VIJAYANAGARA SHREEKRISHNADEVARAYA UNIVERSITY

JNANASAGARA CAMPUS, BALLARI-583105

DEPARTMENT OF PHYSICS

I-IV SEMESTER SYLLUBUS

Effective From

2016-17

VIJAYANAGARA SRI KRISHNADEVARAYA UNIVERSITY
DEPARTMENT OF PHYSICS
M. Sc. (CBCS) Syllabus 2016 - 17

Semester	Course code	Title of the paper	Credits	Teaching hours/wk	Duration of examination theory/practical hours	Max. marks at semester end examination	Max. marks at internal examination	Total Max. Marks
I	PH HCT 110	Mathematical physics I	04	04	04	70	30	100
	PH HCT 120	Quantum mechanics I	04	04	04	70	30	100
	PH HCT 130	Atomic, molecular and Optical Physics	04	04	04	70	30	100
	PH SCT 140	Electronics	04	04	04	70	30	100
	PH HCP 150	Practical I (Physics Lab I)	04	04	04	70	30	100
	PH HCP 160	Practical II (Physics Lab II)	04	04	04	70	30	100
	PH SCT 141	Astrophysics	04	04	04	70	30	100

Semester	Course code	Title of the paper	Credits	Teaching hours/wk	Duration of examination theory/practical hours	Max. marks at semester end examination	Max. marks at internal examination	Total Max. Marks
II	PH HCT 210	Mathematical physics II	04	04	04	70	30	100
	PH HCT 220	Quantum mechanics II	04	04	04	70	30	100
	PH SCT 230	Elements of Solid state Physics	04	04	04	70	30	100
	PH SCT 240	Elements of Nuclear Physics	04	04	04	70	30	100
	PH HCP 260	Practical III (Physics Lab III)	04	04	04	70	30	100
	PH HCP 270	Practical IV (Physics Lab IV)	04	04	04	70	30	100
	PH SCT 241	Atmosphere and Space Science	04	04	04	70	30	100
	PH OET 250	Modern Physics	04	04	04	70	30	100
	PH OET 251	General Physics	04	04	04	70	30	100

Semester	Course code	Title of the paper	Credits	Teaching hours/wk	Duration of examination theory/practical hours	Max. marks at semester end examination	Max. marks at internal examination	Total Max. Marks
III	PH HCT 310	Classical Mechanics	04	04	04	70	30	100
	PH HCT 320	Electrodynamics and Plasma Physics	04	04	04	70	30	100
	PH SCT 330	Solid State Physics I	04	04	04	70	30	100
	PH SCT 331	Nuclear Physics I	04	04	04	70	30	100
	PH SCT 340	Solid state Physics II	04	04	04	70	30	100
	PH SCT 341	Nuclear Physics II	04	04	04	70	30	100
	PH HCP 350	Practical V (Solid state physics Lab I)	04	04	04	70	30	100
	PH HCP 351	Practical V (Nuclear Lab I)	04	04	04	70	30	100
	PH HCP 360	Practical VI (Solid state physics Lab II)	04	04	04	70	30	100
	PH HCP 361	Practical VI (Nuclear l Lab II)	04	04	04	70	30	100
	PH OET 370	Energy science	04	04	04	70	30	100
	PH OET 371	Radiation physics	04	04	04	70	30	100

Semester	Course code	Title of the paper	Credits	Teaching hours/wk	Duration of examination theory/practical hours	Max. marks at semester end examination	Max. marks at internal examination	Total Max. Marks
IV	PH HCT 410	Statistical Mechanics	04	04	03	70	30	100
	PH HCT 420	Analytical techniques & instrumentation	04	04	03	70	30	100
	PH SCT 430	Solid State Physics III	04	04	03	70	30	100
	PH SCT 431	Nuclear Physics III	04	04	03	70	30	100
	PH SCT 440	Solid state Physics IV	04	04	03	70	30	100
	PH SCT 441	Nuclear Physics IV	04	04	03	70	30	100
		Project	50 (Internal) + 150 (Final exam (100 (Project dissertation work) + 50 (Viva)))					200

VIJAYANAGARA SRI KRISHNADEVARAYA UNIVERSITY, BELLARY

Department of studies in Physics (PG)

(2016-17)

Choice Based Credit System, Continuous Assessment Patterned Semester Scheme.

