SCHOOL OF PHYSICAL SCIENCES,
SOLAPUR UNIVERSITY, SOLAPUR
M.Sc – Physics (Materials Science)
Choice Based Credit System
w.e.f June 2016-17

Semester	Code	Title of the Paper	Semester exam			L	T	P	Credits
First		**Hard core**	**Theory**	**IA**	**Total**				
MS	**HCT1.1**	Mathematical Techniques	70	30	100	4		-	4
	HCT1.2	Condensed Matter Physics	70	30	100	4		-	4
	HCT1.3	Analog& Digital Electronics	70	30	100	4		-	4
		Soft Core (Any one)							
	SCT1.1	Classical Mechanics	70	30	100	4		-	4
	SCT1.2	Elements of Materials Science	70	30	100	4		-	
		Tutorial			25		1	-	1
		Practical							
	HCP 1.1	Practical HCP 1.1	35	15	50	-	-	2	6
	HCP1.2	Practical HCP 1.2	35	15	50	-	-	2	
	HCP1.3	Practical HCP 1.3	35	15	50	-	-	2	
		Soft core (Any one)							
	SCP1.1	Practical SCP1.1	35	15	50	-	-	2	2
	SCP1.2	Practical SCP1.2	35	15	50	-	-	2	
		Total for first semester	**420**	**180**	**625**				**25**
Second		**Hard core**							
MS	**HCT2.1**	Quantum Mechanics	70	30	100	4		-	4
	HCT2.2	Electrodynamics	70	30	100	4		-	4
		Soft core (Any one)							
	SCT2.1	Analytical Techniques	70	30	100	4		-	4
	SCT2.2	Statistical Mechanics	70	30	100	4		-	
		Open elective (Any one)							
	OET2.1	Nanomaterials: Synthesis, Properties And Applications	70	30	100	4		-	4
	OET2.2	Conventional & Non conventional Energy	70	30	100	4		-	
		Tutorial			25		1	-	1
		Practical							
	HCP 2.1	Practical HCP 2.1	35	15	50	-	-	2	4
	HCP2.2	Practical HCP 2.2	35	15	50	-	-	2	
		Soft core (Any one)							
	SCP1.1	Practical SCP2.1	35	15	50	-	-	2	2
	SCP1.2	Practical SCP2.2	35	15	50	-	-	2	
		Open elective (Any one)							
	OEP2.1	Practical OEP2.1	35	15	50	-	-	2	2
	OEP2.2	Practical OEP2.2	35	15	50	-	-	2	

		Total for second semester	**420**	**180**	**625**				**25**
Third		**Hard core**							
MS	**HCT3.1**	Semiconductor Devices	70	30	100	4		-	4
	HCT3.2	Atomic, Molecular & Nuclear Physics	70	30	100	4		-	4
		Soft core (Any one)							
	SCT3.1	Dielectric & Ferroelectric Properties of Materials	70	30	100	4		-	4
	SCT3.2	Materials Processing	70	30	100	4		-	
	SCT3.3	Materials Characterization	70	30	100	4			
		Open elective (Any one)							
	OET3.1	Introduction to Nanoscience	70	30	100	4		-	4
	OET3.2	Nuclear Radiations & Effects	70	30	100	4		-	
		Tutorial			25		1	-	1
		Practical							
	HCP 3.1	Practical HCP 3.1	35	15	50	-	-	2	2
	HCP3.2	Practical HCP 3.2	35	15	50	-	-	2	2
	SCP 3.1	Practical SCP 3.1	35	15	50	-	-	2	2
		Open elective (Any one)							
	OEP3.1	Practical OEP3.1	35	15	50	-	-	2	2
	OEP3.2	Practical OEP3.2	35	15	50	-	-	2	
		Total for third semester	**420**	**180**	**625**				**25**
Four		**Hard core**							
MS	**HCT4.1**	Microelectronics	70	30	100	4		-	4
	HCT4.2	Physics of Nano Materials	70	30	100	4		-	4
	HCT 4.3	Magnetic Materials	70	30	100	4		-	4
		Soft core (Any one)						-	4
	SCT4.1	Advanced Techniques of Materials Characterization	70	30	100	4		-	
	SCT4.2	Polymer Science &Technology	70	30	100	4		-	
		Tutorial			25		1	-	1
	MP4.3	Major Project	140	60	200	-	-	-	8
		Total for four semester	**420**	**180**	**625**				**25**
	Total								**100**

L = Lecture T = Tutorials P = Practical IA=Internal Assessment

4 Credits of Theory = 4 Hours of teaching per week

2 Credits of Practical = 4 hours per week

HCT = Hard core theory

SCT = Soft core theory

HCP = Hard core practical

SCP = Soft core practical

OET = Open elective theory

OEP = Open elective practical

MP = Major project

M.SC-I, SEME. I, PHYSICS (MATERIALS SCIENCE)

HCT - 1.1: MATHEMATICAL TECHNIQUES

Choice Based Credit System (CBCS)

(w. e. f. June 2016-2017)

Unit I: Calculus of Residues (15)

COMPLEX VARIABLE AND REPRESENTATIONS: Algebraic Operations, Argand Diagram: Vector Representation, Complex Conjugate, Euler's Formula, De Moiver's Theorem, The n^{th} Root or Power of a complex number.

ANALYTICAL FUNCTIONS OF A COMPLEX VARIABLE : The Derivative of f(Z) and Analyticity, Harmonic Functions, Contour Integrals, Cauchy's Integral Theorem, Cauchy's Integral Formula,

Zeros, Isolated Singular points, Evaluation of Residues, Cauchy's Residue theorem.

Unit II : Operator and Matrix Analysis (15)

Vector Space and its dimensionality, Vector Spaces and Matrices, Linear independence; Bases; Dimensionality, linear dependence, Inner product Hilbert space, linear operators.

Matrix operations, properties of matrices, Inverse, Orthogonal and unitary matrices; Independent elements of a matrix Diaglonization; Complete orthogonal sets of functions, special square matrices, Eigen values and eigenvectors; Eigen value problem.

Unit III: Ordinary Differential Equations (14)

First-Order homogeneous and non homogeneous equations with variable coefficients. The superposition principle, Second-order homogeneous equations with constant coefficient. Second-order non homogeneous equations with constant coefficients.

Unit IV: Fourier Series, Integral Transforms and Laplace transform (16)

Fourier Series: Fourier's theorem; Cosine, Sine and complex Fourier series, Applications to saw tooth and square waves and full wave rectifier. FS of arbitrary period; Half wave expansions; Partial sums Fourier integral and transforms; cosine since complex forms, Parsevals relation, Application to Gaussian distribution, box and exponential functions; FT of delta function.

Laplace transforms: Laplace transforms of common functions, First and second shifting theorems; inverse LT by partial fractions; LT of derivative and integral of a function.

Reference Books:

1. Introduction to Mathematical Physics by C. Harpcr, Prcnticc - Hall of India Ltd. N.Delhi 1993,(Chapters 2,4,6,9)

2. Mathematical Physics by A.G. Ghatak, I.C.Goyal and S.J.Chua, McMillan India Ltd. New Delhi 1995 (Chapters 4,7,9,10)

3. Matrices and Tensors for Physicists,by A W Joshi
4. Advanced Engineering Mathematics, by E Keryszig
5. Mathematical Method for Physicits and Engineers, by K F Reily, M P Hobson and S J Bence

6. Mathematics for Physicists by Mary L B
7. Mathematical Methods for Physics, by G Arfken

M.SC-I, SEME. I, PHYSICS (MATERIALS SCIENCE)

HCT - 1.2: CONDENSED MATTER PHYSICS

Choice Based Credit System (CBCS)

(w. e. f. June 2016-2017)

Unit I: Crystal Structure (15)

Basic Structures; symmetry properties, packing fractions, directions and position-orientation of planes in crystal, concept of reciprocal lattice, concept of brillouin zones, closed packed structure, and structures of some binary/ternary compounds. Elementary concepts of polycrystalline, nanocrystalline and amorphous materials. Elementary concepts of defects in solids. X-ray scattering from solids including Laue conditions and line intensities.

