# DEPARTMENT OF STUDIES AND RESEARCH IN PHYSICS

## Course Structure & Syllabus
## Choice Based Credit System (CBCS)

## SEMESTER-I

| Sl. No. | Paper | Title of the paper | Instruction Hrs per Week | No. of Credits | Duration of the Exam. | Marks | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Internal Assessment | Semester End Exam. | Total Marks |
| 1 | CPT-1.1 | Classical Mechanics | 4 | 4 | 3 Hrs | 20 | 80 | 100 |
| 2 | CPT-1.2 | Mathematical and Computational Physics | 4 | 4 | 3 Hrs | 20 | 80 | 100 |
| 3 | CPT-1.3 | Electronics Circuits, Devices and Communication | 4 | 4 | 3 Hrs | 20 | 80 | 100 |
| 4 | SPT-1.4.A | Condensed Matter Physics-I | 4 | 4 | 3 Hrs | 20 | 80 | 100 |
| | SPT-1.4.B | Material Science-I | 4 | 4 | 3 Hrs | 20 | 80 | 100 |
| 5 | CPP-1.5 | **Practical :** General Physics | 4 | 2 | 3 Hrs | 10 | 40 | 50 |
| 6 | CPP-1.6 | **Practical :** Computer programming –I | 4 | 2 | 3 Hrs | 10 | 40 | 50 |
| 7 | CPP-1.7 | **Practical :** Electronics (General) | 4 | 2 | 3 Hrs | 10 | 40 | 50 |
| 8 | SPP-1.8A | **Practical :** Condensed matter Physics-I | 4 | 2 | 3 Hrs | 10 | 40 | 50 |
| | SPP-1.8B | **Practical :** Material Science -I | 4 | 2 | 3 Hrs | 10 | 40 | 50 |
| | | **Total** | **32** | **24** | | **120** | **480** | **600** |

**Note:** CPT: Core paper theory — CPP: Core paper practical

SPT: Special paper theory — SPP: Special paper practical

**SEMESTER-II**

| Sl. No. | Paper | Title of the paper | Instruction Hrs per Week | No. of Credits | Duration of the Exam. | Marks | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Internal Assessment | Semester End Exam. | Total Marks |
| 1 | CPT- 2.1 | Quantum Mechanics-I | 4 | 4 | 3 Hrs | 20 | 80 | 100 |
| 2 | CPT- 2.2 | Statistical Mechanics | 4 | 4 | 3 Hrs | 20 | 80 | 100 |
| 3 | SPT-2.3.A | Condensed Matter Physics-II | 4 | 4 | 3 Hrs | 20 | 80 | 100 |
| | SPT-2.3.B | Material Science-II | 4 | 4 | 3 Hrs | 20 | 80 | 100 |
| 4 | OEPT– 2.4 | To be offered by other departments of the faculty | 4 | 4 | 3 Hrs | 20 | 80 | 100 |
| 5 | CPP-2.5 | **Practical :** Modern Physics – I | 4 | 2 | 3 Hrs | 10 | 40 | 50 |
| 6 | CPP-2.6 | **Practical:** Computer programming-II | 4 | 2 | 3 Hrs | 10 | 40 | 50 |
| 7 | SPP-2.7.A | **Practical:** Condensed Matter Physics-II | 4 | 2 | 3 Hrs | 10 | 40 | 50 |
| | SPP-2.7.B | **Practical :** Material Science-II | 4 | 2 | 3 Hrs | 10 | 40 | 50 |
| 8 | OEPP-2.8 | To be offered by other departments of the faculty | 4 | 2 | 3 Hrs | 10 | 40 | 50 |
| | | **Total** | **32** | **24** | | **120** | **480** | **600** |

**Note:** CPT: Core paper theory CPP: Core paper practical
SPT: Special paper theory SPP: Special paper practical
OEPT: Open Elective Paper Theory OEPP: Open Elective Paper practical

## SEMESTER-III

| Sl. No. | Paper | Title of the paper | Instruction Hrs per Week | No. of Credits | Duration of the Exam. | Marks | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Internal Assessment | Semester End Exam. | Total Marks |
| 1 | CPT- 3.1 | Quantum Mechanics-II | 4 | 4 | 3 Hrs | 20 | 80 | 100 |
| 2 | CPT- 3.2 | Nuclear Physics | 4 | 4 | 3 Hrs | 20 | 80 | 100 |
| 3 | SPT- 3.3.A | Condensed Matter Physics-III | 4 | 4 | 3 Hrs | 20 | 80 | 100 |
| | SPT- 3.3.B | Material Science-III | 4 | 4 | 3 Hrs | 20 | 80 | 100 |
| 4 | OEPT – 3.4 | To be offered by other departments of the faculty | 4 | 4 | 3 Hrs | 20 | 80 | 100 |
| 5 | CPP-3.5 | **Practical :** Modern Physics – II | 4 | 2 | 3 Hrs | 10 | 40 | 50 |
| 6 | CPP-3.6 | **Practical :** Nuclear Physics | 4 | 2 | 3 Hrs | 10 | 40 | 50 |
| 7 | SPP-3.7 A | **Practical:** Condensed Matter Physics – III | 4 | 2 | 3 Hrs | 10 | 40 | 50 |
| | SPP-3.7 B | **Practical:** Material Science-III | 4 | 2 | 3 Hrs | 10 | 40 | 50 |
| 8 | OEPP-3.8 | To be offered by other departments of the faculty | 4 | 2 | 3 Hrs | 10 | 40 | 50 |
| | | **Total** | **32** | **24** | | **120** | **480** | **600** |

**Note:** CPT: Core paper theory — CPP: Core paper practical
SPT: Special paper theory — SPP: Special paper practical
OEPT: Open Elective Paper Theory — OEPP: Open Elective Paper practical

**SEMESTER-IV**

| Sl. No. | Paper | Title of the paper | Instruction Hrs per Week | No. of Credits | Duration of the Exam. | Marks | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Internal Assessment | Semester End Exam. | Total Marks |
| 1 | CPT- 4.1 | Classical Electrodynamics | 4 | 4 | 3 Hrs | 20 | 80 | 100 |
| 2 | CPT- 4.2 | Atomic Molecular and optical Physics | 4 | 4 | 3 Hrs | 20 | 80 | 100 |
| 3 | SPT- 4.3.A | Condensed Matter Physics-IV | 4 | 4 | 3 Hrs | 20 | 80 | 100 |
| | SPT -4.3.B | Material Science-IV | 4 | 4 | 3 Hrs | 20 | 80 | 100 |
| 4 | CPD- 4.4 | Core Paper Dissertation | 4 | 4 | 3 Hrs | 20 | 80 | 100 |
| 5 | CPP-4.5 | **Practical:** Modern Physics-III | 4 | 2 | 3 Hrs | 10 | 40 | 50 |
| 6 | CPP-4.6 | **Practical:** Atomic Molecular and optical Physics | 4 | 2 | 3 Hrs | 10 | 40 | 50 |
| 7 | SPP- 4.7 A | **Practical:** Condensed Matter Physics –IV | 4 | 2 | 3 Hrs | 10 | 40 | 50 |
| | SPP- 4.7 B | **Practical:** Material Science-IV | 4 | 2 | 3 Hrs | 10 | 40 | 50 |
| 8 | CPPP- 4.8 | Core paper project practicals | 4 | 2 | 3 Hrs | 10 | 40 | 50 |
| | | **Total** | **32** | **24** | | **120** | **480** | **600** |

**Note**: CPT: Core paper theory CPP: Core paper practical
CPD: Core Paper Dissertation CPDP: Core paper Dissertation Practical
SPT: Special paper theory SPP: Special paper practical
OEPT: Open Elective Paper Theory OEPP: Open Elective paper practical

## INTERNAL ASSESSMENT, SEMINAR AND EXTRA ACTIVITIES

**Internal Assessment Marks allotment basis**

1st Test for 10 marks

2nd Test for 10 marks:

| | |
|---|---|
| Average of two tests for marks | : 10 |
| **Seminar** | : 05 |
| **Extra activities (Awareness programmes for general public, extension activities etc…)** | : 05 |
| **Total** | : 20 |

# SYLLABUS

**Note: All the CPT/SPT/OEPT courses consist of four units each and each unit should be taught for a maximum of 16 hours.**

# SEMESTER-I

## CPT 1.1: CLASSICAL MECHANICS

### Unit 1:

**The Lagrangian method:** Constraints and their classifications. Generalized coordinates. Virtual displacement, D'Alembert's principle and Lagrangian equations of the second kind. Examples of (I) Single particle in (a) Cartesian coordinates, (b) Spherical polar coordinates and (c) Cylindrical polar coordinates, (II) Atwood's machine and (III) a bead sliding on a rotating wire in a force-free space. (IV) Simple pendulum. Derivation of Lagrange equation from Hamilton principle. Importance and simple applications of Lagrangian formulism, Symmetry and conservation laws, cyclic coordinates.

