Punyashlok Ahilyadevi Holkar Solapur University, Solapur
School of Physical Sciences
M.Sc. Physics Choice Based Credit System (CBCS)
Course Structure

M.Sc. Part-II Physics (Condensed Matter Physics) w.e.f. 2020-21

M.Sc. PHYSICS SEMESTER-III								
Paper Code	Title of the Paper	Semester Examination			L	P	T	Credits
		Theory	IA	Total				
	Hard Core Theory							
HCT 3.1	Semiconductor Devices	70	30	100	4	--	--	4
HCT 3.2	Atomic, Molecular & Nuclear Physics	70	30	100	4	--	--	4
	Soft Core-Theory (Any one)							
SCT 3.1	Soft Condensed Matter Physics	70	30	100	4	--	--	4
SCT 3.2	Thin Film Physics & Technology							
	Open Elective-Theory (Any one)							
OET3.1	Medical Physics	70	30	100	4	--	--	4
OET3.2	Energy Harvesting Devices							
	Practical							
HCP3.1	Practical-9: (Based on HCT 3.1)	35	15	50	--	2	--	2
HCP3.2	Practical-10: (Based on HCT 3.2)	35	15	50	--	2	--	2
SCP3.1/ 3.2	Practical-11: (Based on SCT 3.1/3.2)	35	15	50	--	2	--	2
OET3.1/ 3.2	Practical-12: (Based on OET 3.1/3.2)	35	15	50	--	2	--	2
	Seminar / Tutorial	---	25	25	--	--	1	1
Total for Semester-I		**480**	**145**	**625**	**--**	**--**	**--**	**25**
M.Sc. PHYSICS SEMESTER-IV								
Code	Title of the Paper	Semester Examination			L	P	T	Credits
		Theory	IA	Total				
	Hard Core Theory							
HCT 4.1	Microelectronics	70	30	100	4	--	--	4
HCT 4.2	Physics of Nano Materials	70	30	100	4	--	--	4
HCT 4.3	Properties of Solids	70	30	100	4	--	--	4

	Soft Core-Theory (Any one)							
SCT 4.1	Experimental Techniques in Physics	70	30	100	4	--	--	4
SCT 4.2	Polymer Science &Technology							
	Practical (Hard and Soft core)							
MP	Major Project	140	60		--	8	--	8
	Seminar / Tutorial	---	25	25	--	--	1	1
Total for Semester-II		**480**	**145**	**625**	**--**	**--**	**--**	**25**

M.SC-II, SEME. III, PHYSICS (CONDENSED MATTER PHYSICS)
HCT - 3.1: SEMICONDUCTOR DEVICES
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

Unit I: MIS Structure and MOS FETs (15)

Schottky diode, MIS structures, basic equations in flat band conditions, MIS capacitances, current flow mechanisms in MS junction and MIS junction, depletion and enhancement type MOS FETS, capacitances in MOS FETs, quantitative analysis of I - V characteristics, thresholds in MOSFETS, charge trapping and flat band voltage, study of CMOS devices.

Unit II: Power Devices (15)

Power diodes, ratings, reverses recovery characteristics, fast recovery diodes, Power transistors, Switching characteristics, construction of SCR, two transistors analogy, I - V characteristics, gate trigger characteristics, turn on and turn - off times, losses, reverse recovery characteristics, SCR ratings, dv/dt and di/dt characteristics, thyrister types, construction and characteristics of DIACs and TRIACs, static induction thyristors, , light activated thyristors, Gate turn off thyristors (GTO), MOS controlled thyristors, programmable Unijunction transistors, Silicon Unidirectional switch (SUS) , IGBT

Unit III: Charge Coupled and Transferred Electron (15)

Charge storage, surface potential under depletion, construction of basic two and three phase of CCD, mechanism of charge transfer, Oxide Charges, charge trapping and transfer efficiency, dark current, buried channel CCD, application of CCD, Transferred Electron Effect, NDR (Negative differential resistivity of voltage and current controlled devices), formation of gun domains, uniform and accumulation layer, operation modes, transistors and quenched diodes, layers and modes of operation, LSA mode of operation, frequency responses and overall device performance of Gunn devices.

