Post Graduate Department of Studies and Research in Physics

Syllabus for I Semester

P.1 01: Classical Mechanics

Part I

System of Particles: Centre of mass, total angular momentum and total kinetic energies of a system of particles, conservation of linear momentum, energy and angular momentum. (3 hours)

Lagrangean Formulation: Constraints and their classification, degrees of freedom, generalized co-ordinates, example of a disk rolling on the horizontal plane; virtual displacement, D'Alembert's principle, Lagrange's equations of motion of the second kind, uniqueness of the Lagrangean, Equivalence of Lagrange's and Newton's equations. Simple applications of the Lagrangean formulation: 1. Single free particle in (a) Cartesian co-ordinates, (b) spherical polar co-ordinates. 2. Atwood's machine. 3. A bead sliding on a uniformly rotating wire in a force-free space. 4. Motion of block attached to a spring 5. Simple Pendulum. (8 hours)

Symmetries of space and time: conservation of linear momentum energy and angular momentum. (2 hours)

.... {13 hours)

Part II

Motion in non-inertial reference frames: Motion of a particle in a general non-inertial frame of reference, notion of pseudo forces, equations of motion in a rotating frame of reference, the coriolis force, deviation due east of a falling body, the Foucault pendulum. (4 hours)

Central forces: Reduction of two particle equations of motion to the equivalent one- body problem, reduced mass of the system, conservation theorems (First integrals of the motion), equations of motion for the orbit, classifications of orbits, conditions for closed orbits, The Kepler problem (inverse-square law of force). (6 hours)

Scattering in a central force field: general description of scattering, cross-section, impact parameter, Rutherford scattering, centre of mass and laboratory co-ordinate systems and Transformations (3 hours).

.... {13 hours)

Part III

Hamiltonian formalism: Generalized momenta, canonical variables, Legendre transformations and the Hamilton's equations of motion, Examples of (a) The Hamiltonian of a particle in a central force field, (b) the simple harmonic oscillator. Cyclic co-ordinates, derivation of Hamilton's equations from variational principle. (5hours)

Canonical transformations: Generating functions (four basic types) examples of canonical transformations, the harmonic oscillator in 1-d.

Poisson brackets; equations of motion in terms of Poisson Brackets, properties of Poisson brackets (antisymmetry, linearity and Jacobi identity), Poisson brackets of angular momentum. (6 hours)
The Hamilton-Jacobi equation, linear harmonic oscillator using Harnilton-Jacobl method. (2 hours)

{13 hours}

Part IV

Rigid body dynamics: Degrees of freedom of a free rigid body, angular momentum and kinetic energy of a rigid body, moment of Inertia tensor, principal moments of inertia, classification of rigid bodies as spherical, symmetric and asymmetric, Euler's equations of motion for a rigid body, Torque free motion of a rigid body, precession of earth's axis of rotation, Euler angles, angular velocity of a rigid body, notions of spin, precession and nutation of a rigid body, brief description of the motion of Heavy symmetric top rotating about a fixed point under the action of gravity. (8 hours)

Small oscillations: Types of equilibria, Quadratic forms for Kinetic and Potential energies of a system in equilibrium, Lagrange's equations of motion, Normal modes and normal frequencies, examples of (i) longitudinal vibrations of two coupled harmonic oscillators (ii) Normal modes and normal frequencies of a linear, symmetric, triatomic molecule, (iii) oscillations of Two linearly coupled plane pendula. (5 hours)

.... {13 hours)

Reference and Textbooks:

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-Hili (1891).
4. Classical dynamics of particles and systems, J. *B. Marion,* Academic press (1970).
5. Introduction to Classical mechanics, *Takwa/e and Puranik,* Tata McGraw-Hill (1983).
6. Classical mechanics, *L. D. Landau and E. M. Lifshitz,* 4th edition, Pergamon press (1985).