### Unit 2

**Central force problem**: Motion of a particle in a central force field, Conservation of energy and angular momentum, classification of orbits, stability of orbits, Kepler's laws of planetary motion. Scattering in a central potential in Laboratory and centre of mass frames, Impact parameter, Total and differential cross section, Rutherford scattering.

### Unit 3:

**Hamilton's equations:** Generalized momenta. Hamilton's equations. Examples (i) the simple harmonic oscillator. (ii) Hamiltonian for a free particle in different coordinates. Cyclic coordinates. Physical significance of the Hamiltonian function. Derivation of Hamilton's equations from a variational principle. Generating functions (Four basic types), examples of Canonical transformations, Poisson brackets; properties of Poisson brackets, angular momentum and Poisson bracket relations. Equation of motion in the Poisson bracket notation. The Hamilton-Jacobi equation; the example of the harmonic oscillator treated by the Hamilton-Jacobi method.

### Unit 4

**Mechanics of rigid bodies:** Degrees of freedom of a free rigid body, Angular momentum and kinetic energy of rigid body. Fixed and moving coordinates, coriolis force, coriolis force acting on falling body. Moment of inertia tensor, principal moments of inertia, products of inertia, the inertia tensor. Euler equations of motion for a rigid body. Torque free motion of a rigid body. Precession of earth's axis of rotation, motion of symmetrical top-rotational motion.

**References:**

1. Classical mechanics, H. Goldstein, C. Poole, J. saflco. 3rd edition. Pearson Education inc. (2002).
2. Classical mechanics. K. N. Srinivasa Rao, University press (2003).
3. Classical mechanics, N. C. Rana and P.S. Joag Tata McGraw-Hill (1991).
4. Classical dynamics of particles and systems, J. B. Marion, Academic press (1970).
5. Introduction to Classical mechanics. Takwale and Puranik, Tata McGraw-hill (1983)
6. Classical mechanics, L. D. Landau and E. M. Lifshitz, 4thedition, Pergamon Press (1985).

## CPT 1.2: MATHEMATICAL AND COMPUTATIONAL PHYSICS

### Unit 1:

**Linear vector space:** Linear dependence and independence of vectors. Dimension. Basis. Change of basis. Subspace. Isomorphism of vector spaces. Linear operators. Matrix representative of a linear operator in a given basis. Effect of change of basis. Invariant subspace. Eigen values and eigenvectors. Characteristic equation. The Schur canonical form. Diago nalisation of a normal matrix. Schur's theorem.

### Unit 2:

**Matrices:** Orthogonal, Hermitian, and unitary matrices; eigenvectors and eigenvalues, diagonalization of matrices, Matrix representation of linear operators, eigenvalues and eigenvectors of operators, simultaneous eigen vectors and commutativity, applications to physical problems
**Tensors:** Curvilinear coordinates, Coordinate transformation in linear spaces, definition and types of tensors, contravariant and covariant tensors, symmetric and antisymmetric tensors, Tensor algebra : equality, addition and subtraction, tensor multiplication, outer product; contraction of indices, inner product, quotient theorem, Kronecker delta, metric tensor**,** Christoffel symbols. Tensors in physics**.**
**Green's functions:** definition and properties.

### Unit 3:

**Special functions:** Differential equations, Hermite and Lagaurre functions: Partial differential equations, Separation of variables- Helmholz equation in cylindrical and spherical polar coordinates. Differential equations: Regular and irregular singular points of a second order ordinary differential equation. Series solutions–Frobinius method. Linear independence of solutions-Wronskian. Hermite functions: Generating functions, Recurrence relations, Rodrigues representation, Orthogonality. Laguerre functions: Differential equation-Laguerre polynomials, Generating function, Recurrence relations, Rodrigues representation, Orthogonality, Associated Laguerre functions and its general properties. The gamma function and beta function; definition and simple properties.

### Unit 4:

C-Language and Programming: Constants and variables, arithmetic expressions, data Types, input and output statements, control statements, switch statements, the loop Statements, format specifications, arrays, functions and programming examples in C.

**References:**


1. Mathematical methods for physicists, Arfken G. B and Weber H.J, 4th Edition, Prism Books Pvt Ltd, India (1995).
2. Mathematical Physics, Sathya Prakash, Sultan Chand and Sons, (1985)
3. Mathematical Physics, Chattopadhyaya P.K, Wiley Eastern, (1980)
4. Methods of Mathematical Physics, Bose H.K and Joshi M.C, Tata McGraw Hill, (1984).
5. Vector Analysis, Murray R Spiegel, Schaum's Outline Series, McGraw Hill International Book Company, Singapore (1981).
6. Tensor Analysis — Theory & Applications. Sokolnikoff LS, 211:i Edition, John Wiley & Sons (1964).
7. Mathematical Methods in the Physical Sciences, Mary L. Boas, 2nd Edition, John Wiley & Sons (1983)
8. C-Programming Language, Balaguruswamy E, Tata McGraw Hill (1999)
9. C-Programming Language, Xavier C, New Age International (2000)

## CPT 1.3: ELECTRONIC CIRCUITS, DEVICES AND COMMUNICATION

**Unit 1:**

**Transistors:** Transistor configurations and characteristics, Methods of biasing-fixed bias, collector to base bias and voltage divider bias, DC and AC load line, Transistor as an amplifier-Single stage and multistage amplifier, frequency response, Push-pull amplifier, Astable multivibrator using transistors, Voltage regulator using transistors.

**Thyristors:** Types of thyristors, Working and characteristics of Silicon Controlled Rectifier (SCR), SCR power controller, Characteristics and application of Triac, Working and characteristics of Unijunction Transistor (UJT), UJT relaxation oscillator.

**Unit 2:**

**Operational amplifier:** Block diagram of an operational amplifier, Characteristics of an ideal operational amplifier, Parameters of an op-amp, Operational amplifier as a feedback amplifier: Inverting and Non-inverting amplifiers, Applications of an operational amplifier: Instrumentation amplifier, Square wave and sine wave generator, Active filters- First order Butterworth low pass and high pass filter, phase shift oscillator.

**Optoelectronic devices**: Photoresistor (LDR) – dark resistance and material constant, Principle and working of a photodiode, Principle and working of Light emitting diode, factors affecting the efficiency of LED, Phototransistor- structure and working, Semiconductor laser- basic structure and working.

**Unit 3:**

**Radio communication:** Principle of AM and FM, Block diagrams of AM and FM transmitters, Principle of AM and FM demodulation, comparison of AM and FM, Principle, Block diagram of super heterodyne receiver.

**Optical fibre communications**: The general system, Advantages of OFC, Optical fibre wave guide, Theory of transmission- total internal reflection, acceptance angle, numerical aperture, Preparation of optical fibres, liquid phase techniques, multimode step index fibres, graded index fibres, single mode fibres, plastic clad fibres, optical fibre connectors, fibre alignment and joint loss, fibre splices.

**Unit 4:**

**Boolean operations and expressions**: Simplification of Boolean expression: SOP and POS. Karnaugh map: two, three and four variable map.

**Logic gates**: Construction of Logic gates (logic families), AND, OR, NAND and NOR gates, AND-OR and NAND-NOR implementation of Boolean Expressions.

**Sequential circuits**: Latches, Flip-flops, SR, JK- Flip-flop, JK Master-Slave, D, T flip-flops, counters, synchronous and asynchronous counters, ripple counters, registers, shift registers, timing sequences.

**A/D and D/A conversion circuits:** Introduction, filtering and sampling, quantization, quantization error, Binary weighted converter, R-2R ladder converter.

**Basics of microprocessor and microcontroller:** Architecture of 8085, Architecture of 8051.

**References:**

1. Basic Electronics and Linear Circuits, NN Bhargava, DC Kulashreshtha and SC Gupta,Tata Mc Graw Hill.
2. Electronic Devices and Circuits: An Introduction, Allen Mottershead**,** Prentice Hall of India
3. Semiconductor Optoelectronic Devices, Pallab Bhattacharya, Pearson education, Asia.
4. Electronic Principles, A P Malvino, (Sixth Edition, 1999), Tata McGraw Hill, New Delhi.
5. A Text Book of Basic Electronics, RS Sedha, S Chand & Company Ltd.
6. Op-Amps and Linear Integrated Circuits, Remakant A Gayakwad, (Third Edition, 2004), Eastern Economy Edition.
7. Linear Integrated Circuits, D Roy Choudhury and Shail Jain, New Age International Limited.
8. Electronic Communication Systems, George Kennedy and Bernard Davis, Tata McGraw Hill Education.
9. Optical fibre Communication, Gerd Keiser, Tata McGraw Hill.
10. Digital principles and applications, Donald P Leach and Albert Paul Malvino, Tata McGraw Hill.
11. Digital systems, Principles and applications, Ronald J Tocci and Neal S Widmer, Pearson Education.
12. Digital Fundamentals, Floyd and Jain, Pearson Education.
13. Digital Electronics: Principles and Integrated Circuits, Anil K. Maini, Wiley India Edition.
14. Introduction to microprocessors, AP Mathur, Tata McGraw Hill.
15. 8051 Microcontroller: Hardware, Software and Applications, V. Udayashankara and MS Mallikarjunaswamy,Tata McGraw Hill.