The Board has framed and approved the Syllabus / Scheme of examination of Choice Based Credit System (CBCS) and recommended for implementation from 2016-2017. The following are the core papers and scheme of examination proposed by the Board.

1. M.Sc., Degree in Physics I & II Semester
2. M.Sc., Degree in Physics III and IV Semester.

The pattern of matrix for two year Master's Degree Program in Physics shall be as follows.

No	COURSES	I SEM			II SEM			III SEM			IV SEM			TOTAL		
		C	P	M	C	P	M	C	P	M	C	P	M	C	P	M
1.	HARD CORE (Theory)	12	3	300	12	2	200	8	2	200	8	2	200	40	10	1000
2	HARD CORE(Practicals)	8	2	200	8	2	200	8	2	200	8	1	200	32	8	800
2.	SOFT CORE	4	1	100	4	2	200	8	2	200	8	2	200	24	6	600
3.	OPEN ELECTIVE	-	-	-	4*	1	100	4*	1	100	-	-	-	08	2	200
	TOTAL	**24**	**6**	**600**	**28**	**7**	**700**	**28**	**7**	**700**	**24**	**6**	**600**	**104**	**22**	**2600**

III and IV semesters will have two specialization, Viz 1) Solid state Physics
2) Nuclear Physics

***The M.Sc. Physics students have to choose open elective papers from other disciplines**

M.Sc. Physics (Semester I) (CBCS)

COURSE: MATHEMATICAL PHYSICS I (PH HCT 110)

Unit 1 **Differential equations** 14 hrs

Ordinary differential equations: First order homogeneous and non-homogeneous equations with variable coefficients. Second order homogeneous and non-homogeneous equations with constant and variable coefficients.

Partial differential equations: Classification, systems of surfaces and characteristics, examples of hyperbolic, parabola and elliptic equations, method of direct integration, method of separation of variables.

Special functions

Power series method for ordinary differential equations, Legendre's equation, Legendre polynomials and their properties, Bessel function and their properties, Laguerre's equation, its solution and properties.

Unit 2 **Fourier series** 14 hrs

Fourier's theorem. Cosine and sine series. Change of interval. Complex form of Fourier series. Fourier integral. Extension to many variables.

Integral transforms

Fourier transforms: Transform of impulse function. Constant unit step function and periodic function. Some physical applications.

Laplace transforms: Transform of Dirac delta function, periodic function and derivatives. Solution of linear differential equations with constant coefficients Physical applications.

Unit 3 **Matrices** 14 hrs

Orthogonal, Hermitian and unitary matrices; eigenvectors and eginvalues, digitalization of matrices, Matrix representation of linear operators, eigenvalues and eigenvectors of operators, simultaneous eigenvectors and commutativity.

Tensors

Coordinate transformation in linear spaces, definition and type of tensors, contravariant and covariant tensors, symmetric and antisymmetric tensors. Tensor algebra: Equality, addition and substraction, tensor multiplication, outer product; contraction of indices, inner product, quotient theorem, Kronecker delta, metric tensor, Christoffel symbols. Tensors in physics.

Unit 4 **Fortran Programming** 14 hrs

Basic concepts, constants, variables, I/O statement, formatted input and output statements, built-in functions, decision making, branching and looping statements, one and two dimensional arrays, function subprograms, subroutines, simple programming using FORTRAN 77. Programming on numerical methods: least square curve fitting, Simpson's 1/3 rule.

References

1. Mathematical Physics by P K Chattopadhyay, Wiley Eastern Lit., Mumbai
2. Introduction to Mathematical Physics by C Harper, PHI
3. Mathematical Physics by Satya Prakash, S Chand and Sons, New Delhi
4. Matrices and Tensors in Physics by A W Joshi
5. Schaum's Outline Series, Programming with FORTRAN by Seymour Lipschutz and Arture Foe, McGraw-Hill Company, Singapore(1982)
6. Computer Based Numerical Analysis By M.Shanthkumar, Kanna Publishers, New Delhi
7. Programming eith FORTRAN 77 by Dhaliwal, Agarwal, Gupta, New Age Int. Ltd.

M.Sc. Physics (Semester I) (CBCS)

COURSE: QUANTUM MECHANICS I (PH HCT 120)

Unit 1 **Physical basis of Quantum mechanics** 14 hrs

Experimental background, inadequacy of classical physics, summary of principal experiments and inferences, uncertainty and complementarity. Wave packets in space and time and their physical significance.