P 102: Electronic Circuits and Devices

Part I

Physics of devices: p-n junction, abrupt junction - band structure - thermal equilibrium - depletion region - depletion capacitance - current and voltage characteristics - BJT - transistor action - static characteristics. MOS structure - MOSFET working - MOSFET characteristics - width of depletion region -junction capacitance-threshold voltage- Metal semiconductor contacts - ohmic and Schottky contacts - MESFET principle - characteristics - Principle of operation of photoelectronic devices: photoconductor - efficiency, current gain, response time. Effect of light on I-V characteristics of a junction photo device, principle and working of a photodiode, Light emitting devices, principle, working and factors affecting the efficiency of LED

.... (13 hrs)

Part II

Transistor circuits: The Common Base configuration - I V characteristics - alpha - equivalent circuit-Common collector configuration (the emitter follower) -input and output impedances - gain; Common emitter configuration - I V characteristics - beta of a transistor - base bias with single supply - gain. Load lines for CE connection - dc load line, ac load line, and optimum operating point. Push-pull amplifier. The Darlington pair. Astable multivibrator using transistors, voltage regulator using transistors, transistor difference amplifiers - four configurations, analysis of dual input and dual output configuration - CMRR - Common Mode gain, Difference mode gain. .

…………(13 hrs)

Part III

Operational Amplifiers: Block diagram of an operational amplifier - Characteristics of an ideal operational amplifier - comparison with 741 - Operational amplifier as a pen loop amplifier - Limitations of open loop configuration - Operational amplifier as a feed back amplifier; - closed loop gain, input impedance, output impedance of inverting and non-inverting amplifiers - Voltage follower - Differential amplifier: voltage gain. Applications of op-amp: Linear applications - Phase and frequency response of low pass, high pass and band pass filters (first order), summing amplifier - inverting and non-inverting configurations, subtractor, difference summing amplifier, ideal and practical Differentiator, Integrator. Non - linear applications: comparators, positive and negative clippers, positive and negative clampers, small signal half wave rectifiers .

.... (13 hrs)

Part IV

Digital Circuits: Review of gates (AND, OR,NAND,NOR,NOT,EX-OR), - Boolean laws and theorems - simplification of SOP equations - Simplification of pas equations - Simplification using Karnaugh Map technique (4 variables)- conversion of binary to Grey code - Flip flops: Latch using NAND and NOR gates- RS flip flop, clocked RS flip flop, JK flip flop, JK master slave flip flop - racing -Shift Registers basics - Counters: Ripple counters-truth table-timing diagram, Synchronous counters-truth table-timing diagram, Decade counter.

.... (13 hrs)

Textbooks and references:-

1. Semiconductor devices Physics and Technology, S M Sze, (Second Edition, 2002), John Wiley and Sons Inc. Asia.
2. Solid-state electronic devices, *Ben* G *Streetman, Sanjay Banerjee,* (Fifth edition, 2000), Pearson Education, Asia.
3. Semiconductor Optoelectronic Devices, *Pallab Bhattacharya,* (Second Edition, 1997), Pearson education, Asia.
4. The art of electronics, *Paul Horowitz and Winfield Hill,* (Second Edition, 1992), Foundation Books, New Delhi.
5. Electronic Principles, A *P Malvino,* (Sixth Edition, 1999), Tata McGraw Hill, New Delhi.
6. Op-Amps and Linear Integrated Circuits, *Remeken:* A *Gayakwad,* (Third Edition, 2004), Eastern Economy Edition.
7. Operational Amplifiers with Linear Integrated Circuits, *William Stanley, (1988),* CBS Publishers and Distributors.
8. Linear Integrated Circuits, *D Roy Choudhury and Shail Jain,* «1991), New Age International (P) Limited.
9. Digital principles and applications, *Donald P Leach and Albert Paul Malvino,* (Fifth Edition, 2002), Tata McGraw Hill.
10. Digital systems, Principles and applications, *Ronald J Tocci and Neal* S *Widmer,* (Eighth Edition, 2001), Pearson Education.

P103: Quantum Mechanics I

Part I

Introductory concepts: Brief review of the concepts of wave-particle duality and wave packets. The wave function and its interpretation; Normalization, Wave packets and Gaussian wave packet evolution. Uncertainty principle and illustrations: Gedanken experiment, Estimation of ground state energy of hydrogen atom. Time and energy uncertainty (5 hours)

Time dependent Schrodinqer equation, Conservation of probability, Time independent Schrodinger equation and stationary states, Superposition of wave functions and orthogonality. Expectation values and operators, Ehrenfest's theorem., Schrodinger equation in momentum space (8 hours)

.... (13 Hours)

Part II

One-dimensional problems: Potential forms: Step and square well potentials. Dirac delta function potentials, Reflection and transmission coefficients. Tunneling of particles through a potential barrier, periodic potential in one dimension (7 hours)

