductors by photoconductivity.		
14	Band gap measurements of thin films using UV-Vis Spectroscopy.		
15	Determination dielectric constant of given ferroelectric material.		
16	Determination of Transition Temperature of a Ferroelectric Material.		
17	Determination dc electrical conductivity of Semiconducting thin films at room temperature and its temperature dependence		
18	Fabrication of MOS and its characterization		
19	Least squares fit/curve-fitting.		
20	Thin film thickness measurement by Gravimetric method.		
21	Thin film deposition by electrode position method.		
22	Synthesis of given material in required stoichiometry by chemical method.		
23	Study of Ionic conductivity of solids.		
24	Study of cyclic voltammetry (CV).		
25	Study of phase diagram of given component system.		

Sem. III Solid State Electronics Project -1

	Course Code **MSPHPR303P**	Course Title: **Project -1**	
	Course Credit: **4**	Total Contact Hours: 120 Hours	
Sr.No.	**List of Experiments**		
	Research Level Project		

Materials Science- Sem. III- Paper I

	Course Code: **MSPHDE307T**	Course Title: **Fundamentals of Materials Science**	
	Course Credit: 4	Total Contact Hours: **60**Hours	

Sr. No.	Course Contents (Topics &Subtopics)	Reqd. Hours
1	**Unit I**	**15 Hours**
	Introduction to Materials: Introduction and structure of materials, Structure of atoms, Quantum states, Atomic bonding in solids-binding energy interatomic spacing, variation in bonding characteristics. Single crystals. Polycrystalline. Non crystalline solids , Imperfection in solids, Vacancies, Interstitials, Geometry of dislocation, Schmid´s law - Surface imperfection, Importance of defects	
2	**Unit II**	**15 Hours**
	Solid Solutions and Alloys: Introduction, Crystals, Single Crystal, Whiskers, Lattice Points and Space Lattice, Unit Cell, Primitive Cell, Crystal Classes, Crystal System, Crystal Structure for Metallic Elements, Atomic Radius, Density of Crystal, Directions, Lattice Planes and Miller Indices, Inter planer Spacing, Representation of Crystal Planes in a Cubic Structure, Sketching the Plane from the given Miller Indices, Phase diagrams , Gibbs phase rule Single component systems – Eutectic phase diagram , lever rule, Study of properties of phase diagrams - Phase transformation , Nucleation kinetics and growth	
3	**Unit III**	**15 Hours**
	Band Model of Semiconductors: carrier concentrations in intrinsic, extrinsic semiconductors, organic semiconductors - Fermi level - variation of conductivity, mobility with temperature – law of mass action - Hall effect – Hall coefficients for intrinsic and extrinsic semiconductors – Hall effect devices. Application of diffusion in sintering, doping of semiconductors and surface hardening of metals.	
4	**Unit IV:**	**15 Hours**
	Mechanical and Magnetic Properties: Mechanical properties, Stress, Strain, Elastic properties – Deformation, elasticity, hardness, Optical properties, Light interaction with solids, Atomic, electronic interaction, nonradioactive transition - refraction, reflection, Absorption, Transmission, Insulators, luminescence Magnetic properties, paramagnetism, ferromagnetism - domain theory, magnetic hysteresis, Weiss molecular field theory, Heisenberg's theory , magnetic anisotropy, domain walls, Exchange energy, antiferromagnetism Decomposition of Austenite, Types and Properties of Carbon – Steels, Isothermal Transformation, TTT Diagram, Transformation of Austenite Upon Continuous Cooling, Transformation Of Austenite to Marten site, Metals for Nuclear Energy	

	Suggested Readings:	
	1. S.L.Kakani Amit Kakani, Materials Sciecne, 2^{nd} Edition, New AgeInternational Publisher Materials Science. 2. Kwan Chi Kao F. R. De Boer;Dielectric Phenomena in Solids, Elsevier Academic Press (2004). 3. J. P. Srivastava, Elements ofSolidState Physics, 2^{nd} Edi Prentice Hall of India(P) Ltd. (2007). 4. Charles Kittle; Introduction to Solid State Physics, 7^{th} Edition, JohnWiley &Sons, (1996). 5. Saxena, Gupta, Saxena; Fundamentals ofSolid State Physics, PragatiPrakashan, (2012). 6. A. J. Dekkar; Solid State Physics, 1^{st} Ed. Macmillan (2000). 7. M.A. Wahab; Solid State Physics: Structure Properties of Materials, Alpha Science International (2005). 8. S.O. Pillai;Solid State Physics, 6^{th}Ed., New Age International (P) LtdPublishers, (2005)	
	Course Outcomes:	
	Students will Come to Know Fundamentals of MaterialsScience, Different Types of Materials, Defects in Materials, Different Phases of Materials Etc.	

Materials Science- Sem. III- Paper II

	Course Code: **MSPHDE308T**	Course Title: **Nanoscience and Nanotechnology**	
	Course Credit:4	Total Contact Hours: 60 Hours	
Sr. No.	Course Contents (Topics &Subtopics)		Reqd. Hours
1	**Unit I** **Nanoscience and Nanomaterials:** Introduction to nanotechnology, physics of low-dimensional materials, quantum effects, 1D, 2D and 3D confinement, Density of states, Excitons, Coulomb blockade, Zero-, One-, Two- and Three-dimensional structure, Size control of metal nanoparticles and their properties: optical, electronic, agnetic properties; surface plasmon resonance, change of band gap; Application: catalysis, electronic devices		**15 Hours**
2	**Unit II** **Growth Techniques of Nanomaterials:** Introduction, Top - down vs. Bottom - up Technique, Importance of size distribution control, size measurement and size selection, assembling and self-organization of nanostructures, Nanofabrication: patterning of soft materials by self-organisation and other techniques, chemical self-assembly, artificial multilayers, cluster fabrication, Nanolithography, Scanning probe lithography, Micro contact printing.		**15 Hours**
3	**Unit III** **Characterization Tools of Nanomaterials:** Basic Principles of SPM,, Techniques, The Details of scanning Tunnelling Microscope (STM), , AFM , Scanning Electron Microscope SEM Techniques, Transmission Electron Microscope, High Resolution TEM, UV-Vis single and dual beam spectrophotometer, photoluminescence spectrometer, X-ray diffractometer.		**15 Hours**
4	**Unit IV** **Applications of Nanomaterials:** Advantages of nanoelectrical and electronic devices, micro and nano electromechanical systems & sensors, actuators, optical switches, bio-MEMS, diodes and nano-wire transistors , data memory lighting and displays, filters (IR blocking), quantum optical devices, batteries - fuel cells and photo-voltaic cells, electric double layer capacitors, lead-free solder, nanoparticle coatings for electrical products		**15 Hours**
	Suggested Readings:		
	1. Textbook of Nanoscience Nanotechnolgy, B.S.Murty, P. Shankar, Baldev Raj Et.Al, Universities Press-Iim 2. Introduction to Nanoscience Nanotechnology : K. K. Chattopadhyay A. N. Banerjee, Phi Publisher. 3. Nanoscience Technology: V. S. Murlidharan, A. Subramanum. 4. Nanotubes Nanofibers:Yurygogotsi		

	5. A Hand book of Nanotechnology: A. G. Brecket 6. Instrumentations Nanostructures: a. S. Bhatia. 7. Nanotechnology: Nanostructures Nanomaterials- M. B. Rao. 8. Nanotechnology-Principles Practices S. K.Kulkurni	
	Course Outcomes:	
	From this course students will able to know the basics of nanoscience, its history, growth techniques. Students will know different characterization tools used for characterization of nano materials.	