Unit IV: Optoelectronic and Advanced Solid State Devices (15)

Light emitting diodes, Performance of LEDs, emission spectra, visible and IR LEDs, semiconductor LASER: p-n junction lasers, heterojunction lasers, materials for semiconductor LASER, threshold current density, effect of temp. Quantum well hetero structures,

Detectors: photoconductors, photocurrent gain and detectivity, photodiodetypes : p-n junction, p-i-n, avalanche characteristics, quantum efficiency, response speed, noise and optical absorption coefficient, efficiency, Solar cells – current voltage characteristics

Reference Book/Text Book:

1. D.A. Roustan: Bipolar Semiconductor Devices.
2. Mauro Zambuto: Semiconductor Devices.
3. D. Nagchoudhari: Semiconductor Devices.
4. Karl Hess: Advanced theory of semiconductors devices.
5. S. M. Sze: Physics of Semiconductor Devices 2nd edition..
6. A Dir - Bar - Lev: Semiconductor and Electronic Devices.
7. M. H. Rashid: Power Electronics.

8. P. C. Sen: Power electronics
9. B. G. Streetman and S. Banergee : Solid state Electronic Devices

M.SC-II, SEME. III, PHYSICS (CONDENSED MATTER PHYSICS)
HCT - 3.2: ATOMIC MOLECULAR AND NUCLEAR PHYSICS
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

Unit I: Atomic structure and Atomic Spectra (10)

Quantum states of an electron, Quantum numbers, spectroscopic terms and selection rules, Pauli's Exclusion principle, Electron spin, Vector atom model, Spin-orbit coupling (LS and JJ coupling), fine structure, Hund's rule etc. Features of one electron and two electron spectra, hyperfine structure, Lande splitting factor (g), Zeeman effect (Normal and Anomalous).

Unit II: Molecular Spectra (10)

Molecular energy states and associated spectra, Types of molecular spectra. Pure rotational; spectra, Diatomic molecule as a rigid rotator, Diatomic molecule as a nonrigid rotator, its Energy levels, Spectra, Rotation spectra of polyatomic molecules, Linear, Spherical top, Symmetric top, Asymmetric molecules, Vibrating diatomic molecule as a Harmonic and Anharmonic oscillator, Vibration-Rotation Spectra, molecule as vibrating rotator, Born-Oppenheimer approximation, Electronic states of diatomic molecules, Franck-Condon principle.

Unit III: Nuclear Forces and Nuclear Models (16)

Nuclear Forces:

Introduction, Nature of nuclear force, Deuteron (Properties, non-excited and excited states), elements of deuteron problem, Neutron-Proton (n-p) scattering at low energies, Theory of n-p scattering, proton-proton (p-p) scattering at low energies; its theory, Low energy n-n scattering, Charge Independence and charge symmetry of nuclear forces. Similarities between n-n and p-p forces, Non-central forces, its properties, Ground state of deuteron, Magnetic moment, Electric Quadrupole moment, Saturation of Nuclear forces, High energy n-p and p-p scattering.

Nuclear Models:

Constitution of the nucleus; neutron-proton hypothesis, Nature of nuclear force, stable nuclides, Liquid drop model: Semi-empirical mass formula, applications of semiempirical mass formula, Limitations of liquid drop model, Nuclear shell model: Shell model and it's evidence, Limitations of shell theory, Fermi gas model, Extreme Single Particle model, Individual Particle model, Superconductivity model.

Unit IV: Nuclear Reactions (12)

Types of Nuclear Reactions, Conservation laws, Nuclear reaction kinematics, Nuclear Transmutations, Charged particle reaction spectroscopy, Neutron spectroscopy, Nuclear reactions-Q values and kinematics of nuclear cross-sections, Analysis of cross section classical and partial analysis, its energy and angular dependence, Thick Target yield, Requirements for a reaction, Reaction mechanism, General features of crosssection, Inverse reaction, Compound Nucleus – introduction, its reactions and disintegration, Different stages of a Nuclear Reactions, Statistical Theory of Nuclear Reactions, Direct reactions, stripping reactions and shell model, Giant Resonance, Heavy ion reactions, Nuclear shock waves.

References:

1. Introduction to atomic spectra, H. E.White, Mc-Graw hill, International Edition.1962.
2. Molecular structure and spectroscopy 2ndEdi., G. Aruldhas, PHI learning Pvt. Ltd. NewDelhi.
3. Fundamentals of Molecular Spectroscopy, Colin Banwell, McGraw-Hill Publishing Company.
4. Introduction to Atomic and nuclear Physics, Harvey E. White, Van Nostrand Reinhold Company, 1964.
5. Nuclear Physics, D.C. Tayal, Himmalaya Publishing House, 5th Edi. 2008.
6. Introductory nuclear Physics, Kenneth S. Krane, John Wiley and Sons, 1988.
7. Nuclear Physics, Irving Kaplan, Addison-wesley publishing company, Inc,1962.
8. Concepts of Nuclear Physics, Bernard L Cohen, Tata McGraw-Hill publishing company limited, 1971.
9. Nuclear Physics, S. N. Ghoshal, S. Chand and company limited, 1994