Free particle and momentum eigen functions. Particle in a cubical box: bound states, density of states. (3 hours)

One dimensional linear harmonic oscillator (3 hours)

.... (13 Hours)

Part III

Formalism : State of a system, Linear vector spaces and linear independence. Basis set and dimensionality. Brief treatment of Hilbert space. Dirac Bra and Ket notation, properties. Operators: Projection, Parity, Unitary, Momentum. Completeness. Adjoint of an operator and self-adjoint (Hermitian) operators. Commutator's. Matrix elements of an operator. Coordinate and momentum representations. (6 hours)

Theorems on the eigenvalues and eigenkets of Hermitian operators, Commuting operators and their eigenkets. Complete set of commuting operators. Harmonic oscillator solution through matrix method. (5 hours)

Schrodinqer and Heisenberg pictures. Equation of motion of an observable. Interaction representation. (2 hours)

(13 Hours)

Part IV

Angular Momentum : Orbital angular momentum, spatial rotations, Eigenfunctions and eigenvalues of L^2 and L_z , Rigid rotator, Operator formalism for angular momentum, Stern Gerlach experiment and spin angular momentum, Intrinsic magnetic moment and spin % particles, Matrix representation of angular momentum operators, Clebsch Gordan coefficients, Addition of (a) two spin ½ particles and (b) spin % and orbital angular momentum. (13 Hours}

Text books and references

1.Quantum Mechanics, *S.H. Sransden and C.J. Joachain,* 2nd Edition, Pearson Education ,(2004)
2.Introduction to Quantum Mechanics, *David* J. *Griffiths,* 2nd Edition, Pearson Education ,(2005)
3. Modern Quantum Mechanics, *J.J. Sakurai,* Pearson Education, (2000)
4. Principles of Quantum Mechanics, *Ghatak and Lokanathan,* Macmillan, (2004)
5. Quantum Physics, *Stephen Gasiorowicz,* John Wiley, (2003)
6. Quantum Mechanics, *E.Merzbacher,* John Wiley, (1999)
7. Quantum Mechanics, *Powell and Crasemann,* ISH, (19~4)

P 104: Mathematical and Computational Methods of Physics-I

Part I

Vectors and Tensors: Review of vector algebra, gradient divergence and curl operations, line surface and volume integrals of vectors, Gauss's Green's and Stokes' theorems (without proof) and their applications, orthogonal curvilinear coordinates, spherical polar and cylindrical coordinates systems, definition and examples of tensors, tensor algebra, moment of inertia, polarizability and electromagnetic field tensors as examples.

…….(13 hrs)

Part II

Special Functions: Power series method for ordinary differential equations, Beta and Gamma functions, Legendre's equation, Legendre polynomials and their properties, Bessel's equation, Bessel function and their properties, confluent hypergeometric equation, its solution Laguerre's equation, its solution and properties, Hermite equation its solutions, Hermite polynomials.

…….(13 hrs)

Part III

Matrices and Calculus of Residues: Review of matrix algebra, different types of matrices, orthogonal, hermitian, unitary and normal eigen values and eigen functions of matrices, diagonalisation of matrices. Properties of analytic functions, Cauchys integral theorem, singularities, Cauchy's residue theorem, evaluation of definite integrals

.... (13 hrs)

Part lV

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 .

……. (13 hrs)

Textbooks and References:

1. Mathematical methods for physicists, *Arlken* 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 1.5,* 2nd 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)

P 201: Statistical Mechanics.

PART I

Basic Concepts: Basic postulates, phase space, ensemble, Liouvile theorem, condition for statistical equilibrium, microcanonical ensemble, ideal gas. Quantum picture: Microcanonical ensemble, quantization of phase space, basic postulates, classical limit, symmetry of wave functions, effect of symmetry on counting, duality matrix.

. ... 13hrs

Part II

Ensembles and Partition functions: Canonical ensemble, entropy of a system in contact with a heat reservoir, ideal gas in canonical ensemble, Maxwell velocity distribution, equipartition of energy, Grand canonical ensemble, ideal gas in grand canonical ensemble, comparison of various ensembles.
Canonical partition function, molecular partition function, translational partition function, rotational partition function, electric and nuclear partition functions, application of rotational partition function, application of vibrational partition function to solids .