Sem. III Materials Science Lab -1

	Course Code: **MSPHLB304P**	Course Title: **Materials Science Lab -1** Minimum number of experiments to be performed and reported in the journal = 10	
	Course Credit: **4**	Total contact hours: 120 Hours	
Sr. No.	**List of Experiments**		
	GROUP-A (Minimum 05)		
1	Structure determination of powder polycrystalline sample by X-ray powder diffraction.		
2	Strain analysis and Particle size determination by XRD.		
3	Thermo-electric power measurement of semiconducting thin films.		
4	Determination of tensile stress and strain of given material.		
5	Corrosion study of electrode materials		
6	Measurement of thermo-emf of Iron-Copper (Fe-Cu) orchromel-alumel thermocouple as a function of temperature.		
7	Study of gas sensing properties of given semiconductor.		
8	Optical transmission and absorption studies of elemental/ compound semiconductors.		
9	Synthesis of composite material in given composition		
10	I-V characteristics of given material and determination of corrosion coefficient.		
11	Study and calibration of Humidity sensor.		
12	Synthesis and Characterization of Polymer materials.		
	GROUP-B (Minimum 05)		
13	Band gap of semiconductors by photoconductivity.		
14	Band gap measurements of thin films using UV-Vis Spectroscopy.		
15	Determination dielectric constant of given ferroelectric material.		
16	Determination of Transition Temperature of a Ferroelectric Material.		
17	Determination dcelectricalconductivityofSemiconductingthinfilmsatroomtemperatureanditstemperature dependence.		
18	Fabrication of MOS and its characterization		
19	Least squares fit /curve-fitting.		
20	Thin film thickness measurement by Gravimetric method.		
21	Thin film deposition by electrodeposition method.		
22	Synthesis of given material in required stoichiometry by chemical method.		
23	Study of Ionic conductivity of solids.		
24	Study of cyclic voltammetry (CV).		
25	Study of phase diagram of given component system.		

Sem. III Materials Science Project-1

	Course Code**MSPHPR304P**	Course Title: **Project-1**	
	Course Credit: **4**	Total Contact Hours: 120 Hours	
Sr. No.	**List of Experiments**		
	Research Level Project		

	Course Code: **MSPHGE301T**	Course Title: **Applications of Scientific Programming Languages**	
	Course Credit: **2**	Total Contact Hours: 30 Hours	
Sr. No.	**Course Contents (Topics &Subtopics)**		**Reqd. Hours**
1	**Unit I**		**9 Hours**
	Programming of Plotting: Relational Logical Operations, Conditional Statement, The If End Structure, The If Else End Structure, The If Else if Else End Structure, The Switch Case Statement. Loops, for End Loops, While End Loops, Nested Loops Nested Conditional Statements, The Break Continue Commands, Examples of Applications. **Two and three-Dimensional Plots:** The Plot Commands; Plot of Given Data, Plot of Functions. The f*plot* Comm. Plotting Multiple Graphs in the Same Plot; Using the Plot Command, Using the Hold on, Hold Off Commands, Using the Line Comm. Formatting a Plot; Formatting a Plot Using Commands; Formatting a Using Plot Editor, Plot with Logarithmic Axes, Plot with Special Graphics, Histogram, Polar Plots, Plotting Multiple Plots on Same Page. Examples of Applications. Problems. **Three Dimensional Plots**: Line Plots, Mesh Surface Plot, Plots with Special Graphs, The View Commands, Examples of Applications.		
2	**Unit II**		**6 Hours**
	Polynomials, Curve Fitting and Interpolations: Polynomials; Value of a Polynomial, Roots of Polynomials, Addition, Multiplications Division of Polynomials, Derivatives of Polynomials. Curve Fitting; Curve Fitting with Polynomials, Polyfit Function, Curve Fitting with Functions Other Than Polynomials. Interpolation; The Basic Fitting Interface. Examples of MATLAB Applications.		
3	**Unit III**		**7 Hours**
	Numerical Method: Solving an Equations with One Variable, Solution of Linear Equations, Solution of Linear Equations for Underdetermined Over determined Cases, Finding Minimum Maximum of a Function, Numerical Integrations, Differentiations Integrations, Ordinary Differential Equations, Solution of Differential Equations by Euler Method, Solution of Differential Equations Using Forth Order Runge-Kutta Method Inverses Determinants, Matrix Powers Exponentials, Eigen-values, Determinations of Roots of Polynomials.		
4	**Unit IV**		**8 Hours**
	Applications in Physics: Determinations of Time Response of R-L-C Circuit, Simple Harmonic Motion Example Using a Variety of Numerical Approaches, Solution fora Non-Linear, Damped, Driven Pendulum, The Physical Pendulum, Using the Euler-Cromer Method, Kepler's Laws, Solution of Laplace's Equation Using the Jacobi Relaxation Method. Time Independent Schrodinger Equation. Shooting Method, Wave-Packet Construction, Time Dependent Schrodinger Equation in One Dimension, Potential Well, Potential Barrier. Leapfrog Method. Uranium Decay.		
	Suggested Readings:		
	1. Programming in MATLAB by Marc E. Hermitter, Thomson Brooks. 2. MATLAB Programming by Rudrapratap. D. Attaway, S.		

	3. a Practical Introduction to Programming Problem Solving. Edition/Publisher: Third Edition. Elsevier. San Fransisco. 4. MATLAB: a Practical Introduction to Programming Problem-Solving Book by Stormy Attaway, Paperback ISBN: 9780128154793 Elsevier.Com. 5. MATLABfor Beginners a Gentle Approach Revised Edition Peter I. Kattan Petra Books. 6. Getting Started with MATLAB: A Quick Introduction for Scientists &Engineers Paperback – 1 January 2010 by Rudra Pratap (Author). 7. MATLAB Programming for Engineers 6th Edition by Stephen J Chapman, Cengage India. 8. MATLABwith Applications to Engineering, Physics Finance Hardcover – Import, 30 October 2009 by David Baez-Lopez (Author). 9. Scientific Computing With Matlab And Octave 4Th Edition by Alfio Quarteroni and Paola Gervasio and Fausto Saleri, SPRINGER. 10. Introduction to Octave: For Engineers and Scientists by Sandeep Nagar 11. MATLAB Guide, Third Edition Desmond J. Higham, Nicholas J. Higham. 12. MATLABfor Engineering Applications William Palm. 13. Advanced Programming in Scilab, by Jain. 14. Scilab A Beginner'S Approach by Anil Kumar Verma, Cengage India. 15. Scilab from Theory to Practice - I. Fundamentals (English, Paperback, Roux Philippe). 16. Octave/Matlab Primer and Applications, by Nakamura S. 17. Programming for Computations - MATLAB/Octave, by Linge Svein, Publisher: Springer International Publishing AG	
	Course Outcomes:	
	After successful completion of the course student will be able to use Scientific programming for various applications such as Numerical technique, Plotting of 2D and 3D plots and simplifications of Differential equations.	

	Course Code:**MSPHAE301T**	Course Title**:** **Python Programming**	
	Course Credit**: 2**	Total Contact Hours: 30 Hours	
Sr. No.	**Course Contents (Topics &Subtopics)**		**Reqd. Hours**
1	**Unit I**		
	Introduction to Python Programming: The Python Programming Language. What Is a Program? What Is Debugging? Formal Natural Languages, The First Program. Variables, Expressions Statements: Values Types, Variables, Variable Names Keywords, Statements, Evaluating Expressions, Operators Operands, Order of Operations, Operations on Strings, Composition. Functions: Function Calls, Type Conversion, Type Coercion, Math Functions, Composition, Definitions Use, Flow of Execution, Parameters Arguments, Variables Parameters Are Local, Stack Diagrams, Functions with Results. Conditionals Recursion: The Modulus Operator, Boolean Expressions, Logical Operators, Conditional Execution, Alternative Execution, Chained Conditionals, Nested Conditionals, The Return Statement, Recursion, Stack Diagrams for Recursive Functions, Infinite Recursion, Keyboard Input. Fruitful Functions: Return Values, Program Development, Composition, Boolean Functions.		**7 Hours**
2	**Unit II**		
	Iteration, Strings, Lists, Tuples, Dictionaries: Iteration: Multiple Assignment, The While Statement, Tables, two-Dimensional Tables, Encapsulation Generalization, More Encapsulation, Local Variables, More Generalization, Functions. Strings: A Compound Data Type, Length, Traversal the for Loop, String Slices, String Comparison, Strings Are Immutable, a Find Function, Looping Counting, The String Module, Character Classification. Lists: List Values, Accessing Elements, List Length, List Membership, Lists for Loops, List Operations, List Slices, Lists Are Mutable, List Deletion, Objects Values, Aliasing, Cloning Lists, List Parameters, Nested Lists, Matrices, Strings Lists. Tuples: Mutability Tuples, Tuple Assignment, Tuples as Return Values, Rom Numbers, List of Rom Numbers, Counting, Many Buckets, a Single-Pass Solution, Dictionaries: Dictionary Operations, Dictionary Methods, Aliasing Copying, Sparse Matrices, Long Integers, Counting Letters.		**8 Hours**
3	**Unit III**		
	Files Exceptions, Classes, Sets of Objects: Files Exceptions: Text Files, Writing Variables, Directories, Pickling, Exceptions. Classes Objects: User-Defined Compound Types, Instances as Arguments, Sameness, Rectangles, Instances as Return Values, Objects Are Mutable, Copying. Classes Functions: Time Pure Functions, Modifiers, Prototype Development Versus Planning. Classes Methods: Object-Oriented Features, Print Time, The Initialization Method, Points Revisited, Operator Overloading. Sets of Objects: Composition, Card Objects, Class Attributes the Str Method, Comparing Cards, Decks, Printing the Deck, Shuffling the Deck, Removing Dealing Cards. a H of Cards, Dealing Cards.		**8 Hours**
4	**Unit IV**		