**SPT 1. 4A : CONDENSED MATTER PHYSICS-I (General)**

**Unit 1:**

**X-ray crystallography:** Crystalline state. Reference axes, equation of a plane, Miller indices. External symmetry of crystals; symmetry operations. Two and three dimensional point groups. Lattices; two dimensional lattices, choice of unit cell. Three-dimensional lattices; crystal systems and Bravais lattices. Screw and glide operations. Space groups; analysis of the space group symbol. Diffraction of Xrays by crystals: Laue equations. Reciprocal lattice. Bragg equations. Equivalence of Laue and Bragg equations. Atomic scattering factor (qualitative).

**Unit 2:**

**Experimental techniques:** Brief introduction to Laue, Oscillation, Weissenberg, Powder and Counter methods. Using synchrotron radiation for structure studies.
**Electron and neutron diffraction:** Basic principles. Differences between them and X-ray diffraction. Applications (qualitative).
**Crystal growth:** Crystal growth from melt and zone refining techniques. Liquid crystals: Morphology. The smectic (A-H), nematic and cholesteric phases. Birefringence, texture and X-ray studies in these phases. Orientational order and its determination in the case of nematic liquid crystals.
**Crystal lattice dynamics:** Vibration of an infinite one-dimensional monatomic lattice, First Brillouin Zone. Group velocity. Finite lattice and boundary conditions. Vibrations of a linear diatomic lattice-optical and acoustical branches; relation.

**Unit 3:**

**Magnetic properties of solids:** Diamagnetism and its origin. Expression for diamagnetic susceptibility.
Paramagnetism. Quantum theory of Paramagnetism. Brillouin function. Ferromagnetism. Curie-Weiss law. Spontaneous magnetization and its variation with temperature. Ferromagnetic domains. Antiferromagnetism. Two sub-lattice model. Susceptibility below and above Neel's temperature.
**Superconductivity:** Experimental facts. Type I and type II semiconductors. Phenomena logical theory. London equations. Meissner effect. High frequency behavior. Thermodynamics of superconductors. Entropy and Specific heat in the superconducting state. Qualitative ideas of the theory of superconductivity.

**Unit 4:**

**Semiconductors:** Intrinsic Semiconductors. Crystal structure and bonding. Expressions for carrier concentrations. Fermi energy, electrical conductivity and energy gap in the case of intrinsic semiconductors. Extrinsic Semiconductors; impurity states and ionization energy of donors. Carrier concentrations and their temperature variation. Qualitative explanation of the variation of Fermi energy with temperature and impurity concentration in the case of impurity semiconductors.

**Semiconductor devices:** Brief discussion of the characteristics and applications of phototransistors, JFET, SCR and UJT.

**References**

1. Stout G.H. and Jensen L.H., X-ray structure determination, MacMillan, USA, 1989.
2. Ladd M.F.C. and Palmer R.A., Structure determination by X-ray crystallography, Plenum Press, USA, 2003.
3. Buerger M.J., Elementary crystallography, Academic Press, London.
4. Dekker A.J., Solid state physics, Prentice Hall, 1985.
5. Kittel C., Introduction to solid state physics, 7th Edn., John Wiley, New York, 1996.
6. Mckelvey J.P., Solid state and semiconductor physics, 2nd Edn., Harper and Row, USA, 1966.
7. Streetman B.G., Solid state electronic devices, 2nd Edn., Prentice-Hall of India, New Delhi, 1983.
8. De Gennes P.G. and Prost J., The physics of liquid crystals, 2nd Edn., Clarendon Press, Oxford, 1998.
9. Wahab M.A., Solid state physics, Narosa Publishing House, New Delhi, 1999.
10. Azaroff L.V., Introduction to solids, McGraw-Hill Inc, USA, 1960.
11. Pillai S.O., Solid state physics, New Age International Publications, 2002.

## SPT 1.4 B: MATERIAL SCIENCE - I (GENERAL)

**Unit 1:**

**Formation and structure of materials**

Introduction to material science- engineering materials- structure - property relationship. Review of ionic, covalent and molecular bindings- bond angle, bond length and bond energy. Lattice energy –Jones potential. Closed pack structures- packing efficiency and density of materials.

Crystal morphology - symmetry elements - crystal systems. Point group symmetry- derivation of point groups- elementary ideas on space groups. Principles of X-ray powder diffraction method, interpretation of powder photographs and powder metallurgy.

**Unit 2:**

**Crystal imperfections and diffusion in solids:**

Review of crystalline imperfections- schottky and Frenkel defects- equilibrium concentrations.
Line imperfections- edge and screw dislocations-interactions of dislocations. Surface imperfections- grain boundary- tilt and twin boundaries- volume imperfections.
Diffusions in solids - Fick's law of diffusion- Solution to Ficks law - error function. Determination of diffusion co efficients- diffusion couple. Applications based on second law Atomic model of diffusion- electrical conductivity of ionic crystals.

**Unit 3:**
**Elastic and plastic behavior of materials**

Atomic model of elastic behavior- the model as a parameter in design- rubber like elasticity-anelastic behavior – viscosity behavior. Fracture of materials – ductile and brittle fracture – ductile brittle transition- protection against fracture.
Plastic deformation by slip – the shear strength of perfect and real crystals- CRSS- the stress to move a dislocation – work hardening and dynamic recovery. Methods of strengthening crystalline materials against plastic deformation- strain hardening, grain refinement, solid solution strengthening, precipitation strengthening.
**Unit 4:**
**Phase diagrams and phase transformations**
Phase diagrams- the phase rule and it's applications to binary alloy systems- isomorphous, eutectic and peritectic - the lever rule. Typical phase diagrams-Cu-Zn, Ag-Pb, Pb-Sn, Fe-C systems. Heat treatment processes- annealing, hardening and tempering.
Phase transformations- Nucleation and growth- nucleation kinetics – transformations in steel. Solidification and crystallization- recovery, recrystallization and gain growth. Microstructure-single phase materials, phase distribution precipitates and eutectoid decomposition- examples of modifications of microstructure.

**References:**


1. Elements of material science and engineering, **Lawrence H. Van Vlack Addison Wesley** (1975).
2. Material science and engineering, **V. Raghavan**, Prentice Hall (1993)
3. Nature of chemical Bond, **L Pauling**, Oxford and IBH (1960)
4. An introduction to crystallography, **F.C. Phillips**, Longman (1970)

5. Crystallography applied to solid state physics, **Verma and srivastava** New age international (2005)
6. Introduction to solid Solid state physics**, C. kittel,** Wiley Eastern (1993)
7. The structure and properties of Materials vol I- IV- **Rose, Shepard** and wulff (1987)
8. Introduction to solids**, L. V Azaroff, Mc Graw** Hill (1977)
9. Foundation of material science and engineering, William **F. Smith,Mc** Graw Hill international Editions (1988)
10. Solid state Physics Source Book- **Sybil P Parker** (Ed), Mc Graw Hill (1987)
11. Solid state phase trasformations, **V. Raghavan**, Prentice hall (1991)

## LABORATORY EXPERIMENTS

**CPP 1.5: General Physics**

**CPP 1.6: Computer programming –I**

**CPP 1.7: Electronics (General)**

**SPP 1.8 A: Condensed matter Physics - I**

**SPP 1.8 B: Material Science - I**

# SEMESTER-II

## CPT 2.1: QUANTUM MECHANICS – I

**Unit 1:**

**Introduction:** Dual nature of matter and waves, Double-slit experiment for photons and electrons as an illustration. Fundamental Postulates of Quantum Mechanics. Review of Linear vector spaces in Dirac Bra-Ket notation. Position and momentum representations. Wavefunctions. Superposition principle. probability densities, probability current. Expectation values. Commutators. Eigenvalues and eigenvectors of a complete set of mutually commuting operators. Waves, wave packets, phase velocity and group velocity. Canonically conjugate variables, General uncertainty principle. Hamiltonian, Schrodinger's equation. Ehrenfest's Theorem. Continuity equation.