..... 13 hrs

Part III

. Ideal Bose - Einstein and Fermi - Dirac gases: Bose - Einstein distribution, Bose - Einstein condensation ,thermodynamic properties of an ideal Bose - Einstein gas, liquid helium, two fluid model of liquid helium -II -strange properties of He II, ^{3}He-^{4}He mixtures, super fluid phases of 3He. Fermi - Dirac (F-D) statistics, properties of ideal Fermi gas, F - D distribution, degeneracy, electrons in metals, thermionic emission, magnetic susceptibility of free electrons.

……13 hrs.

Part IV

Non-equilibrium states and Fluctuations: Boltzmann transport equation, particle diffusion, electrical conductivity, thermal conductivity, isothermal Hall effect Semiconductors - nonequilibrium semiconductors - electron - hole recombination - diffusion flow, Quantum Hall effect.Introduction, mean square deviation, fluctuations in ensembles, concentration fluctuations in quantum statistics, one dimensional random walk, electrical noise (Nyquist theorem).

. .... 13 hrs.

Text and References:

1.Statistical Mechanics, *B.KAgarwal and Melvin Eisner,* New Age International, a. 2nd Edition, 1998.
2: Statistical Mechanics, *R.KPathria,* 2nd edition, Pergamon Press, 1972.
3. Statistical and Thermal physics, *F.Reif,* McGraw Hill International, 1985.

4.Statistical Mechanics, *KHuang,* Wiley Eastern Limited, New Delhi, 1975.
5.Statistical Mechanics and Properties of matter, *E.S.R.Gopal,* Macmillan, India 1976.
6.Elementary Statistical Physics, *Kittel,* John Wiley, New York, 1958.
Statistical Physics, *Landau and Lifshitz,* Pergamon Press, Oxford, 1974.

Electrodynamics and Plasma Physics

Part I

Electrostatics and Magnetostatics: Gauss's law and applications, Electric potential, Poisson's equations, Work, Energy in electrostatitics, Laplace and Laplace's equation in one, two and three dimension cartesian co-ordinates, boundary conditions and uniqueness theorem, Method of images with applications, Multipole expansion of potential, Dipole field, Field inside dielectrics.
Biot - Savart law and applications, Ampere's law and applications, Magnetic vector potential, Multipole expansion of the vector potential, Magnetic field inside matter .

..... 13hrs

Part II

Electrodynamics and Electromagnetic waves: Review of Maxwell's equations, scalar and vector potentials, Gauge transformations, Coulomb and Lorentz gauges, energy and momentum of electromagnetic waves, propagation through linear media, reflection and transmission of electromagnetic waves, plane waves in conducting media, dispersion in non conductors, wave guides, TE waves in rectangular wave guide.

.. .... 13 hrs

Part III

Electromagnetic Radiation: Retarded potentials, electric and magnetic dipole radiation, Lienard -Wiechert potentials, fields of a point charge in motion, power radiated by a point charge, Review of Lorentz transformations, magnetism as a relativistic phenomenon, transformation of electric and magnetic fields, the tensor, electrodynamics in tensor notation, potential formulation of Relativistic Electrodynamics.

. ... 13 hrs

Part IV

Plasma physics. Definition of Plasma, Debye shielding, charged particle motion in electric and magnetic fields at right angles, time varying E and B fields, Adiabatic invariants, Dielectric constant of a plasma, the equations of motion of a plasma fluid, Drift velocities, plasma oscillations, plasma waves, propagation of eiectromagnetic waves in plasma.

....13hrs

Textbooks and references:

1.ElectromagneticS,JhOn O Kraus, McGraw Hill Publications. (1991).
2.Electromagnetic waves and fields, R.N. Singh, Tata McGraw -hlll. (1991).
3.1ntroduction to electrodynamics, D.J. Griffths, Pearson Education, . Ahird Edition.(2004).
4. Electromagnetics,B.B. Laud, New Age International PVT.L TO.(1987).
5.Electromagnetic fields and waves. P. Lorrain and D. Corson, CBS (1986)
6.Electromagnetism.I.!) Grant and W.R Phillips, Jhon Wiley and Sons Ltd.(1975).
r-: 7. Classical Electromagnetism Jackson Wiley Eastern (student) Third Edition 2005.

P203: Quantum Mechanics II

Part I

The Schrodlnqer equation in three dimensions: Separation of Schrodinper equation in Cartesian coordinates. Free particle in a 3-d box - Effects of the exclusion principle on non-interacting fermions in a box.