M.SC-II, SEME. III, PHYSICS (CONDENSED MATTER PHYSICS)
SCT - 3.1: SOFT CONDENSED MATTER PHYSICS
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

Unit-I Energy bands in solids (15)

The basic Hamiltonian in solid, Reduction to one electron problem for determining bands in solids (single particle approximation) - variational principle, Hartree approximation, Hartee-Fock approximation, Density functional approximation- Comparison with conventional wave function approach, Hohenberg-Kohn Theorem; Kohn-Sham Equation; Thomas-Fermi approximation and beyond; Practical DFT in a many body calculation and its reliability.

Unit-II Magnetism (15)

Origin of magnetism, quantum theory of diamagnetism, Landau diamagnetism,
Paramagnetism: Classical and quantum theory, magnetism in rare-earth and iron group atoms, quenching of orbital angular momentum, Van-Vleck Paramagnetism and Pauli Paramagnetism, Ferromagnetism: Cuire Weiss Law, temperature dependence of magnetization, Heisenberg exchange interaction, Ferromagnetic domains, Magnetic domains – exchange energy, magnetostatic energy, wall energy, magnetostrictive energy, Neel and Bloch wall, the Bloch T3/2 law, Neel model of antiferromagnetism and ferrimagnetism. Magnetic anisotropy and magnetostatic interactions- Direct, exchange, indirect exchange and itinerant exchange, (double exchange and RKKY interactions). Spin waves in ferromagnets - magnons, Spin waves in lattices –
ferri and antiferromagnetism, Measurement of magnon spectrum. Magnetic resonance and crystal field theory, Jahn-Teller effect; Hund's rule and rare earth ions in solids. Pinning effects, The Kondo effect, spin glass, solitons, Magneto resistance – spin valves and spin switches, giant magneto resistance (GMR), spintronics.

Unit-III Dielectrics and Ionics: Dielectric properties in solid – polarization, electrical conduction, dielectric loss, breakdown of dialectics, nonlinear dielectrics – ferroelectrics, junction capacitor, piezoelectric, electrets , impedance spectroscopy, complex dielectrics, eclectic modulus. Ionic conduction in solid: defect in solid, conduction mechanism, Nernst Einstein equation, cataonic, protonic and anionic conductor, temperature and frequency dependent of conductivity, hopping mechanism, universal power law (Jonscher's Power Law) oxygen ion conductor, solid electrolyte, fuel cell, SOFC.

Unit-IV Polymers, Composites and Soft matters (15)

Polymer and their classification, Molecular weight, degree of polymerization, techniques of polymerization, crystallinity of polymers, applications of polymers. Polymer electrolyte, conducting polymers- concept of solitons, polarons, biolarons, Doping in conducting polymers, Common conducting polymers, Properties and applications of conducting polymers: PLED, sensors actuators.

Composite Materials- various types of composites, microcomposites and mactrocomposites, fibre composites, and matrix materials, Different kinds of soft matters, Symmetry and order parameters, Dispersion colloids, liquid crystal, biological membranes, macromolecules- DNA condensation, bilayer, Marcelja's molecular field theory mesosphere.

Recommended Books:

1) The Modern Theory of Solids- F.Sitz
2) Solid State Theory-W. Harrison, TMH,
3) Introduction to Solid State Physics by C. Kittel.
4) Solid State Physics – A.J. Dekker.
5) Introduction to Solid State Physics – H.P. Myers.
6) Solid state Physics – N.N. Ashcroft and N.D. Mermin.

M.Sc-II, SEME. III, PHYSICS (CONDENSED MATTER PHYSICS)
SCT – 3.2: THIN FILM PHYSICS AND TECHNOLOGY
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

Unit - I Chemical Methods of Thin films synthesis (15)

Chemical vapor deposition: Common CVD reactions, Methods of film preparation, laser CVD, Photochemical CVD, Plasma enhanced CVD. Chemical bath deposition: ionic and solubility products, preparation of binary semiconductors, Electrodeposition: Deposition mechanism and preparation of compound thin film Spray pyrolysis: Deposition mechanism and preparation of compound thin Films.Ion-assisted deposition (IAD), Laser ablation, Longmuir Blochet film, Sol-gel film deposition.