	Linked Lists, Stacks, Queues, Trees: Linked Lists: Lists as Collections, Lists Recursion, Infinite Lists, the Fundamental Ambiguity Theorem, Modifying Lists, the Linked List Class. Stacks: Abstract Data Types, The Stack ADT, Implementing Stacks with Python Lists, Pushing Popping, Stack to Evaluate Postfix, Parsing, Evaluating Postfix. Queues: The Queue ADT, Linked Queue, Performance Characteristics, Improved Linked Queue, Priority Queue. Trees: Building Trees, Traversing Trees, Expression Trees, Tree Traversal, Building an Expression Tree, Handling Errors, The Animal Tree. Debugging: Syntax Errors, Runtime Errors, Semantic Errors.	**7 Hours**
	Suggested Readings	
	1. Official Python Web Site: <u>Https://Www</u>. 2. Python.Org. Think Python by Allen Downey. 3. Python Programming Fundamentals - a Beginner's Hbook by Nischay Kumar Hegde. 4. Python Programming by M Radhika Mani B N Jagadesh Ch Satyanarayana	
	Course Outcomes:	
	After successful completion of the course student will be able to develop a basic understanding of programming the python programming language. Familiarization about the basic constructs of programming such as data, operations, conditions, loops, functions etc. Students will use their problem-solving abilities to implement programs in python. Introduction to advanced topics in python such as exception handling, multithreaded programming, graphical user interface & database connectivity	

Semester –IV

	Course Code: **MSPHCC401T**	Course Title: **Characterization Techniques**	
	Course Credit:**4**	Total Contact Hours: 60 Hours	
Sr. No.	**Course Contents (Topics &Subtopics)**		**Reqd. Hours**
1	**Unit I**		**15 Hours**
	Optical Microscopy: Need of Materials Characterization Available Techniques. Optical Microscopy: Optical Microscope - Basic Principles Components, Different Examination Modes (Bright Field Illumination, Oblique Illumination, Dark Field Illumination, Phase Contrast, Polarised Light, Hot Stage, Interference Techniques), Stereomicroscopy, Photomicroscopy, Colour Metallography, Specimen Preparation, Applications.		
2	**Unit II**		**15 Hours**
	Electron Microscopy: Electron Microscopy: Interaction of Electrons with Solids, Scanning Electron Microscopy Transmission Electron Microscopy Specimen Preparation Techniques, Scanning Transmission Electron Microscopy, Energy Dispersive Spectroscopy, Wavelength Dispersive Spectroscopy.		
3	**Unit III**		**15 Hours**
	Diffraction Methods: Diffraction Methods: Fundamental Crystallography, Generation Detection of X-Rays, Diffraction of X-Rays, X-Ray Diffraction Techniques, Electron Diffraction. Surface Analysis: Atomic Force Microscopy, Scanning Tunnelling Microscopy, X-Ray Photoelectron Spectroscopy.		
4	**Unit IV**		**15 Hours**
	Spectroscopy Techniques: Spectroscopy: Atomic Absorption Spectroscopy, UV/Visible Spectroscopy, Fourier Transform Infrared Spectroscopy, Raman Spectroscopy. Thermal Analysis: Thermo Gravimetric Analysis, Differential Thermal Analysis, Differential Scanning Calorimetry, Thermo Mechanical Analysis Dilatometry.		
	Suggested Readings:		
	1. Li, Lin, Ashok Kumar Materials Characterization Techniques Sam Zhang; Crc Press, (2008). 2. Cullity, B.D., Stock, R.S., "Elements of X-Ray Diffraction", Prentice-Hall, (2001). 3. Murphy, Douglas B, Fundamentals of Light Microscopy Electronic Imaging,Wiley-Liss, Inc. USA, (2001). 4. Tyagi, A.K., Roy, Mainak, Kulshreshtha, S.K., Banerjee, S., Advanced Techniques for Materials Characterization, Materials Science Foundations (Monograph Series), Volumes 49 – 51, (2009). 5. Wendlt, W.W., Thermal Analysis, John Wiley &Sons, (1986). 6. Wachtman, J.B., Kalman, Z.H., Characterization of Materials, Butterworth Heinemann, (1993).		
	Course Outcomes:		
	Students will be able To1. Apply Appropriate Characterization Techniques for Microstructure Examination at Different Magnification Level Use Them to Understand the Microstructure of Various Materials 2. Choose Appropriate Electron Microscopy Techniques to Investigate Microstructure of Materials at		

	High Resolution 3. Determine Crystal Structure of Specimen Estimate its Crystallite Size Stress 4. Use Appropriate Spectroscopic Technique to Measure Vibrational / Electronic Transitions to Estimate Parameters Like Energy B Gap, Elemental Concentration, etc. 5. Apply Thermal Analysis Techniques to Determine Thermal Stability of Thermodynamic Transitions of the Specimen.	

	Course Code: **MSPHCC402T**	Course Title: **Nuclear Physics**	
	Course Credit: **4**	Total Contact Hours: 60 Hours	
Sr. No.	**Course Contents (Topics &Subtopics)**		**Reqd. Hours**
1	**Unit I**		**15 Hours**
	Structure Properties of the Nucleus: Discovery of the Nucleus, Composition, Basic Nuclear Properties; Charge, Mass, Size, Spin, Magnetic Moment, Electric Quadrupole Moment, Binding Energy, Binding Energy Per Nucleon its Observed Variation with Mass Number of the Nucleus, Coulomb Energy, Volume Energy, Surface Energy Other Corrections. Measurement of Nuclear Size Estimation of R_o (Mirror Nuclei Mesonic Method), Nuclear Quantum Numbers, Angular Momentum, Nuclear Dipole Moment, Parity, Iso Spin **Nuclear Forces:** two Nucleon System, Deuteron Problem its Ground State Properties, Nuclear Potential Well, Pp Pn Scattering Experiments, Meson Theory of Nuclear Forces, Mirror Nuclei, Nuclear Energy Levels, Nuclear Gamma Rays. **Nuclear Models:** Shell Model, Introduction, Assumptions, Evidences, Limitations. Liquid Drop Model, Nilsson Model.		
2	**Unit II**		**15 Hours**
	Radioactivity: Review of Alpha Decay, Decay Constant Half Life, Methods of Measurement of Half Life, Geiger-Nuttal Law, Introduction to Beta Decay, Fermi Theory of Beta Decay, Fermi-Kurie Plot, Selection Rule, Neutrino Antineutrino. Nuclear Radiation. Gamma Decay, Multipole Radiation, Selection Rules of Gamma Ray Transitions, Gamma Interaction with Matter, Charge Particle Interaction with Matter.		
3	**Unit III**		**15 Hours**
	Nuclear Reactions: Conservation Theorems, Q Value, Threshold Energy, Cross Section of Nuclear Reactions, Introduction to Fission, Characteristics of Fission, Energy in Fission, Controlled Fission Reaction, Introduction to Fusion Reaction, Characteristics of Fusion, Solar Fusion CNO Cycle.		
4	**Unit IV**		**15 Hours**
	Cosmic Rays and Elementary Particles: Discovery of Cosmic Rays, Discovery of Muon, Pion, Heavy Mesons Hyperons, Mass Life Time Determination for Muon Pion, Introduction to Elementary Particle Physics, the Eight-Fold Way, the Quark Model, The Stard Model, Revision of Four Forces, Introduction to Quantum Electro Dynamics, Introduction to Quantum Chromodynamics, Weak Interactions Unification Schemes (Qualitative Description), Revision of Lorentz Transformation, Four Vectors, Energy Momentum, Properties of Neutrino, Helicity of Neutrino, Parity, Qualitative Discussion on Parity Violation in Beta Decay Wu's Experiment.		
	Suggested Reading:		
	1. Introductory Nuclear Physics by Kenneth Karne, Wiley India Pvt.Ltd 2. Nuclear Physics by Kaplan 3. Concepts of Nuclear Physics by Cohen 4. Quantum Physics of Atoms Molecules, Solids, Nuclei Particle by		