**Unit 2:**

**Exactly solvable problems in one-dimension*:*** Bound states, examples of particle in a box, rectangular potential wells, Simple Harmonic Oscillator: wave function and operator approach. particle in a spherically symmetric potential, Rigid rotator, hydrogen atom.

Unbound states, Scattering in one-dimension. Examples of scattering from a one-dimensional rectangular potential well and barrier, Tunneling, Transmission and Reflection co-efficients. Ramsauer -Townsend effect, Alpha decay, cold emission of electron in a metal.

**Unit 3:**

**Angular Momentum and spin*:*** Angular momentum operators and their Algebra. Eigenfunctions and eigenvalues of $\mathbf{L}^2$ and $\mathbf{L}_z$ using Schrodinger wave mechanics and matrix mechanics. angular momentum operators.
**Uncertainty relations**. Stern-Gerlach experiment and the concept of spin, Pauli-spin matrices. Addition of angular momentum of two or more particles.

**Unit 4:**

**Exactly solvable problems in three dimensions*:*** Wave function of a free particle in Cartesian, cylindrical and spherical coordinates. Bound state problems. Examples of a particle confined in a box, cylindrical and spherical well. Simple harmonic oscillator in 3-dimensions. Two-particle bound state problems. Reduction to a one-particle problem. Schrodinger's equation for the hydrogen atom and its solution, properties of its wave functions.

**References:**

1. E. Merzbacher, Quantum Mechanics. 3rd edition, John Wiley(1994).
2. V.K. Thankappan, Quantum Mechanics, Wiley Eastern (1985).
3. P.M. Mathews and K. Venkatesan, A Textbook of Quantum Mechanics, TMH(1977).
4. R.L.Liboff, Introduction to Quantum Mechanics,Pearson Education(2003).
5. R. Shankar,Principles of Quantum Mechanics,2nd edition,Plenum US (1994).
6. A Ghatak and S Lokanathan, Quantum Mechanics, Theory and Applications,Macmillan(2004)
7. LI Schiff, Quantum Mechanics, 3rd ed. McGraw-Hill(1968).
8. J.J. Sakurai, Modern Quantum Mechanics, Addison Wesley (1985).
9. B.Bransden,C.Joachain, Quantum Mechanics, 2nd ed, Pearson/Prentice Hall, (2000).
10. J.S.Townsend,A Modern Approach to Quantum Mechanics, 2nd ed, McGraw Hill.
11. C.Cohen-Tannoudji, B.Diu, F.Laloe,Quantum Mechanics (2 vol. set),Wiley Interscience(1996)

## CPT 2.2 STATISTICAL MECHANICS

**Unit 1:**

**Thermodynamics preliminaries:** A brief overview of thermodynamics, Maxwell's relations, specific heats from thermodynamic relations, the third law of thermodynamics. Applications of thermodynamics: Thermodynamic description of phase transitions, Surface effects in condensation. Phase equilibria; Equilibrium conditions; Classification of phase transitions; phase diagrams; Clausius-Clapeyron equation, applications. Van der Wall's equation of state. Irreversible thermodynamics—Onsager's reciprocal relation, thermoelectric phenomenon, Peltier effect, Seebeck effect, Thompson effect, systems far from equilibrium.

**Unit 2:**
**Classical statistical mechanics:** The postulate of equal a priori probability; The Liouville theorem; the microcanonical ensemble, canonical ensemble, Grand canonical ensemble, mean value and fluctuations, Entropy and thermodynamic probability, Reduction of Gibbs distribution to Maxwell and Boltzmann distribution, Entropy of an ideal gas; Gibbs paradox; Law of the equipartition theorem; Sackur-Tetrode formula, Molecular partition function, translational and rotational and vibrational partition function and applications to solids. Chemical equilibrium.

**Unit 3:**
**Quantum statistical mechanics:** The postulates of quantum statistical mechanics. Symmetry of wave functions. The Liouville theorem in quantum statistical mechanics; condition for statistical equilibrium; Ensembles in quantum mechanics; The quantum distribution functions (BE and FD); the Boltzmann limit of Boson and Fermion gases; the derivation of the corresponding distribution functions.

**Unit 4:**
**Applications of quantum statistics:** Equation of state of an ideal Fermi gas (derivation not expected), application of Fermi-Dirac statistics to the theory of free electrons in metals, degeneracy and magnetic susceptibility. Application of Bose statistics to the photon gas, derivation of Planck's law, comments on the rest mass of photons, Thermodynamics of Black body radiation. Bose-Einstein condensation.

### References

1. Agarwal B.K. and Eisner M., Statistical mechanics, New Age International Publishers, 2000.
2. Roy S.K., Thermal physics and statistical mechanics, New Age International Pub., 2000.
3. Huang K., Statistical mechanics, Wiley-Eastern, 1975.
4. Laud B.B., Fundamentals of statistical mechanics, New Age International Pub.,2000.
5. Schroeder D.V., An introduction to thermal physics, Pearson Education New Delhi, 2008
6. Salinas S.R.A., Introduction to statistical physics, Springer, 2004.

## SPT 2.3 A: CONDENSED MATTER PHYSICS –II (SPECIAL)

**Unit 1:**

**Ferromagnetism :** Review of Weiss theory of ferromagnetism, its successes and failures, Heisenberg exchange interaction, exchange integral, exchange energy, Ising model, Spin waves (one dimensional case only), quantization of spin waves and magnons, density of modes, thermal excitation of magnons and Bloch $T^{3/2}$ law, specific heat using spin wave theory. Band theory of ferromagnetism. Ferromagnetic domains, hysteresis curve, magnetocrystalline anisotropy energy, Bloch wall.
**Antiferromagnetism :** Characteristic property of anti ferromagnetic substance, Neutron diffraction experiment. Two sub-lattice model molecular field theory of anti ferromagnetism, Neel temperature, Susceptibility below and above Neel temperature.
**Ferrimagnetism:** Ferrimagnetic order, ferrites, Curie temperature and susceptibility of ferrimagnets.

**Unit 2:**

**Magnetic Resonance :** Basic principles of paramagnetic resonance, spin-spin and spin–lattice relaxation, susceptibility in a.c. magnetic field power absorption, equations of Bloch, steady state solutions, determination of g-factor, line width and spin –lattice relaxation time, paramagnetic resonance and nuclear magnetic resonance. Effect of crystal field on energy levels of magnetic ions (qualitative). Spin- Hamiltonian, zero field splitting.

**Unit 3:**

**Dielectrics :** Review of basic formulae, dielectric constant and polarizability, local field, Clausius-Mossotti relation, polarization catatrophe. Sources of polarizability, Dipolar polarizability : dipolar dispersion, Debye's equations, dielectric loss, dipolar polarization in solids, dielectric relaxation. Ionic polarizability. Electronic polarizability: classical treatment, quantum theory, interband transitions in solids.

**Unit 4:**

**Ferroelectrics :** General properties of ferroelectrics, classification and properties of representative ferroelectric crystals, dipole theory of ferroelectricity, dielectric constant near Curie temperature, microscopic source of ferroelectricity, Lyddane –Sachs-Teller relation and its implications, thermodynamics of ferroelectric phase transition, ferrroelectric domains, Piezoelectricity and its applications.

**References:**


1. The Physical Principles of Magnetism : A. H. Morrish, John Wiley & sons, New York (1965)
2. Solid State Physics : A. J. Dekker, Macmillan India Ltd., Bangalore (1981)
3. Introduction to Solid State Physics : 5th Edn C. Kittel, Wiley Eastern Ltd., Bangalore (1976)
4. Elementary Solid State Physics : M. A. Omar, Addison-Wesley Pvt. Ltd., New Delhi (2000)
5. Introduction to Magnetic Resonance: A. Carrington and A. D. Mclachlan, Harper & Row, New York, (1967).
6. Elements of Solid State Physics (2nd Ed): J.P. Srivastava, PHI Learning Pvt. Ltd., New Delhi (2009)

## SPT 2.3.B MATERIAL SCIENCE –II

**Unit 1:**

**Metals**: Review of free electron theory and Fermi distribution function, Structure andtypes of metals, Electronic properties of metals- electrical and thermal conductivity, Widemann- Franz law, temperature and impurity effects. Heat capacity of metals- debye‘s model of specific heat-contribution of free electrons to heat capacity— dispersion relation- acoustic and optical modes-thermal expansion- anharmonic interactions, Galvanomagnetic effects in metals.

**Alloys**: Solid solutions - substitutional and interstitial. Hume Rothery rules. Super lattice- long range order theory. Diffusion in alloys- Darkens equation. Some special alloys-ferrous and nonferrous, super alloys.