Unit -II Physical Methods of Thin Film Synthesis (15)

. Introduction to Thin Films, Thermal evaporation methods: Resistive heating, Flash evaporation, Laser evaporation, Electron bombardment heating, Arc evaporation, Sputtering process: Glow discharge, DC sputtering, Radio frequency sputtering, Magnetron sputtering, Ion beam sputtering.

Unit -III Physics of Surfaces, Interfaces and Thin films (15)

Mechanism of thin film formation: Formation stages of thin films, Condensation and nucleation, Thermodynamic theory of nucleation, Growth and coalescence of islands, 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

Unit -IV Thin films for Devices & other Applications (15)

Dielectric deposition- silicon dioxide, silicon nitride, silicon oxynitride, polysilicon deposition, metallization, electromigration, silicides. Thin film transistors, thin film multilayers, optical filters, mirrors, sensors and detectors.

References:

1. Ludmila Eckertova, Physics of thin films, 2nd Revised edition, Plenum Press, New York, 1986 (Reprinted 1990),
2. K.L. Chopra, Thin film phenomena, Mc-Graw Hill, New York, 1969.
3. L. C. Feldman and J.W. Mayer, Fundamentals of surface and Thin Films Analysis, North Holland, Amsterdam, 1986.
4. S.M. Sze, Semiconductor Devices-Physics and Technology, John Wiley, 1985.

Additional References:

1. R.W. Berry, P.M.Hall and M.T. Harris, Thin film technology, Van Nostrand, New Jersey, 1970, K.L.Chopra and LK.Malhotra (ed),

2. Thin Film Technology and Applications, T.M.H. Publishing Co., New Delhi (1984).

M.Sc-II, SEME. III, PHYSICS (CONDENSED MATTER PHYSICS)
OET - 3.1: MEDICAL PHYSICS
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

Unit-I: Forces acting on body and Physics of the skeleton (15)
Statics, Frictional forces, Dynamics, Conservation of Energy in the body, Heat losses from body, Pressure in the body. Physical properties of bone, Mechanics of joints,

Unit-II: Electricity within the body (15)
Nervous system and neuron, Electric properties of Nerve, Electrical potential of nerve, Nernst Equation, Bio potentials EMG, ECG, EEG, EOG, ERG, Magnetic signals from heart and Brain

Unit-III: Physics of hearing (15)
Basic definition of Audibility, Physics of ear, Human Audibility Curve, Sensitivity of ear, Testing of hearing. Deafness and hearing aids, Sound in medicine, Sound pollution, Effects of sound pollution on living body, Methods to minimize sound pollution.

Unit-IV: Physics of vision (15)
Optics of eye, Diffraction effects of eye, Refractive effect in eye and its correction, Contact Lenses, Color vision and chromatic aberration, Instruments used in Ophthalmology.

Reference Books:

1. Medical Physics by John R. Cameron, J. G. Skofronick, John Wiley and Sons,Inter.Publ.
2 .Essential of Biophysics by Narayanan, New age Publication.
3. Radiation Biophysics by Edward Alphan, prentice Hall Advance Referes.
4. T.B. of Biophysics by R.N. Roy , Central Publication.
5. Medical Informatics by Smita Mishra and K. C. Mishra, ICFAI university.
6. Fundamental of Bioinformatics by Harisha. S.
7. Biomedical Engineering by S.N. Sarbadhikari, University press.
8. Principles of medical electronics &Biomedicalinstrumentation by c. Raja Rao, S. K. Guha , University press.
9. Electronics in medicine & Biomedical instrumentation by NandiniJog ,
10. Websites of the related topics

M.Sc-II, SEME. III, PHYSICS (CONDENSED MATTER PHYSICS)
OET - 3.2: ENERGY HARVESTING DEVICES
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

Unit -1: Solar Cells (15)

Photovoltaic effect, Solar cell characterization, Types of Solar cells, Solid state solar cells Silicon solar cell, CdTe based solar cells, CdS/Cu_2S solar cells, $CuInSe_2$ based solar cells, Metal-semiconductor solar cells, photoelectrochemical and photo electrolysis cells, Solar cells based on thin film heterojunctions, Ultra thin absorber solar cells, Nanostructured solar cells, Dye sensitised solar cells: basic concepts, working and materials. Organic Solar cells: basic concepts, working and materials.