Unit II : Energy bands and Semiconductors (15)

Energy bands: Electron in periodic potential, Bloch function, solution of wave equation of electron in periodic potential, reduced, periodic and extended zone schemes. Construction of Fermi surfaces in brillouin zones for two - dimensional lattices, Introduction to methods for calculations of energy bands and their features. **Semiconductors:** Direct and indirect band gap semiconductors effective mass, intrinsic carrier concentration, impurity conductivity thermal ionization Revision on p-n junction and rectification, metal- semiconductor contacts, schotky barrier.

Unit III : Dielectric properties of Solids (15)

electronic, ionic, orientational, polarzabilities, static dielectric constant for gases, internal field in solids, dielectric constant of solids, dielectric relaxation in alternating fields, dielectric losses, complex dielectric constant.

Unit IV: Superconductivity (15)

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.

Reference Books:

1) Introduction to Solid State Physics 4 th Ed. C.Kittel,

2) Solid State Physics by A.J.Dekker

3) Solid State Physics by N.W.Ashoroff&N.D.Mermin

4) Solid State Physics S.O.Pillai

5) Solid state Physics by R.L.Singhal

M.SC-I, SEME. I, PHYSICS (MATERIALS SCIENCE)

HCT - 1.3: ANALOG & DIGITAL ELECTRONICS

Choice Based Credit System (CBCS)

(w. e. f. June 2016-2017)

Unit I: Operational Amplifiers (15)

Differential amplifier Circuit Configurations, Dual Input Balanced Output Differential amplifier , DC analysis, AC analysis, Inverting and Non Inverting Inputs, Constant Current Bias Circuit.

Block diagram of a typical Op-Amp, Open loop configuration, Inverting and Non-inverting amplifiers, Op-amp with negative feedback, Voltage Series Feed back, Effect of feed back on closed loop gain, Input resistance, Output resistance, Bandwidth and Output offset voltage, Voltage follower.

Practical Op-amp, Input Offset Voltage, Input bias current- input offset current, total output offset voltage, CMRR frequency response.

Unit II: Applications of Op amps (15)

DC and AC amplifier, Summing, Scaling and Averaging Amplifiers, Instrumentation amplifier, Integrator and Differentiator.

Oscillator: Principles , Oscillator types, Frequency stability, Response , Phase Shift oscillator ,Wein Bridge Oscillator, LC Tunable Oscillator , Multivibrators, Monostable and Astable, Comparators, Square Wave and Triangle wave generators.

Voltage regulations: Fixed regulators, Adjustable voltage regulators, Switching regulators.

Unit III: Combinational & Sequential Logic Circuits (15)

Combinational logic:

The transistor as a switch, OR AND NOT gates- NOR And NAND gates Boolean algebra- Demorgans theorems- exclusive OR gate, Decoder/ Demultiplexer Date selector/ multiplexer - Encoder.

Sequential Logic:

Flip- Flops: RS Flip- Flop, JK Flip- Flop, JK master slave Flip-Flops Flip-Flop, D Flip- Flop, Shift registers Synchronous and Asynchronous counters.

Unit IV: Microprocessors (15)

Architecture of 8085, Signals and timing diagram of 8085, Demultiplexing Address and Data bus, Instruction Set, Addressing modes, Assembly Language Programming of 8085 (Sum of an array, Minimum and Maximum of an array, Multiplication & Division of 4 & 8 bit numbers) .

Reference Books:

1) OP Amp amplifiers by RamakantGaikwad

2) Integrated Circuits by K.R.Botkar

3) Modern Digital Electronics by R.P.Jain

4) Digital Principle and Application by Malvino&Leeach

5) Digital Fundamentals by Floyd

6)8085 Microprocessor by Ramesh Gaonkar

M.SC-I, SEME. I, PHYSICS (MATERIALS SCIENCE)

SCT - 1.1: CLASSICAL MECHANICS

Choice Based Credit System (CBCS)

(w. e. f. June 2016-2017)

Unit I : Mechanics of Particles and Rigid Bodies (15)

Mechanics of Particle and system of Particles using vector algebra and vector calculus, Conversion laws, work-energy theorem, open systems (with variable mass), Gyroscopic forces; dissipative systems, Jacobi integral, gauge invariance, integrals of motion; symmetries of space and time with conservation laws; invariance under Galilean transformations.

Unit II: Lagrangian Formulation and Motion Under Central Force

(15)

Constrainsts, Generalised co-ordinates, D Alemaberts Principle, Lagranges equations of motion, Central Force, definition and characteristics, Reduction of Two-bod problem into equivalent One-body problem, General analysis of orbits, Keplers laws and equations, Artificial satellites, Rutherford Scattering.

Unit III: Variational Principle (15)

Introduction to Calculus of variation, Variational technique for many independent variables, Eulers Lagrange differential equation, Hamilton's principle, Deduction f Lagrange's equation of motion from Hamilton's principle.

Hamilton, Generalized momentum, Constant of motion, Hamilton's canonicl equations of motion, Deduction of canonical equations from Variations principle.

Applications of Hamilton's equations of motion, Principle of least action, Proof of principles of least action, Problems.

Unit IV: Canonical Transformations and Hamilton's - Jacobi Theory (15)

Canonical Transformations, Condition for Transformation to be Canonical, Illustration of Canonical Transformation, Poisson's Brackets, Properties of Poisson's Brackets, Hamilton's Canonical equations in terms of Poisson's Brackets. Hamilton's - Jacobi Theory, Solution of harmonic oscillator problems by HJ Method, Problems.

Texts and Reference Books:

1. Classical Mechanics, By Gupta, Kumar and Sharma (Pragati Prakashan2000).
2. Introduction to Classical Mechanics, by R.G. Takwale and P S Puranik(Tata McGraw Hill 1999).
3. Classical Mechanics, by H Goldstein (Addison Wesley 1980).
4. Classical Mechanics, by N C Rana and P S Joag(Tata McGraw Hill 1991).
5. Mechanics, by A Sommerfeld (Academic Press 1952)

M.Sc-I, SEME. I, PHYSICS (MATERIALS SCIENCE)

SCT– 1.2 (MS): ELEMENTS OF MATERIALS SCIENCE

Choice Based Credit System (CBCS)

(w. e. f. June 2016-2017)

Unit I: Introduction to materials: Classification, Properties and Requirements (15)

Introduction, Classification of Engineering Materials, Metals, Alloys, ceramics, Polymers and Semiconducting materials, Application of Engineering Materials.

Chemical Bonding: Introduction, Crystalline and Non-crystalline Solids, Classification of Bonds, Ionic Bond or Electrovalent Bond, Covalent Homopolar Bonds, Metallic Bonds, Molecular Bonds, Hydrogen Bond, van der Walls bond (Inter-molecular and Intra-molecular bonds).

Unit II: Optical Properties of Materials (15)

Introduction, Classification of Optical Materials, Interaction of light with matter, Absorption in Metals, Insulators and Semiconductors, Reflection, Refraction, Transmission and Scattering, Traps, Excitons, Colour Centers, Tauc and Lambert-Beer laws, Optical properties of Photonic material.

Luminescence and Photoconductivity Luminescence: Introduction, Principle, Classification of Luminescence, Photoluminescence, Cathodoluminescence, Electroluminescence, Thermoluminescence, Phosphorescence, Chemiluminescense, Applications.

Photoconductivity: Introduction, Photoconductivity, Characteristics of Photoconductivity Materials, Photodiodes, Photoresistor, Photodetectors, Photodetector Bias Circuit, Performance of Photodetector, Applications, Light emitting diodes (LED) and LASER's.