**Unit 2:**

**Semiconductors and Superconductors :**

**Semiconductors**: Review of band theory of solids, direct and indirect band gaps, charge carrier in intrinsic semiconductor. Extrinsic semiconductor- effect of doping and mobility of charge carriers. Methods of doping- alloying, diffusion and ion implantation. Preparation of semiconductor single crystals.

**Superconductivity**: Superconducting tunneling phenomena. AC and DC Josephson effect. Applications- Superconducting magnets, super density switches.

**SQUID**. HTS superconductors - materials preparation and structure.

**Unit 3:**

**Dielectrics and Ferroelectrics**

Dielectrics: Review of dielectric polarization- internal field and macroscopic field. The Complex dielectric constant-dielectric losses and relaxation time-Debye equations- Theory of electronic polarization and optical absorption. Dielectric function» LST Relationship, dielectric breakdown- general applications of dielectric materials. Ferroelectrics Piezoelectric, pyroelectric and ferroelectric materials- transducer and detector applications, Classification of ferroelectrics. Ferro electricity in KDP and barium titanate- order—disorder and displacement theories. Thermodynamics of ferroelectric phase transitions.

**Unit 4:**

**Magnetic Materials and Magnetic Resonance:**

Magnetic Materials: Review of dia, para and ferro- magnetic materials, Spontaneous Magnetization— temperature dependence- gyromagnetic experiments. Origin of Ferromagnetic domains- anisotropy of magnetostriction and Bloch wait energies. Antiferromagnetic and ferrimagnetism- Subiattice mode|~ Neel‘s theory. Neutron Diffraction in magnetic structure analysis. Hard and soft magnetic materials- areas of Their application.

Magnetic Resonance: Elements of theory of nuclear magnetic resonance (NMR)-rate of energy absorption- spin lattice and spin-spin relaxation- Bloch equations, Principles of ESR, NOR and Mossbauer techniques, typical areas of application.

**References:**


1. Introduction to Properties of Materials — **D. Rosenthal and R M Asirnov,** East West (1974)
2. Elements of Materials Science and Engineering- **L H Van Vlack,** Addison Wesley (1975)
3. Introduction to solid state Physics,C. **Kittle,** Wiley Eastern (1993)
4. Solid State Physics, **A. J. Dekker,** Mc Milan India (2005)
5. Introduction to solids, **L V Azaroff ,** Mc Graw Hill (1977)
6. Electronic Materials, **S. Muraka ,** Academic Press (1989)
7. Superconductivity and Superconducting Materials- **A. V. Narlikar and S. N. Ekbote ,** South Asian Publications (1983)
8. Semiconductor Physics- **P S Kireev,** Mir Publishers (1975)
9. Solid State and semiconductor Physics, **John Mckelvey,** Harper and Low (1969)
10. Modern Magnetism**- L F Bates,** Cambridge University Press(1963)
11. Electronic Properties of Materials **Ver, Hummel,** Springer lag (1985)
12. Physics of dielectric Materials- ***13*** **Tareev,** Mir Publishers (1979)
13. Magnetic Resonance**- C P Slichter ,** Harper and Row (1985)
14. NQR Spectroscopy, SSP Suppl. **I T P Das and E. L. Hahn,** Academic Press (1957)
15. Mossbauer Effect and its Applications, **V G Bhide ,** Tata McGraw Hill (1973)

## LABORATORY EXPERIMENTS

**CPP 2.5: Modern Physics -I**

**CPP 2.6: Computer programming-II**

**SPP 2.7A: Condensed matter Physics-II**

**SPP 2.7 B: Material Science - II**

# SEMESTER-III

**CPT 3.1: QUANTUM MECHANICS –II**

**Unit 1:**

**The Scrodinger equation in three dimentions:** separation of scrodinger equation in Cartesian coordinates. Free particle in 3-d box – Effects of the exclusion principle on non-interacting fermions in a box. central potential and consequences of rotational invariance – separation of variables r,Φ,Θ; radial equation.

The hydrogen atom – radial equation; energy spectrum; degeneracy of the spectrum; radial wave functions and probability density P(r) for finding the electron at a distance from the center; evaluation of expectation values of $r^n$

**Unit 2:**

**Symmetry in quantum mechanics:** Spatial transition and conservation of linear momentum**.** Discrete symmetries: parity and time reversal. Permutation symmetry: symmetric and anti symmetric wave functions for two identical particles, slater determinant and pouli exclusion principle. Exited states of helium atom: orto and para helium atom

**Approximation methods – I** The variational method: variation theorem, application of variation theorem, application of variational approach to ground states of (i) Hydrogen atom and (ii) Helium atom. The WKB method: one dimentional case, approximate solutions turning pints and connection formulae, Tunneling through a barrier.

**Unit 3:**

**Approximation methods -II:**

Time independent perturbation theory: Perturbation theory for non degenerate states, examples: linear and quadratic stark effects (i) in hydrogen atom, (ii) a particle moving in a 1-d harmonic oscillator. Degenerate perturbation theory, examples: linear stark effect, Normal Zeeman effect.

Time dependent perturbation theory: Time dependent perturbation series. Harmonic perturbation; transition probability, Fermi golden rule, example: sinusoidal perturbation on 1-d simple harmonic oscillator.

Scattering experiments and cross sections: potential scattering, Born approximation, validity of born approximation, Scattering in a central potential, examples: screened coulomb field

**Unit 4:**

**Relativistic quantum mechanics:**

Klein Gordan equation for a free particle and its drawbacks; probability density. Dirac equation for free particle, properties of Dirac matrices, solutions of free particle Dirac equation- ortho

normality and completeness, spin of the Dirac particle, negative energy sea, co variant form of dirac equation. Velocity operator of a free Dirac particle and Zitterbeagung.
Non relativistic limit of Dirac equation for a free particle moving in a central potential – spin – orbit energy. Dirac particle under the influence of a uniform external magnetic field – magnetic moment for the Dirac particle.

**References:**


1. Quantum mechanics, **B.H. Bransden and Joachain,** 2nd Edition Pearson Education (2004)
2. Introduction to Quantum mechanics, **David J. Griffiths**, 2nd Edition, Parson Education (2005)
3. Modern Quantum mechanics**, J.J. Sakurai**, Pearson Education, (2000)
4. Quantum mechanics, V.K Thankappan, 2nd Edition 2004
5. Quantum mechanics, **Stephen Gasiorowicz**, john Wiley (2003)
6. Relativistic Quantum mechanics and Relativistic Quantum fields, J.D. Bjorken and S.D. Drell, Mc. Graw-hill,New York (1968)
7. Quantum mechanics, **L.ISciff,Mc. Graw-hill**, (1955)

## CPT 3.2 NUCLEAR PHYSICS

**Unit 1:**

**Interaction of charged particles:** energy loss of heavy charged particles in matter, Bethe-Bloch formula, energy loss of fast electrons, Bremstrahlung.
**Interaction of gamma rays**: photo electric, Compton, and pair production processes. Gamma ray attenuation- attenuation coefficients, absorber, mass thickness, cross sections.
**Nuclear reactions**: cross section for a nuclear reaction, Differential cross section, Q-value of reaction, threshold energy, Direct and compound nuclear mechanisms, Bhors independence hypothesis and experimental verification .
**Nuclear fission**: energy released in fission, neutron cycle in a thermal reactor and four factor formula.
**Unit 2:**

**Nuclear forces**: characteristics of nuclear forces, short range, saturation, chare independence and exchange characteristics ,Ground state of deuteron, Relation between the range and the depth of the potential using square well potential, Yukawa's theory of nuclear forces (qualitative only)
**Nuclear detectors**: scintillation detectors- Nal(Tl), plastic scintillation- scintillation spectrometer.
**Semiconductor detectors**: Surface barrier detectors, Li ion drift detectors, relation between applied voltage and the depletion region in junction detectors, counter telescopes, particle identification, and position sensitive detector

**Unit 3:**

**Nuclear models and nuclear decay:**
**Liquid drop model**: Semiemphirical mass formula, stability of nuclei against beta decay, mass parabola.
**Fermi gas model**: Kinetic energy for the ground state, asymmetry energy.
**Shell model:** evidence for magic numbers, prediction of energy levels in an infinite square well potential, spin orbit interaction, prediction of ground state spin parity and magnetic moment of odd nuclei, Schmidt limit.
**Beta decay:** Fermi's theory of beta decay, curie plots and ft values, selection rules.
**Gamma decay**: Multi polarity of gamma rays, selection rules, internal conversion (qualitative only).

**Unit 4:**

**Elementary particle physics:** types of interactions between elementary particles, hadrons and leptons, detection of neutrinos.