	Robert Eisberg Robert Resnick Willy(2006). 5. Introduction to Elementary Particles Bydavid Griffith, John Willey Sons. 6. Elements of Nuclear Physics byMeyeroff 7. Nuclear Physics: S. N Ghoshal 8. Nuclear Physics: Roy Nigam 9. Nuclear Physics: S.B. Patel	
	Course Outcomes:	
	Students will able to Understand the Structure Properties of the Nucleus, the Concept of Nuclear Forces, The Various Nuclear Models the Nuclear Reactions. This Course Also Introduces the Cosmic Rays the Elementary Particle Physics to the Students.	

Applied Electronics- Sem. IV- Paper III

	Course Code: MSPHDE401T	**Course Title: Microwave Measurements and Optical Fibre Communication**	
	Course Credit: 4	**Total Contact Hours: 60 Hours**	
Sr. No.	**Course Contents (Topics &Subtopics)**		**Reqd. Hours**
1	**Unit I**		15 Hours
	Microwave Measurements: Frequency Measurements, Measurement of Power, Attenuation Measurements, Measurement of Phase Shift, Measurement of Voltage Sting Wave Ratio VSWR, Measurement of Impedance, Measurement of Insertion Loss, Measurement of Dielectric Constant, Measurement of Noise Factor, Measurement of Q of a Cavity Resonator.		
2	**Unit II**		15 Hours
	Microwave Antennas: Introduction, Antenna Parameters (Directive Gain, Power Gain, Directional Pattern), Beam Width, Bandwidth, Polarization, Impedance, Aperture), Types of Antennas (Hertz, Dipole Marconi Antennas, Yagi-Uda Antenna, Rhombus Antenna, Parabolic Reflector Antenna, Lens Antenna, Horn Antenna, Helical Antenna, Slot Antenna)		
3	**Unit III**		15 Hours
	Microwave Integrated Circuits: **MMIC:** Monolithic Microwave Integrated Circuits-Materials Used for MMIC's Fabrication (Substrate Materials, Conductor Materials, Dielectric Materials, Resistive Materials), MMIC Fabrication Techniques-Thin Film Formation (Planner Resistor Film, Planer Inductor Film, Planer Capacitor Film), Hybrid Integrated Circuit Fabrication. **Planar Transmission Lines:** Strip Line, Microstrip Lines (Advantages Limitations of Microstrip Lines, Characteristics Impedance of Microstrip Line, Effective Dielectric Constant, Losses in Microstrip Lines		
4	**Unit IV**		15 Hours
	Optical Fibre Communication Systems: Introduction to Optical Fibers, Signal Degradation in Optical Fibers, Fiber Optical Sources Coupling, Fiber Optical Receivers, System Parameters, Analog Optical Fiber Communication Links, Design Procedure, Multichannel Analog Systems, FM/FDM Video Signal Transmission, Digital Optical Fiber Systems.		
	Suggested Readings:		

	1. Microwave Devices Circuits- bySamuley Y. Liao, Prentice Hall ofGredia Private Limited, New Delhi. 2. Microwave Circuits Passive Devices-by M.L. Sisodia &G.S. Raghuvanshi, Wiley Eastern Limited, New Delhi. 3. Microwave Engineering- by Sanjeev Gupta, Khanna Publication, New Delhi. 4. Electronics Communication System –by Kennedy George, Mcgraw Hill. 5. Antenna Wave Propagation by Das Das, Mcgraw Hill Education. 6. Antennas Wave Propagation by Kraus, R. J. Marhefkaa. S. Khan, Mcgraw Hill Education. 7. Optical Fiber Comm.by Gerd Keiser; Mcgraw-Hill International, Singapore. 8. Electronic Communication Systems Fundamentals Through Advanced by Wayne Tomasi Singapore. 9. Optical Fiber Communication by G. Keiser.	
	Course Outcomes:	
	After studying this course, the students will be able to do measurement at microwave frequencies using x-b microwave set up. They will be able to measure microwave powers using different microwave components. They will get acquainted with different type of antennas optical fibre communication system.	

Applied Electronics- Sem. IV- Paper IV

	Course Code: **MSPHDE402T**	Course Title: **Microprocessor and Microcontroller**	
	Course Credit: **4**	Total Contact Hours: 60 Hours	
Sr. No.	**Course Contents (Topics &Subtopics)**		**Reqd. Hours**
1	**Unit I**		**15 Hours**
	Architecture of Microprocessor 8085: Intel 8085- Block Diagram, ALU, Timing Control Unit, Registers, Data Address Bus, Pin Configuration, Instruction Word Size, Instruction Cycle, Fetch Operation, Execute Cycle, Machine Cycle State, Instructions Data Flow, Timing Diagram, Memory Read, I/O Read, Memory Write, I/O Write.		
2	**Unit II**		**15 Hours**
	Programming of Microprocessor 8085 Data Transfer Techniques: Introduction, Instruction Set for 8085, Programming of 8085, Assembly Language Programming (Data Transfer, Arithmetic, Branching, Logical Group). Programmed Data Transfer, Synchronous, Asynchronous Interrupt Drivers Modes, DMA, Serial Data Transfer.		
3	**Unit III**		**15 Hours**
	Microprocessor 8086: Architecture of 8086, Pin Diagram Pin Function, Register Organization, Minimum Maximum Mode of 8086, Microprocessor 80286, 80386 (Block Diagram)		
4	**Unit IV**		**15 Hours**
	Micro-Controller 8051: Introduction to 8- Bit Micro-Controller, Architecture of 8051 Signal Description of 8051, Register Set of 8051, Important Operational Features of 8051, Memory I/O Addressing by 8051, Interrupts of 8051, Instructions Set of 8051, Programming of 8051 (Simple Arithmetic Logical Programs).		
	Suggested Readings:		
	1. Microprocessor Microcontroller- B. Ram, Dhanpati Rai Sons Delhi. **2.** Introduction to Microprocessor- A.P. Matur(TMH). **3.** Microprocessor Architecture, Progrmmining Applications with8086 / 8080- R. Gaonkar, Wily-Eastern Ltd. **4.** Advanced Microprocessor Interfacing- B. Ram (Tmh). **5.** Advanced Microprocessor Principles- A.K. Ray, K.M. Bhurchi Tata Mc Graw Hill Publication Co. Ltd. New Delhi.		
	Course Outcomes:		
	At the end of the course, a student will be able to assess solve basic binary math operation s using the microprocessor explain the microprocessor's microcontroller's internal architecture its operation, apply knowledge demonstrate programming proficiency using the various addressing modes data transfer instructions of the target microprocessor microcontroller, analyze assembly language programs, select appropriate assemble into machine across assembler utility of a microprocessor microcontroller, design electrical circuitry to the		

	microprocessor i/o ports in order to interface the processor to external devices, evaluate assembly language programs download the machine code that will provide solutions to the real-world control problems	