Unit III : Functional Materials (15)

Nanophase Materials: Introduction, Synthesis and techniques, Nucleation and growth mechanism, Characterization of Nanostructured Materials, Properties of Nanophase Materials, Applications.

Advanced Ceramics: Introduction, Classification of Ceramics, Structure of the Ceramics, Ceramic Processing, Properties of Ceramics, Applications.

Polymer Materials: Introduction, Polymerization Mechanism, Degree of Polymerization, Classification of Polymers, Structures of polymer and preparation methods, important properties and applications of commercial polymers-viz-polyethylene. Polyvinylchloride, Polystyrene, Nylon, Polyesters, Silicones, Composites, Composite material including nano-materials.

Unit IV: Phase diagrams & Diffusion in Solids (15)

Phase diagrams

Phase rule, Single component system, Binary phase diagram, Microstructure changes during cooling, Lever rule, Phase diagram rules, Applications of phase diagram.

Diffusion in solids

Ficks law of diffusion (1 st& 2 nd), Applications of second law of diffusion, Kirkendall effect, Atomic model of diffusion.

Reference Books:

1. Materials Science : V. Rajendran, A. Marikani, Tata MC Graw Hill
2. Materials Science & Engineering: Raghavan, Tata MC Graw Hill
3. Materials Science: Arumugam
4. Materials Science & Metallurgy : O. P. Khanna
5. Materials Science and Engineering: Callister S.

M.SC-I, SEME. II, PHYSICS ((MATERIALS SCIENCE)

HCT - 2.1: QUANTUM MECHANICS

Choice Based Credit System (CBCS)

(w. e. f. June 2016-2017)

Unit I : Introductory Quantum Mechanics (16)

Waves and quanta: Wave and particle nature of radiation, Wave equation, Interpretation and properties of wave function; Heisenberg uncertainty principle. Operators, postulates of quantum mechanics, some important theorems, Eigen functions of the position operator and Dirac delta function. (AKC, pp 1-32)

Unit II: Wave Mechanics of simple systems (16)

One dimensional Box, Normalization and orthogonality, Discussion of the factors influencing colour. One dimensional harmonic oscillator, Normalization and Characteristics of eigen functions of harmonic oscillator, Hydrogen - like atoms, Total wave function of hydrogen- like atom, Prob. Density of 1s atomic orbital, shape of atomic orbital, physical interpretation of hydrogenic orbital, space quantization, electronic spin, Vibration and vibrational spectra of diatomic molecules. [AKC,pp:33-91]

Unit III : Many electron atoms (12)

Wave function of many electron systems, Helium atom, Many electron atoms, Hartree and HartreeFockself consistent field methods. [AKC, pp: 120-130)

Unit IV: Molecular Orbitals (16)

The Born- Oppenheimer approximation, Molecular orbital theory, Hydrogen molecule ion, Hydrogen Molecule - Molecular Orbital -Valance Band methods. [AKC, pp: 151-180]

Text Books:

1. Introductory Quantum Chemisty (3rd Ed^{n}), A. K. Chandra (Tata McGraw Hill).
2. Quantum Chemistry (4th Edition) - Ira N. Levine (Prentice Hall) of India Pvt. Ltd. New Delhi. 1995.
3. A textbook of Quantum Mechanics - P M Mathews, K Venkatesan. (Tata McGraw Hill).

M.SC-I, SEME. II, PHYSICS (MATERIALS SCIENCE)

HCT - 2.2:ELECTRODYNAMICS

Choice Based Credit System (CBCS)

(w. e. f. June 2016-2017)

Unit I: Multipole expansions and time varying fields (15)

Multipole expansions for a localized charge distribution in free space, linear quadrapole potential and field, static electric and magnetic fields in material media, boundary conditions, Time dependent fields, Faraday's law for stationary and moving media, Maxwell's displacement current, differential and integral forms of Maxwell's equations, Maxwell's equations for moving medium.

Unit II: Energy, force, momentum relations and electromagnetic wave equations (15)

Energy relations in quasi-stationary current systems, Magnetic interaction between two current loops, Energy stored in electric and magnetic fields, Poynting's theorem, General expression for electromagnetic energy, Electromagnetic wave equations, Electromagnetic plane waves in stationary medium, Reflection and refraction of electromagnetic waves at plane boundaries (Oblique incidence), Electromagnetic waves in conducting medium, Skin effect and skin depth.

Unit III: Inhomogeneous wave equations (15)

Inhomogeneous wave equations, Lorentz's and Coulomb's gauges, Gauge transformations, Wave equations in terms of electromagnetic potentials, D'Alembertian operator, Hertz potential and its use in computation of radiation fields.

Unit IV: Radiation emission (15)

Radiation from an oscillating electric dipole, radiation from a half wave antenna, radiation from a group of moving charges, radiation damping, Thomson cross-section.

Text Book:

1. Introduction to Electrodynamics, (3rd Edition) by David J. Griffith Publication: Prentice-Hall of India, New Delhi.

Reference Books:

2. Introduction to Electrodynamics, by A.Z.Capri and P.V.PanatNarosa Publishing House.

3. Classical electricity & Magnetism, by panofsky and Phillips, Addison Wesley.

4. Foundations of Electromagnetic theory, by Reitz & Milford, World student series Edition.

5. Classical Electrodynamics, by J.D.Jackson, 3rd Edition John Wiley.

6. Electromagnetic theory and Electrodynamics, by Satya Prakash, KedarNath and Co.Meerut.

7. Electromagnetics by B.B.Laud, Willey Eastern.

8. Electrodynamics by Kumar Gupta and Singh.

M.SC-I, SEME. II, PHYSICS (MATERIALS SCIENCE)

SCT - 2.1:ANALYTICAL TECHNIQUES

Choice Based Credit System (CBCS)

(w. e. f. June 2016-2017)

Unit I: X-ray Diffraction techniques (18)

Review of basic crystal systems, powder diffraction method, instrumentation of X-ray diffractometer, sources of X-rays, detectors of X-rays, acquisition of raw data, data processing and refinement.

Determination of lattice parameters and crystal structure of cubic systems, structure factors, systematic absence of reflections, intensity calculations for cubic system, determination of particle size using X-ray diffractograms, basic concept for determination of lattice parameters for other crystal systems, use of soft-ware packages**.**

Unit II: Infra-red spectroscopy & Ultraviolet and visible spectrophotometry (18)

Infra-red spectroscopy (IR):

Introduction, Beer Lamberts law, Instrumentation, calculation of absorption maximum of dienes, dienons and polyenes, Qualitative and Quantitative applications.

Ultraviolet and visible Spectrophotometry (UV/Vis.):

Introduction, instrumentation, sampling technique, selection rule, types of bonds, absorption of common functional groups, Factors frequencies, applications.

Unit III: Fourier - Transform Infra Red Spectroscopy (FTIR) and Raman spectroscopy (12)

Basic principle, instrumentation configuration date interpretation and analysis, and special techniques such as Attenuated Total Reflection (ATR).

Unit IV: X-ray photoelectron spectroscopy (XPS) (10)

Basic principle, instrumentation configuration, data interpretation and analysis, chemical shift, quantification, and depth-profiling.