**Symmetries and conservation laws**: conservation of energy, momentum, angular momentum, charge and isospin, parity symmetry, violation of parity in week interactions, lepton number conservation, lepton family and three generations of neutrinos. Conjugation symmetry, CP violation in week interactions.

Strange particles, conservation of strangeness in strong interactions, Baryon number conservation, Gell-Mann Nishijima formula, eight fold way (qualitative only), Quark model, quark content of baryons and mesons, color degree of freedom, standard model (qualitative only)

**References:**


1. Introduction to Nuclear Physics H.Enge: Addison Wesley, 1971
2. Atomic and Nuclear Physics, S. N. Goshal vol II 2000
3. Introductory Nuclear Physics Kenneth S. Krane: John Wiely and Sons, 1987
4. The Atomic Nuclease Evans R.D. : Tata Mc. Graw hill, 1955
5. Nuclear Physics, R R Roy and Nigam: Wiley-eastern Ltd 1983
6. Nuclear physics an introduction, S.B. Patel: New age international (P) limited 2000
7. Radiation Detection and Measurements, G.F. Knoll: 3rd edition, John Wiely and sons, 2000
8. Nuclear Radiation Detectors, S.S. Kapoor and V.S Ramamurthy: Wiley and sons. Introduction to High Energy Physics D.H. Perkins: Addison Wesley, London, 2000.
9. Introduction to Elementary Particles, D.Griffiths: john Wiley1984
10. Nuclear Interactions, S.de Benedetti: John Wiley, New York, 1964.

## SPT 3.3 A: CONDENSED MATTER PHYSICS –III

**Unit1:**

**Disordered systems :** Point defects-shallow impurity states in semiconductors-Localized lattice vibrational states in solids-Vacancies, interstitials in ionic crystals- Color centers in ionic crystals- Types of Color centers- methods of production-mechanism - Characteristic absorption bands, Properties of Color centers- Models and Applications.

Photoconductivity, Luminescence- fluorescence, Phosphorescence- Thermoluminescence, Photoluminescence, Electroluminescence; Mechanisms. Imperfections in crystals, Mechanism of plastic deformation in solids, Stress and strain fields of screw and edge dislocations, Elastic energy of dislocations.

**Unit 2:**

**Disorder in Condensed Matter** : Introduction- Short range order- Long range order- Ordered lattice- Disordered lattice- Compositional. disorder- Topological disorder-Magnetic disorder-Localized states- Anderson Model- Density of states. Concept of glass- Glass transition- Atomic correlation function and structural description of glasses and liquids. Amorphous semiconductors: Classification. band structure- electronic conduction- Optical absorption-Switching. Transport in disordered lattices- Transport in extended states, Fixed range and variable range hopping- conductivity in impurity bands and in amorphous semiconductors-Applications

**Unit 3:**

**Semiconductors**: Structure of typical semiconductors- Fermi energy expression in Intrinsic and extrinsic semiconductors- its variation with temperature and impurity concentration- Law of mass action- Charge neutrality equation- mobility- diffusion- generation- recombination of Carriers in Semiconductors- Conductivity equation- carrier Life time- Haynes-Shockley experiment- Hall effect in semiconductors- Determination of dell coefficient in intrinsic, n-type and p-type semiconductors.

**Devices**: Fabrication of devices- by growth, alloying. diffusion, ion implantation method. MS and SS contacts- energy band diagrams- Contact potentials- Rectification. Artificial structures: Supper lattice, conversion layers

**Unit 4:**

**Films and Surfaces :** Thin films Methods of preparation: Thermal evaporation- sputtering- DC, AC, diode, triode, magneton, ion beam sputtering, Laser and electron beam evoparation technique. Chemical vapor deposition. Characterization of thin films- film thickness: optical methods- interferometry- Fizeau fringes- FECO Method. Mechanical techniques- Stylus method-weight measurement and crystal oscillators. Structural characterization Scanning electron microscopy, Transmission Electron microscopy and Atomic Force Microscopy. Mechanical properties- Internal stress and strain analysis. Electrical properties of thin films- Measurement of resistivity by four frobe method, thin film resistors (Conduction in metal and non metallic films) Magnetic properties- film size effect on MS- films for memory devices.

**References:**


1. Solid State Physics, A. J. Dekker, McMillan India Ltd, 2003.
2. Luminescence of Solids, D. R. Vij, Plenum Press, 1998.
3. Elementary dislocation theory, J. Weertman and J.R. Weertman, New York ; Macmillan 1964
4. Crystallography Applied to Solid State Physics, Verma and Srivasthava, 2nd Edition. New age International publishers, 2001.
5. Introduction to Solid State Physics, C. Kittel, 7"‘ Edition, John Wiley and Sons 1996.
6. Thin Film phenomenon, K.L. Chopra, McGraw Hill Book Company, 1969.
7. Introduction to solid state theory**,** Otfried Madelung, Springer series. 1996.

## SPT 3.3 B: MATERIAL SCIENCE-III

**Unit 1:**

**Elements of Polymer Science** : Monomers- Polymers- Classification of polymes Synthesis of polymers- chain polymerization, step Polymerization, industrial polymerization methods. Average molecular weight —weight, number and viscosity, size of polymer molecule. Microstructure of polymers- chemical, geometric, random alternating, block and graft polymers, stereo regular polymers. Phase transition- polymer melting and glass transition; polymer crystallinity- degree of crystallinity, crystallization and stereo isomerism. Processing of Plastic Materials- inoulcling- compression, injection blow, extrusion, spinning.

**Unit 2:**

**Ceramics and Glasses**: Ceramics and their structure- Silicate structure, Preparation-Forming and thermal treatments, Classification of ceramics- traditional and engineering, Dielectric, ferroelectric and piezoelectric properties of ceramics with specific examples, Ceramic magnets, Mechanical properties- strength, toughness. Fatigue failure, abrasion. Basic refractory materials.

**Glasses:** Preparation and structure, Types of glasses- borates silicate, oxide, metallic and semiconducting glasses; tempered glass and cnernically strengthened glass.

**Unit 3:**

**Composite Materials**: General Introduction, matrix Materials- polymer, metals, ceramics, Reinforcing materials- fibers, particles. Concrete-concrete making materials, structure, composition. properties and applications. Polymer-concrete composites, fabrication, structure, interface, properties, applications of polymer matrix composites, metal matrix composites, ceramic matrix composites and carbon fiber composites, wood-plastic composites, dispersion strengthened. Particle reinforced, fiber and laminate reinforced composites with fabrication, interface, properties and applications.

**Unit 4:**

**Testing of Materials** : Mechanical Testing - Universal Testing Machine. Hardness- Brinnel, Vicker and Rockwell, impact testing and Fatigue Testing. Optical Microscopy- Metallurgical Microscopes-sample preparation and grain size Measurements. Electron microscopy-Transmission microscopy (TEM), scanning microscopy (SEM)- principle, sample preparation techniques and applications. non Destructive Testing- Ultrasonic Testing, X-ray radiography. Neutron radiography.

**References:**

1. Textbook of Polymer Science**. Fred. W. Billmeyer** John Wiley 8. Sons, Inc. (1984)
2. Polymer Science, **V.R. Gowariker, N. V. Vistrwanathan, Jayadev Shreedhar**, Wiley Eastern (1937)

3. Electronic properties of Materials- **Rolf E. Hummel, Springer Verlag**, Springer Verlag (1985)
4. Foundations of Materials Science and Engineering- **William F. Smith**, McGraw Hill international Editions, (1988)
5. Elements of Materials Science and Engineering. Lawrence **H. Van Vlack,** Addison Wesley (1975)
6. Introduction to Ceramics**- W D Kingery, H K Bower and U R Uhlman,** John Wiley (1960)
7. Ultrasonic **B. Carlin** , Mc. Graw Hill (1950)
8. Principles of Neutron Radiography- **N D Tyufyakav and A S Shtan** , Amerind Publishers (1979)
9. Applied X-rays- **George L Clark**, Mc. Graw Hill, (1955)
10. Testing of Metallic Materials**— AVK Suryanarayan** , Prentice Hall India, (1990)
11. Physical Metallurgy Part I, **R W Cahn and P Haasen** (Ed), North Holland (1983)

## LABORATORY EXPERIMENTS

**CPP 3.5: Modern Physics-II**

**CPP 3.6: Nuclear Physics**

**SPP 3.7 A: Condensed Matter Physics-III**

**SPP 3.7 B: Material Science – III**

# SEMESTER-IV

**CPT 4.1: CLASSICAL ELECTRODYNAMICS**

**Unit 1:**

**Electrostatics:**
Divergence and curl of electrostatic field, Gauss law in integral and differential forms, Poisson and Laplace equations, Boundary conditions and uniqueness theorem, electrostatic potential energy and energy density of a continuous charge distribution. Multipole expansion of the potential and energy of a localized charge distribution, monopole and dipole terms, electric field of a dipole, dipole-dipole interaction. Electrostatic fields in matter, polarization, macroscopic field equations, electrostatic energy in dielectric media.