Sem. IV Applied Electronics Lab -2

	Course Code: **MSPHLB401P**	Course Title: **Applied Electronics Lab-2 Minimum Number of Experiments tobe Performed Reported inthe Journal = 10**	
	Course Credit: **4**	Total Contact Hours: 120 Hours	
Sr. No.	**List of Experiments**		
	GROUP-a (Minimum 05)		
1	To Determine the Voltage Sting Wave Ration (VSWR) Reflection Coefficient of Given Load Using X-B Microwave Setup		
2	To Study Characteristics of Gunn Diode Using X-B Microwave Setup		
3	To Study the Radiation Pattern Gain of Waveguide Horn Antenna Using X-B Microwave Setup		
4	To Study Properties of Microwave Magic Tee Using Microwave Setup.		
5	Loss Measurements Numerical Aperture in Optical Fiber.		
6	Linear Control System Using Fiber Optical Communication Method.		
7	Telemetry Using Optical Fiber System.		
8	Attenuation Measurement using Micro wave bench set up		
9	To Study E Plane and H Plane Radiation Pattern of Horn Antenna		
10	Measurement of Gain of an antenna using Mirror Method		
	GROUP-B (Minimum 05)		
11	Write Assembly Language Programme for Ascending /Descending Order of Data.		
12	Write an Assembly Language Programme to Transfer Data Bytes.		
13	Write an Assembly Language Programme to Find Out Smaller Larger Number.		
14	Write Assembly Language Programme for Generation of Square Wave		
15	Write an Assembly Language Programme for Various Arithmetic Operations.		
16	Write Assembly Language Programme for Different Logical Operations.		
17	Write an Assembly Language Programme to Find the 1's Compliment 8 Bit 16 Bit Number Using 8051 Microcontroller.		
18	Write an Assembly Language Programme to Find the 2's Compliment 8 Bit 16 Bit Number Using 8051 Microcontroller.		
19	Write an Assembly Language Programme for Addition Verification by Using 8051 Microcontroller.		
20	Interfacing of Seven Segment Display.		

Sem. IV Applied Electronics Project-02

	Course Code: **MSPHPR401P**	Course Title: **Project-02**	
	Course Credit: **4**	Total Contact Hours: **120**Hours	
Sr. No.	**List of Experiments**		
	Research Level Project		

Solid State Physics - Sem IV- Paper III

	Course Code: **MSPHDE403T**	**Course Title:** **Physical Properties of Solids**	
	Course Credit: 4	Total Contact Hours: 60 Hours	
Sr. No.	**Course Contents (Topics &Subtopics)**		**Reqd. Hours**
1	**Unit I**		**15 Hours**
	Optical Dielectric Properties: Maxwell's Equations the Dielectric Function, Lorentz Oscillator, the Local Field the Frequency Dependence of the Dielectric Constant, Polarization Catastrophe, Ferroelectrics Absorption Dispersion, Kraemers' Kronig Relations Sum Rules, Single Electron Excitations Plasmons in Simple Metals, Reflectivity Photoemission in Metals Semiconductors Inter-B Transitions Introduction to Excitons, Infrared Spectroscopy.		
2	**Unit II**		**15 Hours**
	Transport Properties: Motion of Electrons Effective Mass, The Boltzmann Equation Relaxation Time, Electrical Conductivity of Metals Alloys, Mathiessen's Rule, Thermo-Electric Effects, Wiedmann-Franz Law, Lorentz Number, AC Conductivity, Galvanomagnetic Effects.		
3	**Unit III**		**15 Hours**
	Magnetism and Magnetic Materials: **Review:** Basic Concepts Units, Basic Types of Magnetic Order Origin of Atomic Moments, Heisenberg Exchange Interaction, Localized Itinerant Electron Magnetism, Stoner Criterion for Ferromagnetism, Indirect Exchange Mechanism: Superex change Rkky. **Magnetic Phase Transition:** Introduction to Ising Model Results Based on Mean Field Theory, Other Types of Magnetic Order: Superparamagnetism, Helimagnetism, Metamagnetism, Spinglasses. **Magnetic Phenomena:** Hysteresis, Magnetostriction, Magnetoresistance, Magnetocaloric Magneto-Optic Effect. **Magnetic Materials:** Soft Hard Magnets, Permanent Magnets, Media for Magnetic Recording.		
4	**Unit IV**		**15 Hours**
	Superconductivity: **The Phenomenon of Superconductivity:** Perfect Conductivity Meissner Effect. **Electrodynamics of Superconductivity:** London's Equations, Thermodynamics of the Superconducting Phase Transition: Free Energy, Entropy Specific Heat Jump. **Ginzburg-Lau Theory of Superconductivity:** GL Equations, GL Parameter Classification into Type I Type II Superconductors, the Mixed State of Superconductors. **Microscopic Theory:** The Cooper Problem, The BCS Hamiltonian, BCS Ground State Josephson Effect: DC AC Effects, Quantum Interference.		

	Superconducting Materials Applications: Conventional High Tc Superconductors, Superconducting Magnets Transmission Lines, Squids.	
	Suggested Readings:	
	1. Solid State Physics, H. Ibach H. Luth, *Springer (Berlin)* 2003 (Il). 2. Solid State Physics, Neil Ashcroft David Mermin (Am). 3. Introduction to Solid State Physics (7th/ 8th Ed) Charles Kittel (K). 4. Principles of Condensed Matter Physics, ChaikinLubensky (Cl). 5. Condensed Matter Physics, Michael P. Marder, Wiely, 2^{nd}Edition. 6. Fundamentals of Carrier Transport, Mark Lundstorm, Cambridge University Press, 2^{nd}Edition. 7. Optical Properties of Solids, Frederick Wooten, AC Press (New York) 1972 (FW). 8. Electrons Phonons, J M Ziman. 9. Electron Transport in Metals, J.L. Olsen. 10. Physics of Magnetism Magnetic Materials, K.H.J. Buschow F.R. De Boer. 11. Introduction to Magnetism Magnetic Materials, D. Jiles. 12. Magnetism Magnetic Materials, B. D. Cullity. 13. Solid State Magnetism, J. Crangle. 14. Magnetism in Solids, D. H. Martin. 15. Superconductivity Today, T.V. Ramakrishnan C.N.R.Rao	
	Course Outcomes:	
	Students will be able to learn the various properties of solids viz. Optical, dielectric, magnetic, thermal electrical. The understanding of physics of these properties will be useful for applications of the solids.	

Solid State Physics – Sem. IV- Paper IV

	Course Code: **MSPHDE404T**	Course Title: **Physics of Nanomaterials**	
	Course Credit: **4**	Total Contact Hours: 60 Hours	
Sr. No.	**Course Contents (Topics &Subtopics)**		**Reqd. Hours**
1	**Unit I**		**15 Hours**
	Crystal Bonding, Structure, Growth and Symmetries: Background of Nanoscience Nanotechnology, Definition, Crystal Bonding, Crystal Structure, Crystal Growth Classification of Crystals by Symmetry, Some Important Crystal Structure		
2	**Unit II**		**15 Hours**
	Band Structure and Density of States at Nanoscale: Introduction, Energy Bs, Structure of Energy Bs of Metals, Insulator, Semiconductors, Density of States at Nanoscale.		
3	**Unit III**		**15 Hours**
	Electrical Transport in Nanostructure: Electrical Conduction in Metals, The Drude Model, The Free Electron Model, Conduction Mechanism in Insulators Ionic Crystals, Electron Transport in Semiconductors, Conduction Mechanisms in 3d,2d Low Dimensional Systems, Pool Frankel Effect, Arrhenius Type Thermally Activated Conduction, Hopping Conduction, Polaron Conduction		
4	**Unit IV**		**15 Hours**
	Introductory Quantum Mechanics for Nanoscience: Introduction, Size Effect in Smaller Systems, Quantum Behaviour: Bohr, Model of Hydrogen Atom, De Broglie Wavelength, Wave Function Associated with Electron, Uncertainty Principle, Schrodinger Equation its applications.		
	Suggested Readings:		
	1. Introduction to Nanoscience Nanotechnology, K. K. Chattopadhyay, A. N. Banerjee, PHI. **2.** Text Book of Nanoscience Nanotechnology B. S. Murthy Et. Al, University Press.		
	Course Outcomes:		
	The students will learn the physics of Nanomaterial. How it is different from bulk materials as compare to crystal structure, density, bs properties. They will be exposed to the quantum mechanical understanding of Nanomaterials.		