Reference Books:

1) Elements of X –ray diffraction: B.D. Cullity, Addison-Wiely Publisher

2) Encyclopedia of materials characterization: Surfaces, Interfaces, Thin Films C. Richard Brundle, Charles A. Evans, Jr. Shaun Wilson, BUTTERWORTH-HEINEMANN

3) Nanotechnology: Principles and Practices: S.B.Kulkarni, Capital Publishing Company

M.SC-I, SEME. II, PHYSICS (MATERIALS SCIENCE)

SCT - 2.2: STATISTICAL MECHANICS

Choice Based Credit System (CBCS)

(w. e. f. June 2016-2017)

Unit I: Foundations of statistical Mechanics and Classical Statistical Mechanics (15)

Thermodynamics, Laws of thermodynamics, Contact between statistics and thermodynamics, the classical ideal gas, entropy of mixing and Gibbs and paradox.
Classical statistical mechanics: Phase space, statistical ensembles, Liouville's theorem, Micro canonical ensemble-condition for equilibrium, canonical ensemble-partition function, energy fluctuations, Grand canonical ensemble-partition function, density and number fluctuations.

Unit II: Quantum Statistical Mechanics (15)

Phase space and quantum states, density matrix, Liouvilles theorem, ensembles, various statistics in quantum mechanics-

Maxwell- Boltzmann, Fermi-Dirac and Bose-Einstein statistics, Ideal Bose gas, Fermi gas, Bose- Einstein condensation.

Unit III: Phase transitions and critical phenomena (15)

Phase transition, condition for phase equilibrium, first order phase transition, Clausius- Clayperon equation, second order phase transition, Critical indices, Properties of matter near the critical point. The law of corresponding states.

Unit IV: Fluctuations (15)

Thermodynamic fluctuations, spatial correlations in a fluid, Einstein - Smoluchowski theory of Brownian motion, Langevin theory of Brownian motion, The fluctuation-deposition theorem, The Fokker-Plank equation.

Reference Books:

1) Introduction to Statistical Mechanics by B.B.Laud

2) Statistical Mechanics by S.K.Sinha

3) Statistical Mechanics by I.D. Landau &F.M.Lifshitz

M.SC-I, SEME. II, PHYSICS (MATERIALS SCIENCE)

OET - 2.1: NANOMATERIALS: SYNTHESIS, PROPERTIES AND APPLICATIONS

Choice Based Credit System (CBCS)

(w. e. f. June 2016-2017)

Unit I: (15)

Graphene: Introduction of graphene, Graphite, Definition and structure of graphene, Types of graphene: stacking AA, BB, AB dispersion relation, Single layer, Bi-layer, Few layers

Properties of graphene; Optical: thickness dependency, optical conductivity, Electrical: Boltzmann equation, ambipolar conduction, diamagnetism, magnetoresistance and spin current, thermal conductivity, Surface phenomenon. Characterization of graphene: Transmission electron microscopy (TEM), Scanning tunneling microscopy (STM), Raman Spectroscopy, temperature dependent resistivity measurement.

Preparation of graphene: Chemical deposition (CVD) growth of graphene films, Chemically derived graphene, Hummer's method, Modified Hummer's method, Applications of graphene in the energy application: Li-ion batteries, Supercapacitors..

Unit II: (15)

Carbon Nanotubes: Introduction of Carbon Nanotube (CNT): Introduction and definition of CNT, Bonding of carbon atoms, SP3, SP2, Deformed SP2, Structure of Carbon Nanotubes, Chiral Vector, Armchair, Zig-Zag and Chiral tubes

Properties of Carbon Nanotubes: Electronic, Optical and
Optoelectronic, Mechanical, Chemical and Electrochemical, Opening of tubes

Synthesis Methods: High temperature method, Arc discharge, General technical features of the production process, Growth Mechanism, Chemical Vapor deposition (CVD) process, Vapor Liquid solid (VLS) model, Catalytic role, Methods of Purification, Methods of Functionalization (Chemical and Physical),

Applications of Carbon nanotube: Field emission, Li-ion battery, Supercapacitor, Sensors, Solar cells

Unit III: (15)

Nanotubes and nanowires: Fabrication of TiO_2 Nanotube Arrays by Electrochemical Anodization: Four Synthesis Generations, Material Properties of TiO_2 Nanotube Arrays: Structural, Elemental, Mechanical, Optical, and Electrical, Applications, Boron Nitride Nanotubes: Synthesis and Structure, One-Dimensional Semiconductor and Oxide Nanostructures, Inorganic nanowires

Unit IV: (15)

Polymer nanocomposites: Polymer composites: mechanical properties and composite fabrication. Introduction to polymer nanocomposites: Basic materials for polymer nanocomposite technology. Fabrication techniques: Solution intercalation, melt intercalation, roll milling, emulsion polymerization, in-situ polymerization and

high-shear mixing. Characterization of polymer nanocomposites, Properties of polymer nanocomposites: Thermoplastic nanocomposites, Thermoset Nanocomposites, Elastomer Nanocomposites. Applications of polymer nanocomposites in: high temperature, paint formulation, Automobiles, Aerospace, Injection Molded Products, Coatings, Adhesives, Fire-retardants, Packaging Materials, Microelectronic Packaging, Optical Integrated Circuits and Sensors.

Reference Books:

CNT and Graphene

1) Physics of Graphene, Editors: Aoki, Hideo, S. Dresselhaus, Mildred (Eds.)
2) Graphene: Carbon in Two Dimensions, by Mikhail I. Katsnelson
3) Graphene: Synthesis, Properties, and Phenomena, by C. N. R. Rao (Editor), Ajay K. Sood (Editor),
4) Carbon Nanotube and Graphene Device Physics, by H.-S. Philip Wong (Author), Deji Akinwande (Author)
5) Carbon Nanotube Electronics (Integrated Circuits and Systems) by Ali Javey (Editor), Jing Kong (Editor),
6) Physics and Chemistry of Graphene: Graphene to Nanographene, Toshiaki Enoki, Tsuneya Ando.

Nanotubes and nanowires

7) TiO2 Nanotube Arrays: Synthesis, Properties, and Applications by Craig A. Grimes and Gopal K. Mor, Springer Publisher
8) Nanotubes and Nanofibers; Advanced Materials Series, Series Editor: Yury Gogotsi, Drexel University, Philadelphia, Pennsylvania, USA, Nanotubes and Nanofibers by Yury Gogotsi

Polymer nanocomposites

9) Joseph H. Koo, Polymer Nanocomposites: Processing, Characterization, and Applications, McGraw-Hill, New Delhi, 2006.
10) Suprakas Sinha Ray and Mosto Bousmina, Polymer Nanocomposites and Their Applications, American Scientific Publishers, 2006

M.SC-I, SEME. II, PHYSICS (MATERIALS SCIENCE)
OET - 2.2: Conventional & Nonconventional Energy
Choice Based Credit System (CBCS)
(w. e. f. June 2016-2017)

Unit 1: Elementary electronics and electronic gadgets (Principles and Working) (15)

Different electronic components, semiconductors, different type of diodes, rectifiers, filters, pnp and npn transistors, amplifiers, oscillators. Catoderay Oscilloscope. Concept of modulation and demodulation. Transponder. Integrated circuits. Android phones, Bluetooth. Global Positioning System. Optical fibres Endoscope. Number systems. Decimal, Hexal and Octal systems.

Unit2: Energy Resources (15)

Conventional and Renewable energy resources. Coal, Oil and Natural gas. Oil exporting and importing countries. Oil pipe lines. World reserve estimates. Non conventional energy resources. Wind power and Solar power. Solar cell Ocean thermal energy conversion, energy from waves and tides. Biomass energy. Biogas plant. Ethanol as a fuel.

Concept of nucleus. Atomic number, mass number, isotopes and isobars. Natural and artificial isotopes. Radioactivity, carbon dating. Uses of isotopes. Enriched Uranium. Fission. Simple nuclear reactions. Chain reaction. Nuclear Reactors, moderators. Heavy water and Pressurized heavy water reactor. Breeder reactor. Weapons of mass destruction. Effects of atomic bombs explosions on Hiroshima and Nagasaki. Fusion reaction. Safety of nuclear reactors. Indian nuclear program.