**Unit 2:**

**Magnetostatics:** Current density, continuity equation, magnetic field of a steady current, the divergence and curl of **B**, Ampere's law, magnetic vector potential, multipole expansion of vector potential of a localized current distribution, magnetic moment. Torques and forces on magnetic dipoles, effect of a magnetic field on atomic orbits. Magnetic fields in matter, macroscopic equations, magnetostatic boundary conditions, magnetic scalar potential. Energy in the magnetic field.

**Unit 3:**

**Electrodynamics:** Faraday law of induction, displacement current, Maxwell's equations. Vector and scalar potentials. Gauge transformations, Lorentz gauge, Coulomb gauge. Poynting's theorem and conservation of energy and momentum for a system of charged particles and electeomagnetic fileds.

**Electromagnetic Waves:** Plane waves in non-conducting and conducting medium, skin depth. Linear and circular polarizations. Reflection and refraction of plane waves at a plane interface, total internal reflection, reflection from a surface of a metal.

**Unit 4:**

**Wave guides:** Fields at the surface and within a conductor, cylindrical cavities and wave guides, modes in rectangular wave guide.

**Electromagnetic radiation:** Retarded Potentials. Radiation from an oscillating dipole, liner antenna. Lenard-Wiechert potentials, potentials for a charge in uniform motion, power radiated by an accelerated charge at low velocities, Larmor's formula , radiation from a charged particle with collinear velocity and acceleration, Bremsstrahlung radiation, radiation from a charged particle moving in a circular orbit, cyclotron and synchrotron radiation.

**Plasma Physics**: Plasma behavior in magnetic field, plasma as a conducting fluid-magneto hydrodynamics, magnetic confinement-Pinch effect.

**References:**


1. Classical Electrodynamics: J.D.Jackson , Wiley Eastern Ltd., Bangalore (1978)
2. Introduction to Electrodynamics: D.J.Griffiths, Prentice Hall of India, Ltd., New Delhi (1995).
3. Electromagnetics: B.B. Laud. Wiley Eastern Ltd., Bangalore (1987)
4. Classical Electromagnetic Radiation: J.B. Marion, Academic press, NewYork (1968).
5. Classical Electrodynamics; S P Puri, Tata McGraw –Hill Publishing Company Ltd., New Delhi, (1990).

## CPT 4.2: ATOMIC MOLECULAR AND OPTICAL PHYSICS

**Unit 1:**

**Atomic Physics**: Brief review of early atomic models of Bohr and Sommerfeld. One electron atom: Quantum states, Atomic orbitals, spectrum of hydrogen, Rydberg Atoms (brief treatment), Relativistic corrections to spectra of alkali atoms: Spin-orbit interaction and fine structure in alkali spectra. Lamb shift in hydrogen (qualitative Discussion only) Two electron atom: Ortho and Para states and role of Pauli principle, level schemes of two electron atoms. Perturbations in the spectra of one and two electron atoms: Zeeman effect, Paschen- Back effect, Stark effect in hydrogen spectra. Hyperfine interactions and 21cm line of hydrogen. Many electron atoms: Central field approximation. LS and JJ coupling schemes, Multiplet splitting and Lande interval rule.

**Unit 2:**

**Molecular Physics A**: Brief treatment of chemical bonds: covalent, ionic, Van der waal's interactions. The Born-Oppenheimer approximation (qualitative treatment), diatomic molecule as a rigid rotator, rotational spectra of rigid and non-rigid rotator, intensities of rotational lines. Microwave spectroscopy- principle and technique Types of rotors: Eigenvalues of Linear, Symmetric top, Asymmetric top and Spherical top molecules. Raman spectroscopy: Theory of Raman effect, experimental techniques, rotational Raman spectra of diatomic and linear polyatomic molecules.

**Unit 3:**

**Molecular Physics B** : Diatomic molecule as a simple harmonic oscillator, anharmonicity, Morse potential curves, vibrating rotator: energy levels and vibration spectra, PQR branches in rovibronic spectra , experimental technique and IR spectrometer. Comparison of vibration and Raman spectra.

**Electronic spectra of diatomic molecules**: Vibrational structure, rotational structure in electronic spectra, intensity of vibrational lines in electronic spectra -Frank—Condon principle, dissociation and pre-dissociation, fluorescence and phosphorescence.

**Unit 4:**

Optical Physics: Coherence of light, spatial and temporal coherence, Einstein's Coefficients: spontaneous and stimulated emission, idea of light ampiification, characteristics of a laser beam, threshold condition for laser oscillation, role of resonant cavity, He-Ne lasers, Brief treatment of application of lasers.

Holography: Fundamentals of 3D»mapping of images, recording and reconstruction, applications in microscopy and interferometry.

Fiber optics: Mechanism of light propagation in a fiber wave guide, numerical aperture, types of optical fibers, transmission characteristics of optical fibers—attenuation and dispersion, optical fiber communication system (qualitative).

**References:**


1. Physics of atoms and molecules, Bransden and Joachain, (2nd Edition) Pearson Education, 2004
2. Introduction to Atomic Spectra, H E White, McGraw Hill Kogakusha Ltd.
3. Fundamentals of Molecular Spectroscopy, Banwell and Mccash, Tata McGraw Hill, 1998.
4. Molecular Spectra and Molecular Structure Vol.1, Geralhd Herzberg, D VAN NOSTRAND Company. Inc. New York
5. Modern Spectroscopy, J.M. Hollas, John Wiley, 1998.
6. Molecular Quantum Mechanics, P.W. Atkins and R.S. Friedman. Third Edition, Oxford Press(Indian Edition), 2004
7. Lasers, Silfvast, Cambridge Press,1998
8. Lasers, Nambiar, New Age International, 2004
9. Optical Electronics, Ghatak and Tyagarajan, Cambridge Press, 2004
10. Lasers and Nonlinear Optics- B.B. Laud, Wiley-Eastern Ltd. 1991.

## SPT 4.3 A: CONDENSED MATTER PHYSICS –IV

**Unit 1:**

**Reciprocal lattice:** Elementary considerations, graphical construction, vector algebraic discussion, relation between direct and reciprocal cells, interpretation of Bragg's law using reciprocal lattice concept, general spacing formula, transformation equations and their importance.

**Unit 2:**

**The Laue method:** Reciprocal lattice construction, instrumentation, flat plate cameras, front reflection region, appearance of photographs, back reflection region, appearance of photographs. Rotating crystal methods: Reciprocal lattice construction, instrumentation, cylindrical camera, mounting and adjustment of crystal, interpretation of photographs, unit cell determination, indexing procedure.

**Unit 3:**

**Moving film methods:** Weissenberg method, reciprocal lattice construction for zero level and higher levels, indexing procedure, interpretation of photographs. Single crystal diffractometer: Rciprocal lattice construction, parafocussing and goniometry, intensity measurements. .

**Unit 4:**

**Powder method:** X-ray powder photographic methods, instrumentation, diffraction geometry, measurement of Bragg angles and interplanar spacings, index of power patterns, analytical and graphical methods, precise lattice parameter determination, characteristics of powder pattern lines, application to identification of solid solution and phase changes, line broadening and particle size measurements, interpretation of powder photographs of unknown system, powder diffractometer and applications.

**References:**

1. Elements of X-ray Crystallography, L.V. Azaroff: McGraw Hill, New York, 1968.
2. An introduction to Crystallography, Michael M Wooffen: Cam bridege University Press, 1997
3. Crystal growth Processes and methods, Santhana Raghavan and Ramaswamy: KRU Publications, Kumbakonam.
4. Crystallography for solid state physics, Verma and Srivastava: New age international Ltd. 1997.
5. Solid State Physics, Charles Kittel: Wiley Eastern, 1984.
6. X-ray crystallography, M.J.Burger: John Wiley, New York, 1952.
7. Crystalline Solids, Duncan M and C. Mike: Nelson, London, 1973.
8. The powder method in X-ray cryst. L.V. Azaroff and M.J.Burger: McGraw Hi11,1958.

## SPT 4.3 B : MATERIAL SCIENCE-IV

**Unit 1:**

**Optical and dielectric properties of materials:** Theory of electronic polarization and optical absorption, ionic polarization, orientationl polarization. Optical phonon model in an ionic crystal; Interaction of electromagnetic waves with optical modes, polarization, Dispersion curves of transverse optical (TO) phonon and optical photon in a diatomic ionic crystal, LST relation; Metal-insulator transition. UV-VIS, IR, FTIR and Raman spectroscopy. Optical properties of metals & nonmetals- Luminescence, photoconductivity.