(4 hours)

Central potential and consequences of rotational invariance - Separation of variables r, θ and φ; radial equation.

(4 hours)

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 centre; evaluation of expectation values of r".

(5 hours)

.... 13 hrs

Part II

Symmetries in quantum mechanics: Spatial translations and conservation of linear momentum. Discrete symmetries: parity and time reversal. Permutation symmetry: symmetric and antisymmetric wave functions for two identical particles, Slater determinant and Pauli exclusion principle. Excited states of Helium atom: Ortho andPara Helium. (7 hours)

Approximation methods - I:

The Variational method: Variation theorem, application of variational approach to ground states of (i) Hydrogen atom and (ii) Helium atom.

(3 hours)

The WKB method: One dimensional case, approximate solutions, turning points and connection formulae, Tunneling through a barrier.

(3 hours)

.... 13 hrs

Part III

Approximation methods -II :

(1) Time independent Perturbation theory: Perturbation theory for non-degenerate states, examples: linear and quadratic Stark effect (i) in hydrogen atom, (ii) a particle movin'g in a t-d harmonic oscillator. Degenerate perturbation theory, examples: linear Stark effect, Normal Zeeman effect.

(6 hours)

(2) Time dependent Perturbation theory: Time dependent perturbation series. Harmonic perturbation; transition probability, Fermi Golden rule, example: sinusoidal perturbation on a 1-d Simple harmonic oscillator.

(4 hours)

(3) Scattering experiments and cross-sections: Potential scattering, Born approximation, Validity of Born approximation, Scattering in a central potential, example: screened coulomb field. (3 hours)

13hrs

Part IV

Relativistic quantum mechanics:

Klein-Gordan equation for a free particle; probability density.

(2 hours)

Dirac equation for a free particle, properties of Dirac matrices, solutions of free particle Dirac equation - orthonormality and completeness, spin of the Dirac particle, negative energy sea, covariant form of Dirac equation. Velocity operator of a free Dirac particle and Zitterbewagung.

(7 hours)

Non-relativistic limit of Dirac equation for a particle moving in a central potential - spin- orbit energy.

(2 hours)

Dirac particle under the influence of a uniform external magnetic field - magnetic moment of the Dirac particle.

(2hours)

.... 13 hrs

Textbooks and references

1. Qantum Mechanics, *S.H. Sransden and C.J. Joachain,* 2nd Edition, Pearson Education, (2004)
2. lntroduction to Quantum Mechanics, *David* J. *Griffiths,* 2nd Edition, Pearson Education, (2005)
3.Modern Quantum Mechanics, *J.J. Sakurai,* Pearson Education, (2000)
4.Quantum Mechanics, *V. K Thankappan,* 2nd Edition004)
5.Quantum Physics, *Stephen Gasiorowicz,* John Wiley, (2003)
6. Relativistic Quantum Mechanics and Relativistic Quantum Fields, J. *D.*

Sjorken and S. *D. Dre/l,* Me. Graw-HiII, New York (1968)
7. Quantum Mechanics, *L. I. Schiff,* Mc Graw-Hill, (1955)

P204 : Mathematical and Computational Methods of Physics-II

Part I

Partial Differential Equations: Classifications, systems of surfaces and characteristics, examples of hyperbolic, parabola and elliptic equations, method of direct integration, method of separation of variables, the wave equation, Laplace equation, heat conduction equations and their solutions in cartesian coordinate system In one, two and three dimensions, plane polar coordinates and spherical polar coordinates, spherical harmonics and their properties

13hrs

Part II

Integral Transformations: Review of Fourier series, generalized Fourier series, expansion of functions in Fourier series, Fourier integrals, Sine and Cosine transforms, convolution theorem, Parseval's theorem, applications, Laplace transformations, their properties, convolution theorem, inverse Laplace transformations, solution of differential equations using Laplace transformations.
13hrs

Part III

Green's Functions and Integral Equations: Boundary value problems, Sturm-Lioville theory, self adjoint operators, Dirac delta functions and its properties, Green's functions for one, two and three dimensional equations, eigenfunction expansion of Green's functions, Fredholm and volterra type integral equations, solution of equations with separable Kernals, Newmann series method, examples.