Unit -2: Super Capacitors (15)

Comparison of battery and super capacitors, Super capacitor characterization, Types of super capacitors, double layer and pseudo capacitance, hybrid super capacitors, Recent status of carbon, RuO_2 and polyaniline based super capacitors, different methods for preparation of cathodic and anodic electrode materials, Fabrication of super capacitors with examples, Applications of supercapacitors

Unit -3: Fuel Cells (15)

Comparison between fuel cells and batteries, fuel cell characterizations, Types of fuel cells: Metal oxide, proton exchange membrane, Phosphoric acid, Solid oxide fuel cells, working of fuel cells, Materials for fuel cells, applications of fuel cells

Unit -4: Piezoelectrics (15)

Piezoelectric Energy Harvesting: Energy harvesting basis, case study

Piezoelectric Materials: Piezoelectric polycrystalline ceramics,Piezoelectric Single Crystal Materials, Piezoelectric and Electrostrictive Polymers, Piezoelectric Thin Films.

Piezoelectric transducers, Mechanical energy harvester using Laser Micromachining, Mechanical energy harvester using PlezoelectricFibers, Piezoelectric Microcantilevers, Energy harvesting circuits, Multimadal energy harvesting, Mangetoelectric composites,

Introduction to Piezoelectric bulk Power generators, Piezoelectric Micro Power Generators, Conversion efficiency, Power storage circuits

Reference Books

1. Semiconductor Sensors, S M Sze, A Wiley- Interscience Publication, John Wiley and Sons, NY1994
2. Electrochemical Supercapacitors, B E Conway, Kluwer Academic/ Plenum publishers, NY 1999.
3. C. N. R. Rao and Claudy Rayan Serrao, J. Mater. Chem., 2007, 17, 4931–4938
4. Solar Cells by Martin Green.
5. Photoelectrochemical Solar Cells by S. Chandra, Gordon &Breach Science Publisher, UK
6. Energy Harvesting Technologies, ShashankPriya, Daniel J. Inman Springer

M.SC-II, SEME. III, PHYSICS (CONDENSED MATTER PHYSICS)
SCT - 4.1: MICROELECTRONICS
Choice Based Credit System (CBCS)
(w. e. f. June 2020-21)

Unit I: Single crystalline Silicon and crystal structure (15)

(111) and (100) planes, Characteristics of substrates: physical (dimensional), electrical, dielectric, mechanical, Wafer cleaning process and wet chemical etching techniques, Environment for VLSI technology: clean room and safety requirements.

Epitaxial Process: Epitaxial Growth: VPE, LPE and MBE techniques, Mechanism, Chemistry and growth kinetics, evaluation of grown layer.

Unit II: Oxidationand Impurity Incorporation (15)

Oxide growth: dry, wet, rapid thermal oxidation; Deal Grove model of thermal oxidation, plasma oxidation,orientation dependence of oxidation rate, electronic properties of oxide layer, masking characteristics, oxide characteristics.

Impurity Incorporation: Interstitial and substitutional diffusions, diffusivity, laws governing diffusion, constant source and instantaneous source diffusion, Solid Source, liquid source and gas source Boron and Phosphorus diffusion systems, Ion implantation, annealing; Characterization of impurity profiles, buried layers

Unit III: Lithographic and Deposition Techniques (15)

Lithography: Types, Optical lithography –contact, proximity and projection printing, masks, resists: positive and negative, photo - resist pattering, characteristics of a good photo - resist, Mask generation using co-ordinaton graph and electron beam lithography.

Deposition Techniques for polysilicon and metals

Chemical Vapour deposition techniques: CVD technique for deposition of polysilicon, silicon dioxide and silicon nitride films; Metallisation techniques: Resistive evaporation and sputtering techniques. (D.C. and magnetron), Failure mechanisms in metal interconnects; multilevel metallisation schemes.

Unit IV: Device fabrication, Assembling and Packaging (15)

Masking Sequence and Process flow for pnp and npn devices , p-MOS and n-MOS, Die separation, bonding and attachments, encapsulation, package sealing, flat package, PGA (Printed Grid Array), BGA (Ball Grid Array)

Reference Books:

1. S.M.Sze (Ed), "VLSI Technology", 2nd Edition, McGraw Hill, 1988.
2. Streetman," VLSI Technology". Prentice Hall, 1990
3. C.Y. Chang and S.M. Sze (Ed), "VLSI Technology", McGraw Hill Companies Inc., 1996.
4. S.K.Gandhi, "VLSI fabrication Principles", John Wiley Inc., New York, 1983.
5. Sorab K. Gandhi, "The Theory and Practice of Microelectronics", John Wiley & Sons
6. A.S Grove, "Physics and Technology of semiconductor devices", John Wiley & Sons,
7. Integrated Ckts: Design principles and Fabrication: Warner.

Topics for Tutorials/Seminars: The problem/ exercise / short questions answers/ block diagrams given in the reference books will from the Tutorial Course.