Unit 3: Our Universe (15)

Units of stellar distances solar system earth's atmosphere. Variation of temperature and pressure with height. Different parts of atmosphere. Earth's magnetic field. Aurora Borealies. Characteristics of different planets. Asteroides. Comets, Meteorides. Stars. Binary and Multiple stars system Lunnosities of stars. Hertzsprung-Russell diagram. Evolution of stars. Neutron star, white dwarf and blackhole. Pulsars. Chandrashekhar limit. Galaxies and their classification. Hubble's law. Origin of universe (qualitative) Electromagnetic spectrum. Radio and Optical window. Reflecting and refracting telescopes. Different mountings. Radio telescopes. Few world famous telescopes. Mount Palomer, Jodrell bank and Keck telescopes. Few Indian telescopes: Kodaikanal, Kawalur, Leh, Gurushikar and Udaipur telescopes. Radio Telescope at Narayangaon.

Unit 4: Space Exploration (15)

Newtons laws of motion, law of gravitation and other kinematic equations. Free fall under gravity. Escape velocity. Keplers laws. Satellites natural and artificial. Different orbits. Near earth orbit, geosynchronyous orbit and polar orbit. Near earh orbit satellites. GTO satellites. Remote sensing satellites and their role in measurements of national resources and mapping. Rockets. Fuels used in rockets. Chandrayan, Mangalyan, Astrosat. Missiles and their classification. Indian Space program.

M.Sc-II, SEME. III, PHYSICS (Materials Science)
HCT -3.1:SEMICONDUCTOR DEVICES (C)
Choice Based Credit System (CBCS)
(w. e. f. June 2016-2017)

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 activatedthyristors, Gate turn off thyristors (GTO), MOS controlled thyristors, programmable Unijunction transistors, Silicon Unidirectional switch (SUS) , IGBT

Unit III: Charge Coupled and Transferred Electron Devices (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 gunn 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 (Materials Science)

HCT - 3.2: ATOMIC, MOLECULAR AND NUCLEAR PHYSICS(C)

Choice Based Credit System (CBCS)

(w. e. f. June 2016-2017)

Unit I: Atomic structure and Atomic Spectra (15)

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 (15)

Molecular energy states and associated spectra,Types of molecular spectra. Pure rotational; spectra, Diatomic molecule as a rigid rotator, Diatomic molecule as a non-rigid 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 (15)

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 semi-empirical 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 (15)
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 cross-section, 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 2nd Edi., 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 (Materials Science)

SCT– 3.1 (MS): DIELECTRIC AND FERROELECTRIC PROPERTIES OF MATERIALS

Choice Based Credit System (CBCS)

(w. e. f. June 2016-2017)

Unit I: Introduction (10)

Maxwells equations, Amperes law, Faradays law, Gauss law in presence of dielectric, Electric field, Electric flux density, Polarization, Permittivity, electric susceptibility, Dipole moment , Polar and non-polar dielectrics.

Unit II: Electric Polarization and Relaxation (20)

Fundamentals: Force acting on the boundary between two different dielectric materials, Force elongating a dielectric fluid, Dielectrophoretic force, Electrostriction force, Electrostatic induction , Electric polarization and relaxation in static electric fields, Vacuum space, Conducting materials.

Dielectric Materials and its Polarization: Mechanism of electric polarization, Electronic polarization, Classical and Quantum Mechanical Approach, Atomic or Ionic Polarization, Orientational polarization, Polarizability, Spontaneous polarization, Space charge polarization, Hopping polarization, Interfacial polarization, Classification of dielectric materials, Non-ferroelectric and ferro-electric materials, Internal fields, Local fields for Non-dipolar materials, Clausius-Mosotti Equation.

Dielectrics in AC field: Lorentz - Lorenz equation, Reaction Field for dipolar materials, Electric polarization and relaxation in time -varying electric fields, Time domain approach and the frequency - domain approach, Complex permittivity, Time dependent electric polarization, Kramers - Kronig equations, Debye equations, Absorption, and Dispersion for dynamic polarizations, Effects of the local field, Effects of DC conductivity, Cole - Cole plot, Temperature dependence of complex permittivity, Field dependence of complex permittivity of ferroelectric materials, Insulating materials, Dielectric relaxation phenomena.

Unit III: Optical and Electro-Optic Processes (10)

Modulation of light, Double refraction and birefringence, Quarter - Wave plate, Electro - Optic effects: Linear Electro – Optic effect, Photorefractive effect, Magneto - Optic effect, Faraday effect, Voigt effect, Acousto-Optic effect.

Unit IV: Ferroelectrics, PiezoelectricsandPyroelectrics (20)

Ferroelectrics: Ferroelectric phenomena, Representative crystal, types of ferroelectrics: Properties of Rochelle salt, $BaTiO_3$, Theory of ferroelectric displacive transitions, Thermodynamic theory, Ferroelectric and antiferroelectric transition,

Formation and dynamics of ferroelectric domains, Experimental evidence of domain structure, Applications of ferroelectric materials

Piezoelectrics: Piezoelectric phenomena, Phenomenological approach to piezoelectric effects, Piezoelectric parameters and their measurements, Piezoelectric materials and their applications.

Pyroelectrics: Pyroelectric phenomena, Phenomenological approach to pyroelectric effects, Pyroelectric parameters and their measurements, Pyroelectric and thermally sensitive materials, NTC and PTC materials, Applications of pyroelectric materials.

References Books :

1. Kwan Chi Kao and F. R. de Boer;Dielectric Phenomena in Solids, Elsevier Academic Press (2004).
2. J. P. Srivastava, Elements of Solid State Physics, 2nd Edi Prentice – Hall of India(P) Ltd. (2007)
3. Charles Kittle; Introduction to Solid State Physics, 7th Edition, John Wiley & Sons, (1996).
4. Saxena, Gupta, Saxena; Fundamentals of Solid State Physics, PragatiPrakashan, (2012).
5. A. J. Dekkar; Solid State Physics, 1st Ed. Macmillan (2000).
6. M.A. Wahab; Solid State Physics: Structure and Properties of Materials, Alpha Science International (2005)
7. S.O. Pillai; Solid State Physics, 6th Ed., New Age International (p) Ltd publishers, (2005)
8. Neil W. Ashcroft, N. David Mermin, Solid State Physics; Saunders College, (1976).

M.Sc-II, SEME. III, PHYSICS (Materials Science)

SCT– 3.2 (MS): MATERIAL PROCESSING

Choice Based Credit System (CBCS)

(w. e. f. June 2016-2017)

Unit I : Vacuum Technology (12)

Principles of vacuum pump – principle of different vacuum pumps : roots pump, rotary, diffusion turbo molecular pump, cryogenic-pump, ion pump, ti-sub limitation pump, importance of measurement of vacuum, Concept of different gauges, bayet - albert gauge, pirani, penning, pressure control.

Unit II : Physical Vapor Deposition & CVD Techniques (12)

Thermal evaporation, resistive evaporation, Electron beam evaporation, Laser ablation, Flash and Cathodic arc deposition, laser ablation, laser pyrolysis, molecular beam epitaxy, electro deposition.

Chemical Vapor Deposition Techniques (12)

Advantages and disadvantages of Chemical Vapor deposition (CVD) techniques over PVD techniques, reaction types boundaries and flow, Different kinds of CVD techniques: Atmospheric pressure CVD (APCVD) – Low pressure CVD (LPCVD) – Plasma enhanced chemical vipor deposition (PECVD) or –The HiPCO method – Photo-enhanced chemical vapor deposition (PHCVD) – LCVD Laser –Induced CVD, Metallorganic CVD (MOCVD), Thermally activated CVD, Spray pyrolysis,etc.

Unit III : Electrical Discharges used in Thin Film Deposition(10) Sputtering, Glow discharge sputtering, Magnetron sputtering, Ion plating, oxidizing and Nitriding, Atommic layer deposition (ALD), Importance of ALD technique, Atomic layer growth.