Sem. IV - Solid State Physics Lab -2

	Course Code: **MSPHLB402P**	Course Title: **Solid State Physics Lab -2 Minimum number of experiments to be performed and reported in the journal =10**	
	Course Credit: **4**	Total contact hours: 120 Hours	
Sr. No.	**List of Experiments**		
	GROUP-a (Minimum 05)		
1	Fe^{57}Mossbauer spectra: Calibration and determination of isomer shift and hyperfine field.		
2	Determination of isomer shift in stainless steel using Mossbauer spectra.		
3	B-H loop in low magnetic fields(dc and ac methods).		
	Hysteresis of ring-shaped ferrite.		
4	Determination of Curie/Neel temperature.		
5	Susceptibility of paramagnetic salt by Guoy's method.		
6	Resistivity of metallic alloy specimens with varying temperatures.		
7	Study of percolation limit by resistivity measurement of ceramic.		
8	I-V at different temperatures of different diodes.		
9	C-V at room temperature and determination of barrier height.		
10	Solar Cells :I-V characteristics and spectral response.		
11	Infrared detector characteristics and spectral response.		
12	Optical fibers- Attenuation and dispersion measurements.		
	GROUP-B (Minimum 05)		
13	MR of Semiconductor, Bismuth and LSMO (Manganate) specimen.		
14	XPS analysis of given sample.		
15	Study of Raman Spectra of given materials.		
16	Ceramic synthesis of BaTiO3.		
17	Thermoelectric power of thin film		
18	Contact angle measurement of thin film		
19	Brinell hardness		
20	Corrosion study of given material.		
21	Chemical Bath deposition of CdS.		
23	SEM and EDAX analysis of given samples		
24	Successive Ionic Layer Adsorption and Reaction.		
25	Computer program for file handling.		

Sem. IV Solid State Physics Project-02

	Course Code: **MSPHPR402P**	Course Title: **Project-02**	
	Course Credit: **4**	Total Contact Hours: **120**Hours	
Sr. No.	**List of Experiments**		
	Research Level Project		

Solid State Electronics- Sem. IV- Paper III

	Course Code: **MSPHDE405T**	Course Title: **Semiconductor Technology**	
	Course Credit: 4	**Total Contact Hours: 60 Hours**	
Sr. No.	**Course Contents (Topics &Subtopics)**		**Reqd. Hours**
1.	**Unit I**		**15 Hours**
	Crystal Growth Epitaxy: (A) Crystal Growth: Czochralski Technique, Bridgman Technique, Float Zone Process, Zone Refining, Zone Levelling. (B) Epitaxy Vapour Phase Epitaxy (VPE), Liquid Phase Epitaxy (LPE, Molecular Beam Epitaxy (MBE), Mocvd, Heteroepitaxy, Growth of III-V Compound Semiconductors, Growth of Silicon on Insulator (SOI) Structures. (C) Oxidation Film Deposition: Oxide Formation, Kinetics of Oxide Growth, Thin Oxide Growth, Oxidation Systems.		
2.	**Unit II**		**15 Hours**
	Diffusion and Ion-Implantation: Diffusion: Nature of Diffusion, Basic Diffusion Theory, Extrinsic Diffusion, Diffusion Related Physical Processes, Boron Diffusion System, Phosphorus Diffusion System. (A) Ion-Implantation: Range of Implanted Ions, Ion Distribution, Ion Stopping, Ion Channelling, Radiation Damage Annealing, Implantation Related Processes, Evaluation Techniques for Epitaxial Layer, Diffused Layer Implanted Layer Oxide Layer.		
3.	**Unit III**		**15 Hours**
	Lithography and Etching: (A) Lithography: Clean Room, Masking, Photoresist, Passivation, Optical, Electron beam, X- Ray & Ion-Beam Lithography. (B) Etching: Wet Chemical Etching, Dry Etching, Plasma Etching.		
4.	**Unit IV**		**15 Hours**
	Integrated Devices Device Circuit Design Fabrication: Passive Components-Integrated Circuit Resistor, Capacitor Inductor. Bipolar Technology: Discrete Bipolar Circuit Fabrication, Bipolar Technology, MOSFET Technology, MESFET Technology, Fundamental Limits of Integrated Devices, ULSI Technology; Simulation.		
	Suggested Readings:		
	1. S.M. Sze, Semiconductor Devices-Physics Technology, John Wiley, 1985. 2. Integrated Circuits (Design Principles &Fabrication) – R.M.Warner, Motorola Series in Solid State Electronics. 3. K. Martin, Digital Integrated Circuit Design Oxford University Press, Ymca, New Delhi, 2004. 4. E.L. Wolf, Nanophysics Nanotechnology, Wiley-Vch Verlag, Weinheim, 2004. 5. S.K. Ghhi, The Theory Practice of Microelectronics, John Wiley Sons. 6. S.M. Sze, VLSI Technology, Mc Graw Hill Book, N.Y., 2nd Ed.		

	7. S.K. Ghhi, Vlsi Fabrication Principles, John Wiley, N.Y., 1983	
	Course Outcomes:	
	Students able to Understand the current voltage characteristics of semiconductor devices. Analyze dc circuits relate ac models of semiconductor devices with their physical operation. Classify different semiconductor memories. Able to analyze find applications limitations of microwave semiconductor devices.	

Solid State Electronics- Sem. IV- Paper IV

	Course Code:**MSPHDE406T**	Course Title: **Physics of Semiconductors Devices**	
	Course Credit: **4**	Total Contact Hours: 60 Hours	
Sr. No.	**Course Contents (Topics &Subtopics)**		**Reqd. Hours**
1.	**Unit I** **Transport Properties of Semiconductors:** The Boltzmann Transport Equation its Solutions for (I) Electric Field Alone (II) Electric Magnetic Fields Together. Hall Effect Magneto Resistance (Van Der Ziel). Scattering Mechanism Relaxation Time Concept, Transport in High Electric Fields, Hot Electrons (Wang), Transferred Electron Effects (Smith). Transport in 2- Dimensional Quantum Well - (a) High Field Effects (I) Lau Levels, (II) Shubnikov De Hass Effect, (III) Quantum Hall Effect (B) Perpendicular Transport - Resonant Tunnelling (Js- Art.17.3, 17.6, 17.7, 14.9).		**15 Hours**
2.	**Unit II** **Optical Properties of Semiconductors:** Optical Properties of Semiconductors: Fundamental Absorption, Exciton Absorption, Impurity Absorption, Free Carrier Absorption. Radiative Recombination. Photoconductivity. Surface Recombination (Smith). Optical Processes in Quantum Wells: Interb Transitions in Quantum Wells,Intrab Transitions (Js-Art.15.7.2, 15.10)		**15 Hours**
3.	**Unit III** **Amorphous & Organic Semiconductors:** Electronic Density of States, Localization, Transport Properties, Optical Properties, Hydrogenization of Amorphous Silicon, Si:H Fields Effect Transistors-Design, Fabrication Characteristics. Organic Semiconductors, Polymers.		**15 Hours**
4.	**Unit IV** **Advanced Electronic Materials:** Photovoltaics Fundamentals & Materials, Spintronics Materials, Dilute Magnetic Semiconductors, Magnetites, Giant-Magneto Resistance. Composites, Glasses, Ceramics, Liquid Crystals-Introduction to Liquid Crystals Types of Liquid Crystals, Quasicrystals.		**15 Hours**
	Suggested Readings:		
	1. Aldert Van Der Ziel, Solid State Physical Electronics, 2nd Edition, Prentice-Hall, New Delhi, 1971. 2. S.Y. Wang, Introduction to Solid State Electronics, North Holl, 1980. 3. R. A. Smith, Semiconductors, 2nd Edition; Cambridge University Press, London, 1978. 4. Jasprit Singh, Physics of Semiconductors Their Heterostructures, Mcgraw-Hill, New York, 1993. 5. M.H. Brodsky (Ed), Topics in Applied Physics Vol.36, Amorphous Semiconductors. 6. S.R. Elliott, Physics of Amorphous Materials, Longman, London, 1983.		