M.Sc-II, SEME. IV, PHYSICS (CONDENDED MATTER PHYSICS)
HCT - 4.2: PHYSICS OF NANO MATERIALS
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

Unit I: Introduction (15)

Background of Nanoscience and Nanotechnology, Definition of Nanoscience and Nanotechnology, Possible Applications of Nanotechnology, Top-down and Bottom-up approach (Brief).

Band Structure and Density of States at Nanoscale: Introduction, Energy Bands, Density of States at Low - dimensional Structures, Quantum confinement – semiconductors, quantum wells, quantum wires, quantum dots, quantum rings. Manifestation of quantum confinement, quantum confinement effect, dielectric quantum confinement, effective mass approximation, core-shell quantum dots.

Unit II: Properties of Nanomaterials (15)

Optical properties: Absorption, transmission, Beer-Lamberts law (derivation), Photoluminscence, Fluorescence, Phosphorescence,Cathodoluminscence, Electroluminescence, Surface Plasmon resonance (SPR), effect of size of nanoparticles (metal, semiconductor) on absorption and SPR spectra.

Electrical transport: Electrical Conduction in Metals, Classical Theory - The Drude Model Quantum Theory - The Free Electron Model Conduction in Insulators/Ionic Crystals, Electron Transport in Semiconductors, Various Conduction Mechanisms in 3D (Bulk), 2D(Thin Film) and Low – dimensional Systems**,** Thermionic Emission Field – enhanced Thermionic Emission (Schottky Effect), Field - assisted Thermionic Emission from Traps (Poole - Frenkel Effect), Hopping Conduction, Polaron Conduction.

Unit III: Growth Techniques and Characterization Tools of Nanomaterials (20)

Growth techniques: Introduction, Top - down vs. Bottom - up Technique, Lithographic Process and its limitations , Nonlithorgraphic Techniques ,Plasma Arc Discharge Sputtering ,Evaporation, Chemical Vapour Deposition ,Pulsed Laser Deposition ,Molecular Beam Epitaxy, Sol - Gel Technique , Electrodeposition , Different chemical routes, Other Processes.

Characterization Tools of Nanomaterials: Scanning Probe Microscopy (SPM): Introduction, Basic Principles of SPM Techniques, The Details of scanning Tunneling Mocroscope (STM), General Concept and Definite Characteristics of AFM, Scanned - Proximity Probe Microscopes Laser Beam Deflection, AFM Cantilevers ,Piezoceramics, Feedback Loop Alternative Imaging Modes. Electron Microscopy: Introduction, Resolution vs. Magnification Scanning Electron Microscope SEM Techniques, Electron Gun Specimen Interactions Environmental SEM (FESEM), Transmission Electron Microscope, High Resolution TEM Contrast Transfer Function. Near-field scanning optical microscopy (SNOM/NSOM), UV-Vis single and dual beam spectrophotometer,

photoluminescence spectrometer, X-ray diffractometer. Surface area and Pore size measurements (BET analysis)

Unit IV: Some Special Topics in Nanotechnology (10)

Introduction ,The Era of New Nanostructure of Carbon Buckminsterfullerene, Carbon Nanotubes, Nanodiamond, BN Nanotubes Nanoelectronics ,Single Electron Transistor, Molecular Machine, Nano-biometrics.

Reference Books:

1) **Introduction to Nanoscience and Nanotechnology:** K.K. Chattopadhyay and A.N. Banerjee, PHI Publisher
2) **Nanoscience and Technology:** V. S. Murlidharan, A. Subramanum.
3) **Nanotubes and Nanofibers:**YuryGogotsi
4) **A Handbook of Nanotechnology :** A. G. Brecket
5) **Instrumentations and Nanostructures:** A. S. Bhatia
6) **Nanotechnology: Nanostructures and Nanomaterials -** M. B. Rao
7) **Nanotechnology-Principles and practices -** S. K. Kulkurni (Capital Publication Company)

Reference Books:

1) Handbook ofApplied Solid State Spectroscopy, D. R. Vij, Springer
2) Phtoelectron and Auger Spectroscopy,T.A.Carlson, Plenum Press , 1975
3) Practical Guide to Surface Science and Spectroscopy,Yip-WahChung,Academic Press
4) Fundamental of Molecular Spectroscopy, C.N.Banwell,TataMc-Graw Hill.