13hrs

Part IV

Numerical Techniques using C Language: Solution of linear algebraic equations using matrix method, solution of transcendental equations by bisection and Newton-Raphson methods, curve fitting by least squares method, Numerical integration by trapezoidal and Simpon's rules, numerical solutions of differential equations by Eulers and Runge-Kutta methods.

13hrs

Texts and References

1.Mathematical methods in physical sciences, Mary L. Boas, Z= edition, John Wiley and sons, 1983.
2.Mathematical methods for physicists, Arfken. G, 5th edition, Academic press, 2001.
3.Mathematical physlcs. Sathya prakash, Sultan Chand and sons, 1985.
4. Mathematical physics, Chattopadhyaya P.K. , Wiley Eastern, 1980
5.Methods of Mathematical Physics, Bose. H.K. and Joshi M.C. Tata McGraw Hill,

1984.
6. Tensor Analysis, Sokolnikoff I.S.
7.Programming in ANSI - C, E. Balaguruswamy, a= edition, Tata McGraw - Hill publication, New Delhi, 1992.

P301. Atomic, Molecular and Optical Physics (General)

Part I

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 (qualitativediscussion only) (4 hours)

Two electron atom: Ortho and Para states and role of Pauli principle, level schemes of two electron atoms. (2 hours)

P302. Nuclear and Particle Physics

Part I

Interaction of nuclear radiation with matter:
(a) Interaction of charged particles: Energy loss of heavy charged particles in matter, Bethe-Bloch formula, energy loss of fast electrons, Bremsstrahlung. (3 hrs.).
(b) Interaction of gamma rays: Photoelectric, Compton, and pair production processes. Gamma ray attenuation-attenuation coefficients, absorber mass thickness, cross sections.
(3 hrs.).
Nuclear Reactions: Cross section for a nuclear reaction, differential cross section, Q-value of a reaction, threshold energy (3 hrs.)

Direct and compound nuclear reaction mechanisms, Bohr's independence hypothesis, experimental verification (2 hrs.).
Nuclear Fission: Energy release in fission, neutron cycle in a thermal reactor and four factor formula (2 hrs.)
13 hrs.

Part II

Nuclear forces and Nuclear Detectors:
Nuclear forces: Characteristics of nuclear forces, short range, saturation, charge independence and exchange characteristics (3 hrs.).
Ground state of the deuteron using square-well potential, relation between the range and depth of the potential, Yukawa's theory of nuclear forces (qualitative only)
(3 hrs.).

Nuclear Detectors: Scintillation Detectors-Nal(TI), Plastic scintillator- Scintillation spectrometer (3 hrs.).

Semiconductor detectors: Surface barrier detectors, Li ion drifted detectors, relation between the applied voltage and the depletion region in junction detectors, counter telescopes, particle identification, position sensitive detector (4 hrs.)
13 hrs

Part III

Nuclear Models and Nuclear Decay:
Liquid drop model: Semi-empirical mass formula, stability of nuclei against beta decay, mass parabola.

Fermi gas model: Kinetic energy for the ground state, asymmetry energy.
(2hrs.)
(3 hrs.).

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-A nuclei, Schmidt limit.

(4 hrs.)

Beta decay: Fermi's theory of beta decay, Curie plots and "ft" values, selection rules. Gamma decay: Multipolarity of gamma rays, Selection rules, Internal conversion (qualitative only).

(4 hrs.)

13 hrs

Part IV

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 weak interactions - handedness of neutrinos, Lepton number conservation, Lepton family and three generations of neutrinos. Charge conjugation symmetry, CP violation in weak interactions. (7 hrs.)

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).(6 hrs.)

13 hrs

Text Books & References

1.Introduction to Nuclear Physics, H. Enge: Addison Wesley, 1971.

2.Atomic and Nuclear Physics,S N. Ghoshal: Vol. 11.,2000.

3.Introductory Nuclear Physics,Kenneth S. Krane: John Wiley and Sons, 1987.

4.The Atomic Nucleus,Evans R. D.: Tata McGraw Hill, 1955.

5.Nuclear Physics, R. R. Roy and B. P. Nigam: Wiley-Eastern Ltd. 1983.

6.Nuclear Physics- an Introduction, S.B.Patel: New Age international (P) Limited,1991.

7.Radiation Detection and Measurements, G.F. Knoll: 3rd edition, John Wiley and ons, 2000.