Unit IV : Conditions for the Formation of Thin Films (12)

Environment for thin film deposition,deposition parameters and their effects on film growth, formation for thin films (sticking coefficient, formation of thermodynamically stable cluster – theory of nucleation), capillarity theory, microstructure in thin films, adhesion, properties of thin films, Mechanical ,Electrical, and optical properties of thin films, few applications of thin films in various fields, Quartz crystal thickness for measurement of film thickness.

Unit V :Adsorption And Diffusion in Thin Films (12)

Physisorption – Chemisorption –Work function changes induced by induced by adsorbates – Two dimensional phase transititionsinadsorbate layers – Adsorption kinetics – Desorption techniques. Fundamentals of diffusion – Grain Boundary Diffusion –Thin Film DiffusionCouples –Inter Diffusion –Electromigration in thin films –Diffusion during film growth, Stress in Thin Films.

Reference Books:

1. Hand book of Thin films Technology : L I Maissel and R Clang.
2. Thin film Phenomena : K L Chopra.
3. Physics of thin films,vol.12,Ed George Hass and others.
4. Vacuum deposition of thin films – L Holland.
5. Milton Ohring,Materials Science of Thin films Published by Academic Press Limited (1991)
6. L.B.Freund and S.Suresh,Thin Film Materials,(2003)
7. Hans Luth, Solid Surfaces, Interfaces and Thin Films' 4thedition,Springer Publishers (2010)
8. HaraldIbach, Physics of Surfaces and Interfaces,Springer Publishers (2006). AMY
9. R L Banshow

M.Sc-II, SEME. IV, PHYSICS (Materials Science)

SCT –3.3: MATERIALS CHARACTERIZATION

Choice Based Credit System (CBCS)

(w. e. f. June 2016-2017)

Unit I: (12)

Introduction to the Common Concepts in Materials Characterization:

Measurements of Mass and Density, Different kinds of Balances. Roughness, Porosity and Surface area measurement. Microscopic tools and necessity, Spectroscopic tools and necessity, Resonance techniques and necessity, Surface properties and the necessary tools, Understanding Crystallinity, Thermal properties and thermal analysis like thermal conductivity ,specific heat, melting temperature and other phase transitions using TG,DTG,DTA etc. Methods of Temperature measurements, Hardness of material measurements and associated Physics, Materials aspects: particles, bulk, thin and thick films, gel, suspension and rheological properties. General behavior of metals, ceramics, semiconductors, polymers and tools required to characterize them, Methods of Sample preparation: polishing, grinding, sectioning, annealing, sintering, etching.

Errors in measurements, Analysis of errors, Curve Fitting. Standard Distribution functions, International Standards: ASTM and other standards

UnitII : Vacuum Techniques (12)

Fundamental concept of vacuum, units of measurements, Kinetic theory of gases. practical aspects of vacuum technology: vapor pressure, out-gassing, seals, pumping speeds, conductance, through puts. Order of vacuum and necessity during the material characterization

Vacuum pumps: Mechanical pumps ,Water pumps, Rotary oil pumps, Roots pumps,

Unit III: Structural analysis of materials by X-ray diffraction analysis (12)

Introduction to generation and detection of X-rays, Crystalline, polycrystalline ,nano-crystalline and amorphous solids. Laue method for single crystal structural analysis. Powder diffraction methods, Analysis of cubic structures, introduction to crystal symmetry and crystal structure, Factors affecting the intensity in Powder XRD, Structure factor , few examples of NaCl, KCl, KBr etc.. Different X-Ray Cameras and geometries.

Unit IV: Characterization of Electrical Properties (12)

Electrical transport in metals, semiconductors and insulators and difficulty in measurements, Bulk conductivity , practical aspects of methods , Surface conductivity measurements ,Four probe method of conductivity measurement,Van der Pauw measurement for an arbitrary shape ,Practical aspects and problems, Non contact mode of conductivity measurement.Microwave techniques, Hall effect in semiconductors, Hall mobility measurements. Measurement of Introduction to Deep Level Transient Spectroscopy (DLTS).Electrical conductivity with temperature

,Defects in semiconductors and their measurements .Estimation of mobility band gap in semiconductors, Photoconductivity,

Unit V: Characterization of Optical Properties (12)

Introduction to electromagnetic (EM) spectrum Energy wavelength and frequencies of EM radiations. Interaction of EM radiations with matter in different regions of EM spectral regions.Absorption. Reflection and Transmission in materials, Beer Lambert Law . Laboratory sources of EM radiations , Basic definition of spectrometer .and its components. Vibrational spectroscopy for determining the molecular bonds and structure, UV-Visible absorption spectroscopy, Its use to determine the Band gap of semiconductors ,Refractive index of thin films, Factors affecting the absorption. Photoluminescence (PL) spectroscopy for understanding the band gap solids.

Reference Books:

1)"Charecterization of Materials", Elton N.Kaufmann,Vol I & II ,Wiley Interscience,2003.
2)Elements of X-Ray Diffraction",CulityB.D.,Addison Wesley Publishing Company.
3)"Fundamentals of Molecular Spectroscopy" ,C.N.Banwell,Tata McGraw–Hill Publishing Company Limited
4)"Instrumental Methods of Analysis" ,H.H.Willard, L.L.Merritt, J.A.Dean, F.A.Settle, CBS Publishers & Distributors, Delhi.
5)"X-Ray Diffraction", C.Suryanarayana and Grant Norton,SpringerScience+Business Media, LLC
6) Absorption Spectroscopy, Bauman R.P., Wiley .New York

M.SC-I, SEME. II, PHYSICS (MATERIALS SCIENCE)
OET - 3.1: INTRODUCTION TO NANOSCIENCE
Choice Based Credit System (CBCS)
(w. e. f. June 2016-2017)

Unit I: Introduction **(15)**

Background of Nanoscience and Nanotechnology, Definition of Nanoscience and Nanotechnology, Applications of Nanotechnology,

Crystal Bonding, Structure, Growth and Symmetries: Introduction, Crystal Bonding, Crystal Structure, Crystal Growth, Classification of Crystals by symmetry, Some Important Crystal Structres

Band Structure and Density of States at Nanoscale: Introduction, Energy Bands, Density of States at Low-dimensional Structures

Unit II: Nanomaterials Synthesis **(15)**

Physical methods: Introduction, Mechanical Methods, Methods Based on Evaporation, Sputter Deposition, Chemical Vapour Deposition, Electric Arc Deposition, Ion Beam Techniques, Molecular Beam Epitaxy

Chemical Methods: Introduction, Colloids and Colloids in Solutions, Growth of Nanoparticles, Synthesis of Metal Nanoparticles by Colloidal Route, Synthesis of Semiconductor Nanoparticles by Colloidal Route, Microemulsions, Sol-Gel Method.

Unit III: Analysis Techniques **(10)**

Introduction, Microscopes (Optical Microscopes, Confocal Microscope), Electron Microscopes (SEM, TEM), Scanning Probe Microscopes (STEM, AFM), Diffraction Techniques (XRD, Neutron), Spectroscopies (UV-VIS, IR, FTIR, XPS, UPS), Magnetic Measurements (VSM).

Unit IV: Properties and Applications of Nanomaterials: **(20)**

Properties: Mechanical Properties, Structural Properties, Melting of Nanoparticles, Electrical Conductivity, Optical Properties, Magnetic Properties.

Applications: Electronics, Energy, Automobiles, Sports and Toys, Textiles, Cosmetics, Domestic Appliances, Biotechnology and Medical Field, Space and Defence, Nanotechnology and Environment

References:

1. Introduction to Nanoscience and Nanotechnology: K. K. Chattopadhaya and A. N. Banerjee, PHI Learning Pvt. Ltd.
2. Nanotechnology: Principles and Practices, Sulabha K Kulkarni, Capital Publishing Company Pune.