M.SC-II, SEME. IV, PHYSICS (CONDENSED MATTER PHYSICS)
HCT - 4.3: PROPERTIES OF SOLIDS
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

Unit - I Optical and Dielectric properties (15)

Maxwell's equations and the dielectric function, Lorentz oscillator, the Local field and the frequency dependence of the dielectric constant, Polarization catastrophe, Ferroelectrics Absorption and Dispersion, Kraemers' Kronig relations and sum rules, single electron excitations and plasmons in simple metals, Reflectivity and photoemission in metals and semiconductors Interband transitions and introduction to excitons, Infrared spectroscopy.

Unit -II Transport Properties (15)

Motion of electrons and effective mass, The Boltzmann equation and relaxation time, Electrical conductivity of metals and alloys, Mathiessen's rule, Thermo-electric effects, Wiedmann-Franz Law, Lorentz number, ac conductivity, Galvanomagnetic effects.

Unit -III Magnetism and Magnetic materials (15)

Review: Basic concepts and units, basic types of magnetic order Origin of atomic moments, Heisenberg exchange interaction, Localized and itinerant electron magnetism, Stoner criterion for ferromagnetism, Indirect exchange mechanism: superexchange and RKKY.

Magnetic phase transition: Introduction to Ising Model and results based on Mean field theory, Other types of magnetic order: superparamagnetism, helimagnetism, metamagnetism, spin glasses.

Magnetic phenomena: Hysteresis, Magnetostriction, Magnetoresistance, Magnetocaloric and magneto-optic effect.

Magnetic Materials: Soft and hard magnets, permanent magnets, media for magnetic recording.

Unit -IV Superconductivity (15)

The phenomenon of superconductivity: Perfect conductivity and Meissner effect.

Electrodynamics of superconductivity: London's equations, Thermodynamics of the superconducting phase transition: Free energy, entropy and specific heat jump.

Ginzburg-Landau theory of superconductivity: GL equations, GL parameter and classification into Type I and Type II superconductors, The mixed state of superconductors.

Microscopic theory: The Cooper problem, The BCS Hamiltonian, BCS ground state Josephson effect: dc and ac effects, Quantum interference.

Superconducting materials and applications: Conventional and High Tc superconductors, superconducting magnets and transmission lines, SQUIDs.

Assignments: should be based on numerical problems related to the syllabus.
Main References:

1. 1. Solid State Physics, H. Ibach and H. Luth, *Springer(Berlin)* 2003 (IL)
2. Solid State Physics, Neil Ashcroft and David Mermin (AM)
3. Introduction to Solid State Physics (7th/ 8th ed) Charles Kittel (K)
4. Principles of Condensed Matter Physics, Chaikin and Lubensky (CL)

Additional References:

1. Principles of Condensed Matter Physics, Chaikin and Lubensky (CL)
2. Intermediate theory of Solids, Alexander Animalu (AA)
3. Optical Properties of Solids, Frederick Wooten, Ac Press (New York) 1972 (FW)
4. Electrons and Phonons, J M Ziman, Electron transport in metals, J.L. Olsen
5. Physics of Magnetism and Magnetic Materials, K.H.J. Buschow and F.R. de Boer Introduction to Magnetism and Magnetic Materials
6. Magnetism and Magnetic Materials, B. D. Cullity
7 Solid State Magnetism, J. Crangle
8 Magnetism in Solids, D. H. Martin

M.SC-II, SEME. IV, PHYSICS (CONDENSED MATTER PHYSICS)
SCT - 4.1: EXPERIMENTAL TECHNIQUES IN PHYSICS
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

Unit-I Electronic instrumentations (15)

Measurement system- mechanical and electrical, Transducers and its types, sensors, differential output transducer, LVDT, Hygrometers, Measurement of thermal Conductivity (gas analyzer), Physiological transducers Bio-potential electrodes. Digital and analog measuring instruments – voltmeter, ammeter, oscilloscope, power meter, LCR meter, instrumentation amplifier, filtering and noise reduction in instruments, shielding and grounding, lock-in detector, box-car integrator, interfacing sensors and data acquisition, Integrated circuits technology – fabrications, Power supplies- primary and secondary cell, regulated power supply, SMPS, UPS, Step down switching regulator, Inverters- voltage driven inversion, current driven inversion.

Unit-II Lasers and Optoelectronic instrumentation (15)

Lasers: - Temporal and special coherence, Einstein coefficients, The threshold condition, two, three and four level laser systems, Modes of a rectangular cavity
and open planar resonator, Quality factor, mode selection, The Ruby laser, The Helium-Neon laser, the carbon dioxide (CO2)laser. Optoelectronic devices : Photoconductivity, LDR, photodiode, phototransistor, solar cell, metal semiconductor detector, LCD, CCD , LED, Laser diode, PIN photodiode, Avalanche photodiode, Heterojunction photodiode, Organic light emitting diodes,. Optical fiber- ray propagation Step –index and graded-index fibers, dispersion and attenuation in fiber optics, Dispersion compensation mechanism, Erbium-doped fiber amplifiers, Optoelectronic modulators.