8.Nuclear Radiation Detectors, S.S. Kapoor and V.S.Ramamurthy: Wiley-Eastern, New Delhi, 1986.

9.Detection, Butterworths W.H. Tait: Radiation, London, 1980.

10. Nuclear Radiation Detection,W.J.Price: Mc Graw Hill, New York, 1964.

11.Introduction to High Energy Physics,D.H.Perkins: Addison Wesley, London, 4th Edition, 2000.

12. Production to Elementary particles, D. Griffiths: John Wiley, 1987.

13. Nuclear Interaction,S. de Benedetti: John Wiley, New York" 1964.

Elementary Particles, J. M. Longo, II edition, Mc Graw-HiII, New York, 1973.

P303: CONDENSED MATTER PHYSICS (General)

Part I

Crystal Physics: Crystalline solids, Unit cells and direct lattice, representation of lattice, notation of lattice points and planes in a lattice- two and three dimensional Bravais lattices- closed packed structures- Sodium chloride- Cesium chloride, hcp, diamond, cubic zinc sulphide. Interaction of X-rays with matter- absorption of X-rays-Elastic scattering from a perfect lattice- Miller indices- spacing formula. Diffraction techniques- powder method- Laue method- rotating crystal method. Reciprocal lattice and its applications to diffraction techniques.

13hrs

Part II

Defects in Crystals : Point defects-Schottky and Frenkel defects and their concentrations- line defects and planar (Stacking) faults. Dislocations- Burger Vectors- Shear strength of single crystals- the role of dislocations in deformation and crystal growth- the observation of imperfections in crystals- X-ray and microscopic techniques. 8 hrs

Advanced materials: Basic concepts and classification of polymers and non-Crystalline solids - electrical and optical properties. 5hrs

13hrs

Part III

Electronic properties of solids : Electrons in periodic lattice-band theory-Bloch theorem statement-Kronig-penny model- E(k) curves-extended zone scheme-number of states in a band-motion of electrons in 1 D-effective mass-concept of hole-freeness factor-classification of solids. Calculation of energy and bandwidth; nearly free electron approximation and tight binding approximation method (qualitative). 9 hrs

Super conductivity: Critical temperature-persistent current-occurrence of super conductivity - ideal and non-ideal superconductors-Destruction of super conductivity by magnetic field-Meissner effect- heat capacity-energy gap-microwave and infrared properties- Isotope effect-exotic superconductors- high Te super conductors. 4hrs

13hrs

Part lV

Dielectrics and Ferroelectrics : Dielectric constant-polarization-different kinds of polarization - local electric field-Lorentz field-Clausius-Mossatti relation. Ferroelectricity and peizo electricity-structural phase transitions-examples.

6 hrs

Magnetism : Origin of magnetic moment-classification of magnetic materials-classical theory of dia and para magnetism. Ferromagnetism -domains-Weiss theory (classical) exchange forces-Heisenberg model. Antiferro and ferrimagnetism-molecular field theory. 7 hrs

13hrs

Texts & References

1.Crystallography Applied to Solid State Physics, A.R.Verma and C.N. Srivastava: 2nd edition, New age International publishers, 2001
2.Introduction to solids,A.Azaroff: McGraw-Hili, New York, 1960
3.Elementary Solid State Physics,M.AIi Omar: Addison-Wesley, 2000
4.Solid State Physics,F.W. Aschroft and N.D.Mermin : Saunders college Publishing, New York 1976
5.Solid State Physics, Charles Kittel: 7thEdition, John Wiley and Sons, New York 1996.

P 304 d:(special) Condensed matter physics I

Part I

Energy bands in solids Origin of the energy gap - Bloch theorem - statement and proof - Kronig - penney model - E(k) curves - The motion of electrons in one dimension according to the band - Concept of hole -Brillouin zones - Construction of Brillouin zones in a linear lattice, square lattice and cubic lattice - Density of states : overlapping of energy bands- Motion of electrons in a three dimensional lattice.

<u>Fermi surfaces and metals</u>

Reduced zone scheme - periodic zone scheme - Nearly free electron approximation - magnitude of energy gap-Fermi surfaces for nearly free electrons - Electron orbits - hole orbits and open orbits - Calculation of energy bands - Tight binding method for energy bands - Wigner- Seitz method - Cohesive energy
Experimental methods in Fermi surface studies. (qualitative). **13 hrs.**

Part II

Lattice energy and lattice dynamics in solids

Lattice energy of ionic crystals- Iintroductory remarks-fundamental assumptions of Born's theory-calculation of the repulsive exponent from compressibility data- the repulsive exponent as a function of electron configuration -calculated and experimental lattice energies-stability of structures and ionic radii-refinements of Born theory.