**Unit 2:**

**Electrical properties of crystalline, nanocrystalline and polymeric materials:** Resistivity variation in metals, alloys, semiconductors and nanocrystalline materials, electrical conduction in ionic ceramics, clay materials and conducting polymers. Two-probe and four probe techniques, DC and AC conductivity measurements.

**Mechanical Properties of metals and ceramics:** Concepts of stress & strain, stress-strain behavior, elasticity, Plastic deformation, Hardness-Knoop & Vicker's hardness test.

**Unit 3:**

**Thermal properties of metals & alloys:** Temperature effects on the intensities of Bragg reflections. Influence of temperature on diffraction of X-rays: Normal coordinates of lattice vibration and X-ray scattering from a vibrating lattice and origin of thermal diffuse spots. First order TDS. Debye-Waller factor' Debye's method of calculating isotropic temperature factor for a cubic crystal. DTA, TGA, DSC (Outline only). Annealing processes, Heat treatment of steels, mechanism of hardening. Quenching, thermal stresses.

**Unit 4:**

**Structure - Property correlation**, Correlation of structure with physical properties of materials, application prospects of materials in different areas.

**Basic concepts of measurements & instruments:** Static characteristics of instruments, accuracy & precision, sensitivity, reproducibility, errors, Transducers, classification & selection criteria, principles of piezoelectric, photoelectric, thermoelectric transducers, resistance temperature transducers (RTD), Thermister, strain gauge, load cells, LVDT Electronic instruments for measurement, Digital voltmeter, principles of electronic multimeter, digital multimeter, Q-meter, Electronic LCR meter, Frequency & time interval counters.

**References:**

1. Introduction to Ceramics by W. D. Kingery, H. K. Bowen and D. R. Uhlmann, John Wiley & Sons

2. Diffraction analysis of the microstructure of materials by E. J. Mittemeijere and P. Scardi, Springer
3. Materials Science & Engineering by William D. Callister, John Wiley & Sons, Inc.
4. Modern techniques of surface science by D. P. Woodruff & T. A. Delchar, Cambridge University Press
5. X-ray spectroscopy by B. K. Agarwal, Springer-Verlag.

## LABORATORY EXPERIMENTS

**CPP 4.4 (4.1): Modern Physics -III**

**CPP 4.5 (4.2): Atomic Molecular and Optical Physics**

**CPP 4.6 (4.3.A): Condensed Matter Physics –IV**

**SPP-4.6 (4.3.A): Material Science – IV**

**SYLLABUS OF OPEN ELECTIVE COURSES TO BE OFFERED BY THE DEPARTMENT FOR OTHER STUDENTS OF OTHER DEPARTMENTS OF THE FACULTY**

## OEPT 2.4: MODERN PHYSICS

**Unit 1:**

**Blackbody Radiation:** Nature of Blackbody spectrum; classical radiation laws and their limitations; Planck's radiation law and quantum hypothesis.
**The Photoelectric Effect:** Experimental arrangement of the Photoelectric Effect; laws of Photoelectric Effect; Einstein Photoelectric Equation.
**X-Rays:** Nature and production of X-rays; the Bragg law; Bragg X-ray crystal spectrometer.
**The Compton Effect:** X-ray Compton scattering from an electron; experimental set-up for Compton scattering**.**

**Unit 2:**

**Atomic Structure:** Hydrogen spectrum; the Bohr model; experimental measurement of the Rydberg constant; Franck-Hertz experiment.
**Matter Waves:** The de Broglie wavelength and its relation with the Bohr model; Davisson-Germer experiment. Heisenberg Uncertainty principle: Momentum-position and Energy-time relations.
**Quantum Physics:** Idea of wave function and probability. One-dimensional Schrödinger wave equation: Its application to the particle in a box and Hydrogen atom; energies and wave functions.

**Unit 3:**

**Molecular Structure:** Bonding mechanisms: Ionic bonds; Covalent bonds; the Hydrogen bond; Van der Waals bonds. Molecular vibration and rotation spectra. Molecular orbitals: Hydrogen molecular ion and molecule.
**Solid State Physics:** Ionic solids; covalent solids; metallic solids; molecular crystals; amorphous solids. Classical models of electrical and heat conductivities in solids; Ohm's Law; Wiedemann-Franz law; the quantum view point.
**Lasers:** Absorption, Spontaneous and Stimulated emissions; Population inversion; laser action, Ruby Laser.

**Unit 4:**

**Magnetism;** Magnetic moment; Hysteresis and Magnetization. Magnetic materials: Diamagnetic, paramagnetic and ferromagnetic materials.

**Nuclear Structure:** Nuclear properties: Charge, Mass, Size and Structure; Nuclear spin and magnetic moment; Nuclear Magnetic Resonance (NMR) phenomenon. Binding energy and nuclear forces. The liquid drop model. Radioactivity**:** Decay constant**,** Half-life**.**

**Relativity:** The Michelson-Morely experiment. Postulates of Special theory of Relativity; Time dilation; Length contraction; Simultaneity of events; $E = mc^2$.

**References:**

1. Modern Physics (2nd Ed) Serway, Moses and Moyer, Saunders College Pub, 1997.
2. Fundamentals of Physics extended with Modern Physics (4th Ed) Halliday, Resnick and Walker, John Wiley, 1993.
3. Concepts of Modern Physics by Arthur Beiser, Mcgraw- Hill Higher education, 2003

## OEPT 3.4: NANOSCIENCE AND NANOTECHNOLOGY

**Unit 1:**

**Basics of nano science:** The nanoscale, historical background, quantum confinement, size dependent properties, surface to volume ratio.
**Basic quantum mechanics:** Wave-particle duality, Heisenberg uncertainty principle Schrödinger equation --solution of one-dimensional time-independent equation, particle in a one-dimensional box; density of states for zero-, one-, two- and three-dimensional box; particle in a coulomb potential. Tunneling of a particle through potential barrier

**Unit 2:**

**Synthesis of nanomaterials:** Synthesis and nanofabrication, Bottom-Up and Top-Down approach with examples. Chemical precipitation methods, sol-gel method, chemical reduction,
Physical methods- mechanical-ball milling, melt mixing; RF sputtering, Physical Vapour deposition (PVD), chemical vapour deposition, molecular beam epitaxy.
Chemical methods: colloidal synthesis and capping of nanoparticles.

**Unit 3:**

**Characterization techniques:** microscopes - optical, SEM, TEM, STM, AFM; diffract-tion techniques -XRD, EXAFS neutron diffraction; spectroscopes --UV-visible-IR absorption, FTIR, Photoluminescence

**Unit 4:**

**Properties of nanomaterials:** Mechanical; Electrical --classification - metals semi-conductors, insulators, band structures; mobility, resistivity, Hall effect, magneto- resistance; Optical --optical absorption and transmission, photoluminescence.

**References:**

1. Nanotechnology: Principles and practices, S. K Kulkarni, Capital Publ. Co., New Delhi (2007)
2. Nanocrystals : Synthesis, Properties and Applications, C.N.R.Rao, P. John Thomas and G.U. Kulkarni, Springer series in Materials Science 95, Springer-Verlag, Berlin, Heidelburg (2007).
3. Quantum Mechanics – Vol 1 & 2, Cohen, Tannoudji
4. The Physics and Chemistry of Solids, Stephen Elliot & S.R. Elliot
5. Solid State Physics- A.J. Dekker
6. Introduction to Nanotechnology- Charles P.Poole Jr and Franks J. Owens
7. Electronic Transport in macroscopic systems, Supriyo Datta
8. Nanotubes and Naowires- CNR Rao and A Govindaraj, RCS Publishing.
9. Encyclopedia of Nanotechnology- Hari singh Nalwa

## THEORY QUESTION PAPER PATTERN

**Max. Marks = 80**

**NOTE: Question no. 1 is compulsory. Answer all questions from 2 to 6.**

1. **Answer in Brief (Answer any eight)** **8 X 2 = 16**
   a.
   b.
   c.
   d.
   e.
   f.
   g.
   h.
   i.
   j.
2. **Essay type question** 16
3. **Essay type question** 16
4. **Essay type question** 16
5. **Essay type question** 16
6. **Write short notes on any four of the following** **4 X 4 =16**
   a.
   b.
   c.
   d.
   e.

## PRACTICAL QUESTION PAPER PATTERN

**Max. Marks = 40**

1. Experiments, Spotting, Demonstration 30marks
2. Records and submissions 05 marks
3. Viva -Voce 05 marks

***Note: Equal Weightage should be given to all the units while setting the question paper***