Unit III (a). X-ray analysis (15)

Origin of X-rays, X-ray generators. Scattering of X-ray, atomic scattering factor,
Diffraction of X-ray, various X-ray diffraction methods, X-ray powder diffraction method -indexing of powder lines, Laue's method, rotational/oscillation method, X-ray diffractormeter, determination of crystal structure and lattice parameter, small angle x-ray diffraction and its applications. XPS, XRF and its applications.

(b).Low pressure and Low temperature: Production of low pressure -Rotary, oil diffusion, turbo molecular, getter and cryo pumps; gauges – Macleod thermoelectric (thermocouple, thermistor and pirani), penning, hot cathode partial pressure measurement; leak detection; gas flow through pipes and apertures; effective pump speed; vacuum components. Production of Low temperature**:** Gas liquifiers; Cryo -fluid baths; liquid He cryostat design; closed cycle He refrigerator; low temperature measurement.

Unit-I Analytical Instrument (15)

Electron Microscopy (SEM, TEM, HRTEM), Scanning probe microscopy (AFM, MFM, STM), UV-Vis, spectroscopy and its applications. FT-IR spectroscopy, Luminescence spectroscopy techniques- Fluorescence spectroscopy, Raman spectroscopy, Thermal analysis using DTA, TGA, DSC; Electronic transport analysis using Current vs Voltage characteristics – two probe and four probe techniques - various types of contacts, Dielectric and impedance spectroscopy, spectrum analyzer,

fluorescence and Raman spectrometer, Interferometers for different analytical study.

Recommended Books:

1) Electronic Instrumentation - Kalsi H S
2) X-Ray Crystallography – B.E. Warren.
3) Materials Characterization: Introduction to Microscopic and Spectroscopic Methods,
4) Materials Characterization Techniques Sam Zhang, Lin Li, Ashok Kumar

M.SC-II, SEME. IV, PHYSICS (CONDENSED MATTER PHYSICS)
SCT - 4.2: POLYMER SCIENCE AND TECHNOLOGY
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

Unit I: Historical developments in polymeric materials (15)
Basic concepts & definitions: monomer & functionality, oligomer, polymer, repeating unites, degree of polymerization, molecular weight & molecular weight distribution.

Unit II: Natural Polymers (15)
Chemical & Physical structure, properties, source, important chemical modifications, applications of polymers such as cellulose, lignin, starch, rosin, shellac, latexes, vegetable oils and gums, proteins etc.

Unit III: Methods of Polymer Synthesis (15)

Unit IV: Applications of Polymers (15)

Textbooks/Sourcebooks:
1. Raw Materials for Industrial Polymers by H Ulrich, Hanser Publication1989.
2. Principles of Polymer Science, by Bahadur and Sastry, Narosa Publishing House 2002.
3. Polymer Science by Gowarikar, Johan wiley and Sons 1986.
4. Encyclopedia of Polymer Science and Technology, Johan Wiley and Sons, Inc 1965.
5. Encyclopedia of Polymer Science and Engineering, Johan Wiley and Sons, Inc 1988.
6. Petrochemicals the Rise of an Industry by Peter H. Spitz, Johan Wiley and sons 1988.
7. Polymer Chemistry by Malcolm P. Stevens, Oxford University Press, Inc, 1990.

M.SC-, PHYSICS (CONDENSED MATTER PHYSICS)
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

HCP 3.1/3.2

1) Susceptibility measurement of $FeCl_3 6H_2O$ solution.
2) Successive Ionic Layer Adsorption and Reaction.
3) Chemical Bath deposition of PbS.
4) Chemical Bath deposition of CdS.
5) Strain gauge II.
6) Optical studies on CdS thin film (α vs λ, determination of E_g and m).
7) LVDT II.
8) Band gap determination using four probe method.
9) Hydroxide co-precipitation of $Ba_{0.8}Sr_{0.2}\,TiO_3$
10) Electrodeposition of Ni.
11) Ceramic synthesis of PZT.
12) Antocombustionsyrthesis of $Cofe_2O_4$.

SCP 3.1

1) Faraday Effect.
2) Kerr Effect.
3) Pockel Effect.
4) Electrical conductivity measurement and determination of activation energy.
5) Thermoelectric power measurement.
6) Determination of Curie temperature.
7) Particle size estimation.

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