M.Sc-II, SEME. IV, PHYSICS (Materials Science)

OET - 3.2: NUCLEAR RADIATION & EFFECTS
Choice Based Credit System (CBCS)

(w. e. f. June 2016-2017)

Unit-1: Interaction of Charged Particles with Matter (10)
Introduction to Charged Particles, Theory and general features for charged particles - the Bethe-Bloch equation, Photon interactions - photoelectric effect, Compton scattering, Pair production, Neutron scattering and absorption, Attenuation and shielding. **(J S Lilley),** Interaction of Heavy Charged Particles, Interaction of Fast Electrons, Interaction of Gamma Rays, Interaction of Neutrons **(Glenn F Knoll)**

Unit-2: Nuclear Radiation Units (08)
The Roentgen and the Rad, Photon Flux and Radiation Dose, Dose rate and radioactive source strength, Radiation dose from internal source, The Rem, Gray, Rad to Gray Conversion, Fluence**(Samuel Glasstone)**

Unit-3: Radiation effects on Semiconductor Materials (12)
Basic Radiation Damage Mechanisms in Semiconductor Materials and Devices:Introduction. Fundamental Damage Mechanisms: Ionization Damage, Displacement Damage. Impact ofRadiation Damage on Device Performance: Spectroscopic Study of Microscopic Radiation Damage: Electron Paramagnetic Resonance (EPR), Deep Level Transient Spectroscopy (DLTS), Photo-luminescence Spectroscopy (PL)
Displacement Damage in Group IV Semiconductor Materials: Introduction, Displacement Damage in Silicon: Radiation Defects in Silicon, Impact of Radiation Defects on Silicon Devices, Substrate and Device Hardening, Displacement Damage in Germanium: Potential Applications of Ge, Cryogenic Irradiation of Ge, Room Temperature Irradiation of Ge, Impact Radiation Damage on Ge Materials and Device Properties, Displacement Damage in SiGe Alloys: SiGe Material Properties and Applications, Radiation Damage in SiGe, Processing-Induced Radiation Damage in SiGe, Radiation Damage in SiGe Devices **(C. Claeys)**

Unit-4: Biological Effects of Radiation (15)
Introduction, Somatic effects of radiation, genetic effects of radiation, The radiation back ground, Radiation dose from nuclear power operations, estimates of biological consequences. **Radiation Hazards:** Health-physics activities, Effects of different types of radiation, External and internal radiation sources, Protection from radiation hazards.**(Samuel Glasstone)**

Unit-5: Useful Applications of Nuclear Radiation:Nuclear Medicine (15)
Production of various radioactive isotopes, application of the isotope in therapeutic process like gamma ray therapy, boron neutron capture therapy, heavy ion therapy applications of radioisotopes in imaging process like, gamma camera, positron

emission tomography and magnetic resonance imaging are discussed. **(Fieldmen&Soete)**

TEXT BOOKS

1. Gnell F Knoll, Radiation Detectibn and Measurement, Third Edition, John Willey, 2000
2. John S Lilley, Nuclear Physics Principles and Applications, Willey, 2001
3. C. Claeys E. SimoenRadiation Effects in Advanced Semiconductor Materials and Devices, Springer
4. S. Glasstone and A. Sesonske, Nuclear Reactor Engineering, D. Van Nostrand Company, INC. 1967.
5. De Soete, D. R. Gijbels and J. Hoste, Neutron Activation Analysis. John Wiley and Sons: New York, NY. (1972).
6. L. C. Feldmen and J. W. Mayer, Fundamentals of surface and thin films analysis, North-Holland, Elsevier, 1986.

REFERENCE BOOKS

1. Robley D Evans, The Atomic Nucleus, TMH, 1955
2. L. Cohen, Concepts of Nuclear Physics, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2004.

M.Sc-II, SEME. IV, PHYSICS (Materials Science)

HCT - 4.1:MICROELECTRONICS

Choice Based Credit System (CBCS)

(w. e. f. June 2016-2017)

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-ordinatongraph 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 (Materials Science)

HCT - 4.2: PHYSICS OF NANO MATERIALS

Choice Based Credit System (CBCS)

(w. e. f. June 2016-2017)

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.

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)

M.Sc-II, SEME. IV, PHYSICS (Materials Science)

HCT - 4.1: MAGNETIC MATERIALS

Choice Based Credit System (CBCS)

(w. e. f. June 2016-2017)

Unit I: Introduction (15)

Measurement of Field Strength, Hall Effect, Electronic Integrator or Fluxmeter, Magnetic Measurements in Closed Circuits, Demegnetizing Fields, Magnetic Shielding, Demagnetizing Factors, Magnetic Measurements in Open Circuits, Instruments for Measuring Magnetization, Vibrating - Sample Magnetometer, Altering (Field) Gradient Magnetometer - AFGM or AGM, (also called Vibrating Reed Magnetometer), Magnetic Circuits and Parameters, Permanent Magnet Materials, Susceptibility Measurements.

Unit II: Magnetism in Materials (20)

Diamagnetism and Para magnetism:

Introduction, Magnetic Moments of Electrons, Magnetic Moments of Atoms, Theory of Diamagnetism, Diamagnetic Substances, Classical Theory of Para magnetism, Quantum Theory of Para magnetism, Gyro magnetic Effect, Magnetic Resonance

Ferromagnetism: Introduction, Molecular Field Theory, Exchange Forces, Band Theory, Ferromagnetic Alloys, Theories of Ferromagnetism

Antiferromagnetism: Introduction, Molecular Field Theory, Above $T_{N,}$ Below $T_{N,}$ Comparison with Experiment, Neutron Diffraction, Antiferromagnetic, Ferromagnetic, Rare Earths , Antiferromagnetic Alloys.

Ferrimagnetism: Introduction, Structure of Cubic Ferrites, Saturation Magnetization, Molecular Field Theory, Above Tc, Below Tc, General Conclusions, Hexagonal Ferrites, Other Ferromagnetic Substances, y - $Fe_2O_{3,}$ Garnets, Alloys.

Unit III: Magnetic Anisotropy, Magnetostriction and the Effects of stress

(15)

Magnetic Anisotropy: Introduction, Anisotropy in Cubic Crystals, Anisotropy in Hexagonal Crystals, Physical Origin of Crystal Anisotropy, Anisotropy Measurement, Torque Curves, Torque Magnetometers, Anisotropy Measurement (from Magnetization Curves), Fitted Magnetization Curve, Anisotropy Constants, Polycrystalline Materials

Magnetostriction: Introduction, Magnetostriction of Single Crystals, Cubic Crystals, Magnetostriction of Polycrystals, Physical Origin of Magnetostriction, Form Effect, Effect of Stress on Magnetic Properties, Effect of Stress on Magnetostriction, Applications of Magnetostriction, ΔE Effect, Magnetoresistance.

Unit IV: Domains and the Magnetization Process (10)

Introduction, Domain Wall Structure, Neel Walls, Magnetostatic Energy and Domain Structure, Uniaxial Crystals, Cubic Crystals, Domain Wall Motion, Magnetization in Low Fields, Magnetization in High Fields, Shapes of Hysteresis Loops.

Reference Books:

1. K. H. J. Buschow& F. R. de Boer: Physics of Magnetism and MagneticMaterials.
2. C. Kittle : Introduction to SolidState Physics.
3. Azoroff : Introduction to Solids.
4. Saxena, Gupta, Saxena: Fundamentals of SolidState Physics.
5. R. L. Singhal: SolidState Physics.
6. V. Raghavan: Materials Science and Engineering.
7. A. J. Dekkar :SolidState Physics.