Schrodinger wave equation

Development of wave equation: One-dimensional and extension to three dimensions inclusive of forces. Interpretation of wave function: Statistical interpretation, normalization, expectation value and Ehrenfest's theorem. Energy eigen functions: separation of wave equation, boundary and continuity conditions.

Unit 2 **Some exactly soluble eigenvalue problems** 14 hrs

One dimensional: Square well and rectangular step potentials, Rectangular barrier, Harmonic oscillator.

Three dimensional: Particle in a box. Particle in a spherically symmetric potential, rigid rotator, Hydrogen atom.

Unit 3 **General formalism of Quantum mechanics** 14 hrs

Hilbert space. Operators-definition and properties, eigen values and eigen vectors of an operator; Hermitian, unitary and projection operatore, commuting operators, Bra and Ket notation for vectors. Representation theory: matrix representation of an operator, change of basis. Co-ordinate and momentum representations.

The basic formalism: The fundamental postulates, expectation values and probabilities; uncertainty principle. Matrix method, solution of linear harmonic oscillator.

Unit 4 **Approximation methods for stationery states** 14 hrs

Time-independent perturbation theory; non-degenerate and degenerate cases, perturbed harmonic oscillator.

The variation method. Application to ground state of Helium. WKB method, application to barrier penetration.

Theory of scattering

Scattering cross-section, wave mechanical picture of scattering, scattering amplitude. Born approximation. Partial wave analysis: phase shifts, scattering amplitude in terms of phase shifts, optical theorem; exactly soluble problem-scattering by square well potential.

References

1. Quantum Mechanics by L. I. Schiff (McGraw-Hill, 1968)
2. Quantum Mechanics by F. Schwabl (Narosa, 1995)
3. A Text Book of Quantum Mechanics by P.M. Mathews and K Venkateshan.
4. Quantum Mechanics by V.K. Thankappan (Wiley Eastern, 1980)
5. Quantum Mechanics by B.K. Agarwal and Hari Prakash.

M.Sc. Physics (Semester I) (CBCS)

COURSE: ATOMIC, MOLECULAR AND OPTICAL PHYSICS (PH HCT 130)

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. 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. Many electron atom: Central field approximation. LS and JJ coupling schemes, multiplet splitting and Lande interval rule.	14 hrs
Unit 2	**Molecular physics A** Brief treatment of chemical bond: Covalent, ionic, Van der Waal's interactions. The Bron-Oppenheimer approximation (qualitative treatment), diatomic molecule as a rigid rotator, rotational spectra of rigid and non-rigid rotator, Intensities of rotational lines. Diatomic molecule in excited vibrational states, microwave spectroscopy-principle and technique. Types of rotors: Eigen values of linear, symmetric top, asymmetric top and spherical top molecules. Raman spectroscopy: Theory of Raman effect, experimental technique, rotational Raman spectra of diatomic and linear polyatomic molecules.	14 hrs
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. Applications of IR spectroscopy for material characterization, comparision of vibration and Raman spectra. Electrical spectra of diatomic molecules: Vibrational coarse structure, Deslandrer table, rotational fine structure in electronic spectra, Fortrat parabola, intensity of vibrational lines in electronic spectra-Frank-Condon principle, dissociation and pre-dissociation, fluorescence and phosphorescence-Jablonski diagram. Selection rules.	14 hrs
Unit 4	**Optical physics** Coherence of light, spatial and temporal coherence, Einstein's coefficients: spontaneous and stimulated emission, idea of light amplification, 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).	14 hrs

References

1. Physics of Atoms and Molecules, Bransden and Joachain, (2^{nd} Edition) Pearson Education, 2004
2. Fundamentals of Molecular Spectroscopy, Banwell and McCash, Tata McGrawHill, 1998
3. Modern Spectroscopy, J.M. Hollas, John Wiley, 1998
4. Molecular Quantum Mechanics, P.W. Atkins and R.S. Friedman, Third Edition, Oxford Press (India Edition), 2004
5. Lasers, silfvast, Cambridge Press, 1998
6. Lasers, Nambiar, New Age International, 2004
7. Optical Electronics, Ghatak and Tyagarajan, Cambridge Press, 2004
8. Laser and Nonlinear Optics, B.B. Laud, Wiley-Eastern Ltd. 1991

M.Sc. Physics (Semester I) (CBCS)
COURSE: ELECTRONICS (PH SCT 140)

Unit 1 **Bipolar junction transistor** 14 hrs

Transistor operation, transistor amplification action and CB, CE, CC configuration. BJT hybrid equivalent circuits and low frequency analysis; small signal analysis for input output impedances, voltage gain, current gain and power gain. Biasing techniques for BJT and design consideration for CE and CC. Concept of feed back criteria for oscillation.