5 hrs.

Lattice dynamics

Vibration of crystal with mono - atomic basis- First Brillouin zone - group velocity - long wavelength limit - derivation of force constants from experiment - Two atom per primitive basis - quantisation of elastic waves - phonon - momentum - Optical phonons and dielectric constants. Inelastic scattering of phonons - Inelastic neutron scattering - Mossbauer effect and lattice dynamics. 8 hrs.

13hrs

Part III

Thermal and optical properties of Solids. Thermal properties of solids-Introduction-Lattice specific heat, classical theory (Dulong and Petit law}-Einstein theory of specific heat- Oebye theory-vibrational modes of continuous medium-Density of vibrational modes-Debye's approximation-Born cut-off procedure. Anharmonic crystal interactions-thermal expansion-thermal conductivity-thermal resistivity of phonon gas-Umklapp process.

7 hrs

Optical properties of solids Introduction-classical model (Orude model), ionic conduction-optical refractive index and relative dielectric constant-optical absorption in metals, insulators and semiconductor skin effect and anomalous skin effect. 6 hrs

13hrs

Part IV

Superconductivity : Superconductors - D C and A C Resistivity - Mechanism of superconductors - Energy gap - properties dependent on energy gap. Classification of Superconductors- Type I and Type II superconductors with examples-Electro magnetic theory - London theory-Microscopic theory - BCS theory, -Theoretical approach by Ginsburg, Landau theory - Tunneling effect - Josephson theory. 13 hrs

Text and Reference Books:

1. Introduction to Solid State Physics, Otfried Madelung: Springer series, 1996.

2. 2Energy band theory, Callaway: Academic press, New York, 1963.
3. Solid State Physics, H.lbach & H.Luth: 3rd Edition, Springer series, 2004.
4. Quantum Theory of Solids,Charles Kittel: John Wiley, New York, 1963. 5.
5. Introduction to Superconductivity, A.C. Rose-Innes and E.H. Rhoderick: Pergamon Press, New York, 1969.

6. Superconductivity and Applications,J.E.C. Williams: Pion Ltd., London, 1970 .

7. :r.-sond State Physics,A.J.Dekker Macmillan Student edition 1991.

,8. Solid State Physics, S.O.Pillai: 5th Edition New age International publishers 2002.

P304 : (special}Atomic, Molecular and Optical Physics - I
(Molecular structure and spectra)

Part I
Molecular symmetry and vibrations: Symmetry properties, point groups, characters and representation of groups, reducible and irreducible representations, character tables (for C_{2V}, $C_{3v}$and $C_{\infty v}$ point groups) with suitable example.
(7 hours)

Polyatomic vibrations: normal co-ordinates and normal modes of vibrations, spin statistics: example of hydrogen molecule. Vibrational selection rules: infrared and

P 401: General Astrophysics ~

Part I

Basic Concepts:
Coordinate systems, Time systems, Trigonometric parallaxes, parsec, Apparent and absolute magnitudes, Atmospheric extinction, Angular radii of stars, Michelson's Stellar interferometer, Binary stars and their masses, Radial and transverse velocities, types of optical telescopes and their characteristics.
13 hrs

Part II

Properties of Stars
Spectra of stars, Spectral sequence-temperature and luminosity classifications, H-R diagram, Saha's ionization formula and application to stellar spectra, Virial theorem, Stellar structure equations, Star formation and main sequence evolution, White dwarfs, Pulsars, magnetars, Neutron stars and Black holes, Variable stars

13hrs

Part III

The Solar System:
The surface of the sun, solar interior structure, solar rotation, sun spots, the active sun, Properties of interior planets and exterior planets, Satellites of Planets, comets, asteroids, meteorites, Kuiper Belt Objects and Oort Cloud, Theories of formation of the solar system

13 hrs

Part Ⅳ
Star clusters, Galaxies and the Universe:
Open and global clusters, the structure and contents of milky way galaxy, Hubble's classification of galaxies, Galactic structure and dark matter, galactic motions, Hubble's