	7. C.S. Solanki, Solar Photovoltaics-Fundamentals, Technologies Applications, Phi Lpl, New Delhi, 2009.	
	Course Outcomes:	
	Student who successfully fulfils the course requirements will be able to demonstrate and utilize semiconductor models to analyze carrier densities carrier transport. An ability to understand utilizes the basic governing equations to analyse semiconductor devices. An ability to understand analyse the inner working of semiconductor p-n diodes, Schottky barrier diodes new semiconductor devices.	

Sem. IV- Solid State Electronics Lab -2

	Course Code: **MSPHLB402P**	Course Title: **Solid State Electronics Lab -2 Minimum number of experiments to be performed and reported in the journal =10**	
	Course Credit: 4	**Total contact hours: 120 Hours**	
Sr. No.	**List of Experiments**		
	GROUP-A (Minimum 05)		
1	Fe^{57}Mossbauer spectra: Calibration and determination of isomer shift and hyperfine field.		
2	Determination of isomer shift in stainless steel using Mossbauer spectra.		
3	B-H loop in low magnetic fields (dc and ac methods).		
	Hysteresis of ring-shaped ferrite.		
4	Determination of Curie/Neel temperature.		
5	Susceptibility of paramagnetic salt by Guoy's method.		
6	Resistivity of metallic alloy specimens with varying temperatures.		
7	Study of percolation limit by resistivity measurement of ceramic.		
8	I-V at different temperatures of different diodes.		
9	C-V at room temperature and determination of barrier height.		
10	Solar Cells :I-V characteristics and spectral response.		
11	Infrared detector characteristics and spectral response.		
12	Optical fibers- Attenuation and dispersion measurements.		
	GROUP-B (Minimum 05)		
13	MR of Semiconductor, Bismuth and LSMO (Manganate) specimen.		
14	XPS analysis of given sample.		
15	Study of Raman Spectra of given materials.		
16	Ceramic synthesis of BaTiO3.		
17	Thermoelectric power of thin film		
18	Contact angle measurement of thin film		
19	Brinell hardness		
20	Corrosion study of given material.		
21	Chemical Bath deposition of CdS.		
23	SEM and EDAX analysis of given samples		
24	Successive Ionic Layer Adsorption and Reaction.		
25	Computer program for file handling.		

Sem. IV Solid State Electronics Project-02

	Course Code: **MSPHPR403P**	Course Title: **Project-02**	
	Course Credit: **4**	Total Contact Hours: 120 Hours	
Sr. No.	**List of Experiments**		
	Research Level Project		

Materials Science- Sem. IV- Paper III

	Course Code: **MSPHDE407T**	Course Title: **Applications of Materials**	
	Course Credit: **4**	Total Contact Hours: 60 Hours	
Sr. No.	Course Contents (Topics &Subtopics)		**Reqd. Hours**
1	**Unit I**		**15 Hours**
	Ceramics Composites: Structure of Simple Ceramics, Silicate Structures, Materials Preparation, ferroelectric ceramics: barium titanate, PZT, PLZT materials, magnetic ceramics: spinel ferrites, zinc ferrites, garnets, superconducting ceramics: varistors,Bioceramic materials, high temperature applications, ceramic fibers, Glasses, Composites: Introduction, General Characteristics, Particle-Reinforced Composites, Fibre -Reinforces Composites.		
2	**Unit II**		**15 Hours**
	Organic Materials: Polymers: Classification of polymer, Polymerization Mechanism, Degree of Polymerization, synthesis of polymers: step growth polymerization, chain growth polymerization, polymerization techniques, ordering of polymer chains, Introduction to visco elasticity – dynamic mechanical analysis – mechanical models of viscoelastic behaviour – Boltzmann superposition principle.		
3	**Unit III**		**15 Hours**
	Superconductivity Superconducting Materials: Basic concepts, Meissner effect, heat capacity, energy gap, London equation, coherence length Josephson effect (flux quantization), type I and II superconductors, BCS theory, Introduction to high Tc Superconductors. High Tc, Superconductor materials		
4	**Unit IV**		**15 Hours**
	Applications of Carbon Nanomaterials: CNT, Application of Fullerene, Fabrication of CNTs and CNFs ,Graphene and other carbon nanomaterials - Mechanical, Thermal Applications, Electronic Applications and biological Applications, Metallic glasses or metaglass, shape memory alloys		
	Suggested Readings:		
	1. S.L.Kakani Amit Kakani, New Age International, 2nd Edition. 2. M.A. Wahab; Solid State Physics: Structure Properties of Materials, Alpha Science International (2005). 3. Materials Science: V. Rajendran, A. Marikani, Tata Mc Graw Hill. 4. Materials Science &Engineering: Raghavan, Tata Mc Graw Hill. 5. "Carbon Materials Nanotechnology", byAnke Krueger,		

	Wiley-Vch,2010. 6. YuryGogotsi, “Carbon Nanomaterials”, Taylor Francis, 2006.	
	Course Outcomes:	
	Students will come to know different materials and its applications in their day-to-day life as well as in industry.	

Materials Science- Sem. IV- Paper IV

	Course Code: **MSPHDE408T**	Course Title: **Properties of Materials**	
	Course Credit: **4**	Total Contact Hours: 60 Hours	
Sr. No.	Course Contents (Topics &Subtopics)		**Reqd. Hours**
1	**Unit I**		**15 Hours**
	Mechanical Properties of Materials: Introduction, Common Terms, Atomic Model of Elastic Behaviour, Modulus(Y) as a Parameter of Design, Fundamental Mechanical Properties, Factors Affecting Mechanical Properties, Mechanical Tests, Non- Destructive Testing (NDT),Fracture.		
2	**Unit II**		**15 Hours**
	Oxidation Corrosion: Introduction, Corrosion- resistant Materials, Electrochemical, Corrosion, Galvanic (Two Metal) Corrosion, Corrosion Rates, High Temperature Oxidation or Dry Corrosion, Passivity, Environmental Effects, Specific Forms of Corrosion, Corrosion Prevention and Control, Corrosion Monitoring and Management.		
3	**Unit III**		**15 Hours**
	Thermal Optical Properties of Materials: Thermal Properties: Introduction, Heat Capacity, Theoretical Models, Thermal Expansion, Thermal Conductivity (K), Refractories, Thermal Stresses, Thermal Fatigue, Thermal Shock, Melting Point (M.P.) Optical Properties: Optical Properties, Interactions of Light with Solids, Atomic and Electronic Interactions, Optical Properties of Non-Metals, Optical Properties of Non- Metals, Application of Optical Phenomena.		
4	**Unit IV**		**15 Hours**
	Electrical Magnetic Properties of Materials: Introduction, Electrical Conduction, Electrical Conductivity, Electronic and Ionic Conduction, Band Structure in Solids, Conduction in Terms of Band and Atomic Bonding Models, Electrical Resistivity of Metals, Electrical Characteristics of Alloys Used for Commercial Purpose, Mechanism of Strengthening in Metals, Insulators, Dielectrics, Magnetism		
	Suggested Readings:		

	1. S. L. Kakani Amit Kakani, Materials Science, 2nd Edition, New AgeInternational Publisher materialsScience. 2. Kwan Chi Kao F. R. De Boer;Dielectric Phenomena in Solids, Elsevier Academic Press (2004). 3. J. P. Srivastava, Elements ofSolidState Physics, 2nd Edi Prentice – Hall of India(P) Ltd. (2007). 4. Charles Kittle; Introduction to Solid State Physics, 7th Edition, John Wiley&Sons, (1996). 5. Saxena, Gupta, Saxena; Fundamentals ofSolid-State Physics, PragatiPrakashan, (2012). A. J. Dekkar; Solid State Physics, 1st Ed. Macmillan (2000). 6. Neil W. Ashcroft, N. David Mermin,Solid State Physics; SaundersCollege, (1976).	
	Course Outcomes:	
	Students will come to know the different properties of materials viz. Electrical, magnetic, optical, thermal mechanical properties. Understanding of these properties will be useful for applications of these materials.	