M.Sc-II, SEME. IV, PHYSICS (Materials Science)

SCT - 4.1: ADVANCED TECHNIQUES OF MATERIALS CHARACTERIZATION

Choice Based Credit System (CBCS)

(w. e. f. June 2016-2017)

Unit I: Microscopic Techniques: (25)

Optical Microscopy and limitations: Principle of Diffraction of light, Airy Disc, Resolution and magnification ;Rayleigh Criteria, Numerical aperture, Major lens defects. Different kinds of optical microscopes (Bright field ,Stereo , Phase contrast ,Differential Interference Contrast ,Fluorescence ,Confocal ,Polarizing light microscope)

Electron Microscopy: Limitations of Light microscopy and advantages of electron microscopy. Wavelength of electrons, Theoretical Resolving power, Source of electron emission .Electron Focusing , Effect of magnetic fields, Electrostatic and magnetic focusing , Optical Column, Magnetic lenses.Vacuum requirements. Schematic of complete SEM

Scanning Electron Microscopy(SEM):Interaction of electrons with matter. Secondary electron emission(SEE),Yield of SEE ,Universal yield curve, Beam scanning and Magnification in SEM, Secondary electrons Detector, Back scattered electrons detector.Electronics. Image analysis.Size histogram. Sample preparation .

Transmission Electron Microscopy(TEM) : Principle of operation, Lens systems, Schematic of TEM ,Apertures, Bright Field Image, Dark Field Image ,.Electron Diffraction, Bragg's Condition, Selective Area Electron Diffraction (SEAD), Image analysis. Sample preparation

Scanning Tunneling Microscopy

Historical perspective, Electron tunneling ,Principle of STM imaging , STM image interpretation ,STM implementation in instrument , Pizoelectric drive, Tip preparation, Vibration isolation, Data acquisition and analysis,Application of STM , high resolution imaging of surfaces, Spectroscopy, Lithography,Currentfluctuation,Limitation of STM and solution,

Atomic Force Microscopy:Priciple and equations of force curves ,Contact and Non contact modes, Amplitude modulation and Frequency modulation ,Forfe versus distance curve,,Experimental details of AFM, Practical applications .

Unit II: X-Ray Photoelectron Spectroscopy (15)

Definition of surface, Different Probes for Surface-characterization. Necessity of Ultra High Vacuum, Photoelecton Emission, Introduction and Basic Theory , Historical Perspective ,Instrumentation ,Vacuum System. Energy analyzers, X-Ray Source,Electron Energy Analyzer . Sample Selection and Preparation , Sample Charging .X-Ray Beam Effects., Spectral Analysis ,Core Level Splitting .,Linewidths. Elemental Analysis: Qualitative and Quantitative ,Secondary Structure ,Angle-Resolved XPS, Depth profiling.

Auger Electron Spectroscopy
Basic principle, Auger Transitions, Kinetic Energies of Auger Electrons, Sensitivity of detection, Instrumentation,Electron Energy Analyzers ,Electron Detector, Sample preparation, Data analysis, Qualitative and Quantitative analysis.

Unit III: Raman Spectroscopy (10)
Introduction, Quantum theory of Raman effect, Classical theory of Raman effect, Polarizability and vibrational modes in molecules, IR active and Raman active modes , Introduction to lattice phonon, Optical and acoustical phonon modes, Transverse and Longitudinal modes and their coupling, Examples of Raman Spectra in carbon systems-diomond, carbon nano tubes etc.

Unit IV: Resonance spectroscopy (10)
Nuclear magnetic resonance and Electron Spin Resonance Spectroscopies.
Properties of Nuclear Spins ,Nuclear Spin Interactions in Solids General Structure of the Internal Hamiltonians , Quantum Mechanical Calculations, Quantum Mechanical Description of NMR , The NMR Signal—Zeeman Interaction ,High Resolution Solid State NMR Methods , Dipolar Decoupling ,Magic-Angle Spinning (MAS), Cross-Polarization (CP) The CP-MAS Experiment ,NMR Spectra.
EPR Condition, Continuous Wave-EPR, EPR Lineshape: Relaxation Times, Electron-Nuclear Interactions: Hyperfine Structure

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) Fundamebntal of Molecular Spectroscopy, C.N.Banwell,TataMc-Graw Hill.

M.Sc-II, SEME. IV, PHYSICS (Materials Science)
SCT - 4.2: POLYMER SCIENCE AND TECHNOLOGY
Choice Based Credit System (CBCS)
(w. e. f. June 2016-2017)

Unit I: Historical developments in polymeric materials (5)
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.

UnitIII: Raw material for synthetic polymers (25)
Manufacturing of various fractions of crude petroleum important for polymer industry for (a) Raw Materials such as ethylene, propylene, butadiene, vinyl chloride, vinylidene dichloride, styrene, acrylic monomers like acrylic acid, acrylonitrile, methacrylic acid, methacrylates, acrylamide etc, (b) Polyacids such as phthalic acid, terephthalic acid, isomers and anhydrides etc. (c) phenols, polyols and their modifications, (d) Isocyanates, (e) Amino Compounds, (f) Other petroleum based material

Unit IV: (15)
Solvents such as alcohols, toluene, xylene, acetone, ketones, terpenes, chloromethanes etc. Evaluation of raw materials and reactants for synthesis & manufacturing of polymers.

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 (MATERIALS SCIENCE)
Choice Based Credit System (CBCS)
(w. e. f. June 2016-2017)

Practical List

HCP 1.1/1.2/1.3

1) Determination Band gap of Ge Diode.
2) Crystal Structure FCC type.
3) Temp. Variation of Breakdown voltage of zerer diode.
4) Temperature Transducer (Thermister).
5) P.N. Junction capacitance.
6) LVDT.
7) Photovoltaic cell.
8) Hall Effect.
9) CC with CC Amplifier.
10) DC Amplifier.
11) Voltage Regulator
12) Astablenultivibrator (using IC741Op Amp)
13) Op-Amp Phase Lead Circuit.
14) Op-Amp Phase Lag circuit.
15) Verificaiton of De Morgans theorem.
16) Wein Bridge Oscillator.
17) Op-Amp Phase shift Oscillator.
18) Negative feedback Amplifier.
19) D.T.L. gates.
20) Study of filters.
21) Transistor Biasing.
22) CE amplifier Desing.
23) FET characteristics and Designing of Amplifier.
24) Divide by 2 Divide by 5 & Divide by 10 counter using IC-7490.

SCP 1.1/1.2

1) Op-Amp (Adder, Subtractor, Integratorc, Differentiator).
2) Op-Amp I to V, V to I converter.
3) Voltage source.
4) Constant current source (floating load).
5) Constant current source (Grounded load).
6) Variable duty cycle MV using Op-Amp.

HCP 2.1/2.2

1) Wave form generator (square & triangular)
2) Twin T network.
3) Bear Lamberts law
4) Resistivity by four probe method.
5) Strain gauge I.
6) Lattice prarameter&particlesiretestimation.
7) Op-Amp instrumentation amplifier IC324.
8) Characteristics of UJT.
9) Electrodepositon of Mn.
10) Op-Amp. Parameters.

SCP 2.1/2.2

1) Study of thermocouple &thermister.
2) Intensity calculation.
3) Crystal structure I.
4) Crystal structure II.
5) Study of phase diagram.
6) Hall Effect II.

OEP 2.1/2.2

1) Transister Parameters.
2) Op-Amp inverting and non-inverting amplifiers.
3) Monostablemultivibratorvsing IC555.
4) FET charaterishes.
5) Op-Amp Adder.
6) Op-Amp subtractor.
7) First order High pass filter.
8) First order Low pass filter.
9) Determination of optical gap.
10) Determination of optical absorption by materials & hence determination of type of transition.
11) Study of p.n. junction photo voltaic.
12) Characterization of a PV cell in dark & in light & hence determination of junction ideality factor.

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.

_____xxxx_____xxxx_____