Sem. IV Materials Science Lab -2

	Course Code: **MSPHLB404P**	Course Title: **Materials Science Lab -2** **Minimum number of experiments to be performed and reported in the journal =10**	
	Course Credit: **4**	Total contact hours: 120 Hours	
Sr. No.	**List of Experiments**		
	GROUP-A (Minimum 05)		
1	Corrosion study of given material.		
2	Brinell hardness		
3	I-V Characteristics of given semiconducting material		
4	Hysteresis of ring-shaped ferrite.		
4	Determination of Curie/Neel temperature.		
5	Susceptibility of paramagnetic salt by Guoy's method.		
6	Resistivity of metallic alloy specimens with varying temperatures.		
7	Study of percolation limit by resistivity measurement of ceramic.		
8	Synthesis of Porous Materials		
9	Sensor specification study		
10	C-V at room temperature and determination of barrier height.		
11	Solar Cells: I-V characteristics and spectral response.		
12	Infrared detector characteristics and spectral response.		
	GROUP-B (Minimum 05)		
13	MR of Semiconductor, Bismuth and LSMO (Manganate)specimen.		
14	XPS analysis of given sample.		
15	Study of Raman Spectra of given materials.		
16	Ceramic synthesis of BaTiO3.		
17	Thermoelectric power of thin film		
18	Contact angle measurement of thin film		
19	Synthesis of inorganic composite materials		
20	Element analysis by optical wave guide methods		
21	Chemical Bath deposition of CdS.		
23	SEM and EDAX analysis of given samples		
24	Successive Ionic Layer Adsorption and Reaction.		
25	Computer program for file handling.		

Sem. IV Materials Science Project-02

	Course Code: **MSPHPR404P**	Course Title: **Project-02**	
	Course Credit: **4**	Total Contact Hours: **120**Hours	
Sr. No.	**List of Experiments**		
	Research Level Project		

	Course Code: **MSPHSE401T**	Course Title: **Materials for Energy**	
	Course Credit: **4**	Total Contact Hours: 60 Hours	
Sr. No.	**Course Contents (Topics &Subtopics)**		**Reqd. Hours**
1	**Unit I:**		**15 Hours**
	Photovoltaics: Solar energy and energy conversion, Fundamentals of semiconductor physics and photovoltaic cells, Generation-recombination in semiconductors, p-n junction, metal-semiconductor and hetero junction, Photovoltaic device fabrication and characterization, Current status of silicon based solar cells, Advancement in photovoltaic research and design of new generation solar cells (hybrid, quantum dot, dye-sensitized and perovskite solar cells)		
2	**Unit II**		**15 Hours**
	Batteries & Supercapacitors: Basic concepts of Batteries, Supercapacitors and Fuel cells, Thermodynamics and kinetics involved in electrochemical reactions, Primary and rechargible batteries, Li-ion Battery, Components and processes in batteries (Battery operations), Cell characterization: (Charging/discharging cycles, overpotential, battery capacity, state of charge, state of health, impedance spectroscopy), Large scale applications,, Different types of supercapacitors (Electrochemical double layer capacitor, pseudocapacitor and hybrid capacitor), Components of supercapacitors, Elecetrochemical properties (Charging/discharging cycles, Cyclic Voltametry and impedance spectroscop, lifetime stability), Different applications.		
3	**Unit III**		**15 Hours**
	Thermoelectric Materials: Fundamentals of thermoelectricity (Seebeck, Peltier and Thomson effects), Thermoelectric Effects and Transport Properties, Basics of Thermoelectric devices, Heat Conduction in Bulk Thermoelectric Materials (Heat Conduction by Phonons, Heat Conduction by Electrons), Progress in Thermoelectric Materials (Bulk Thermoelectric Materials, Nanostructured Thermoelectric Materials), Reduction of Thermal Conductivities in Bulk and Nanostructured Materials), Thermoelectric Devices.		
4	**Unit IV**		**15 Hours**
	Fuel Cells Catalysis: Why Fuel cells, Thermodynamics of Fuel Cells, Basic principles and reaction kinetics, Charge and Mass transport, Cell characterization, Different types of Fuel Cells (Phosphoric acid fuel cell (PAFC), polymer electrolyte membrane fuel cell (PEMFC), alkaline fuel cell (AFC), molten carbonate fuel cell (MCFC) and solid-oxide fuel cell (SOFC).Concepts of Electrocatalysis and Photocatalysis, Thermodynamics and reaction kinetics for water splitting, Basic		

	principles and properties for photocatalytic and electrocatalytic water splitting, Few examples of Electro and photocatalysts, Cell fabrication and measurement techniques.	
	Suggested Reading:	
	1. Solar Photovoltaics: Fundamentals, Technologies Applications, Book by Chetan Singh Solanki 3rd Edition 2009 Phi Publication. 2. Solar Energy: Fundamentals Applications Book by H. P Garg.Tata McGraw-Hill Education, 2000. 3. Solar Energy: Principles of Thermal Collection Storage Book bySuhasPurangSukhatme. D. Patranabis, Phi Learning Private Limited. 4. Nanomaterials in Advanced Batteries Supercapacitors, by Kenneth I. Ozoemena, Shaowei Chen. 5. Electrochemical Supercapacitors: Scientific Fundamentals Technological Applications Book by Brian Evans Conway. 6. Thermoelectric Materials: AdvancesApplications Novel.by Enrique Maciá Barber. 7. Thermoelectric Materials Devices.byStephen Beeby,Iris Nhakumar, Neil M. White. 8. New Future Developments in Catalysis.by Steven L. Suib2019. 9. Non-Noble Metal Fuel Cell Catalysts. Editor(S) Zhongwei Chen, Jean-Pol Dodelet, Jiujun Zhang Dodelet,.First Published:21 March 2014.	
	Course Outcomes:	
	Students will be able to understand the concept of Photovoltaics. Student will be aware of various tools and quality attributes required Batteries & Supercapacitors. They will also be able to select a Thermoelectric Materials based on requirement with static characteristics and measure the parameter	

Guidelines for Project:

Every student will have to complete one project each in semester III semester IV with four credits (100 marks) each. Students can take one long project or two short projects. However, for one long project students have to submit two separate project reports / dissertation consisting of the problem definition, literature survey current status, objectives, methodology some preliminary experimental work in semester III. Actual experimental work, results analysis in semester IV with four credits each. Those who have opted for two separate projects will also have to submit two separate project reports at each examination. The project can be a theoretical or experimental project, related to advanced topic, electronic circuits, models, industrial project, training in a research institute, training of handling a sophisticated equipment etc.

Maximum three students can do a joint project. Each one of them will submit a separate project report with details/part only he/she has done. However, he/she can in brief (in a page one or two) mention in introduction section what other group members have done. In case of electronic projects, guide should not allow his/her students to use readymade electronic kits available in the market. The electronics project/models should be demonstrated during presentation of the project. In case a student takes training in a research institute/training of handling sophisticate equipment he/she should mention in a report what training he/she has got, which instruments he/she handled, their principle and operation etc.

Each project will be of 100 marks with 50% by internal and 50% by external evaluation.

The project report should be file bound/spiral bound/hard bound and should have following format

Title Page/Cover Page
Certificate Endorsed by Project Supervisor Head of Department
Declaration
Abstract of the Project
Table of Contents
List of Figures
List of Tables
Chapters of Content –
Introduction and Objectives of the Project
Experimental/Theoretical Methodology/Circuit/Model etc. details
Results and Discussion if any
Conclusions
References

Evaluation by External Examiner will be Based on Following Criterion: (Each Semester)

Literature Survey	: 05 Marks
Objectives/Plan of the Project	: 05 Marks
Experimental/Theoretical Methodology/Working Condition of a Project or Model	: 10 Marks
Significance and Originality of the Study/Society Application Inclusion of Recent References	: 05 Marks
Depth of Knowledge in the Subject / Results and Discussions	: 10 Marks
Presentation	: 15 Marks
Maximum Marks by External Examiner	**: 50 Marks**
Maximum Marks by Internal Examiner/Guide	**: 50 Marks**
Total Marks	**: 100 Marks**