Unit 2 **Analog electronics** 14 hrs

Op-Amp

Ideal characteristics, offset voltage, current, CMMR, Skew rate, negative feedback in Op-amp of feedback on gain and bandwidth. Current amplifier, summing amplifier, difference amplifier, integrator and differentiator.

Active filters

Types and specifications, filter transfer function, first order and second order filter functions, low-pass, high-pass band-pass and band-reject filters, Butterworth filter.

Signal generators

Basic principles. Wien bridge oscillator, phase shift oscillator, triangular wave generator.

Unit 3 **Integrated circuits (ICs)** 14 hrs

Microelectronics technology; integrated circuits package relevant to BJT and MOS

Digital electronics

Boolean operations and expressions, Boolean analysis of logic gates, simplification of Boolean expression. Karnaugh map: two, three and four variable map, product of sums (POS) and sum of products (SOP) simplification.

Digital logic gates

AND, OR, NAND and NOR gates, AND-OR and NAND-NOR implementation of Boolean expressions. Logic gate operation with pulse waveforms.

Combinational logic circuits

Adder, parallel binary adder, subtractor, comparators, decoders, BCD to seven segment decoder, encoders, code conversion, multiplexers, demultiplexers, parity generators and checkers.

Unit 4 **Sequential circuits** 14 hrs

Latches, flip-flops, edge triggered flip-flops, SR, JK, Master-Slave JK, D, T flip-flops, counters, synchronous counters, ripple counters, registers, shift registers.

A/D and D/A conversion circuits

Introduction, filtering and sampling, quantization, quantization error, flash converter and dual slop converter, conversion errors. Binary weighted converter, R-2R ladder converter, characteristic properties.

References

1. Microelectronics, J Millman and Arvin Grabel.
2. Introduction to electronics, K J M. Rao.
3. Integrated electronics, Milmann and Halkias.
2. Electronic Fundamentals and Application, J D Ryder.
3. Basic Electronics, M N Farugui and S L Maskara.
4. Operational Amplifiers and Linear IC's, F Robert Coughlin and F Frederick, PHI Publications (1994).
5. Op-Amps and Linear Integrated Circuits, R Gayakwad, PHI Publications, New Delhi (2000).
6. Digital Principles and Applications, A P Malvino and D Leach, TMH Publications (1991).
7. Digital fundamentals, Thomas L Floyd, 8th edition, Pearson Education (2003).

M.Sc. Physics (Semester I) CBCS
Practical I: ELECTRONICS LAB I (PH HCP 150)

LIST OF EXPERIMENTS:

1. Studies on Cathode Ray Oscilloscope
   DC/AC voltages and frequencies of sine and square signals,
   Unknown frequencies using Lissageous figures.
2. Study of RC/RL/LCR circuits
   Time constants of RC and RL circuits, resonance frequencies and quality factors of LCR series and parallel circuits.
3. Astable multivibrator using transistors
   Frequency studies
4. Full-wave bridge rectifier using diodes
   Design and study the performace of CR, L and π type filters
5. Clipping and clamping circuits
   Design circuits using diodes and resistors and study their performance
6. Operational Amplifier characteristics
   Set up a circuit and study offset voltage and currents, CNRR and slew rate
7. Op-Amp: configurations
   Voltage and current follower, Inverting and non-inverting
8. Op-Amp: Mathematical operations
   Addition, subtraction, integration and differentiation
9. Weinbridge Oscillator using Op-Amp
   Design and study frequency response.
10. Comparator using Op-Amp
    Design simple voltage and regenerative comparators and study performance.
    With the permission of BOS, new experiments may be added to the list whenever they are developed.

Note: Minimum of eight experiments must be carried. Experiments listed under S.NO.1 & 2 are compulsory.

Experiments may be added as and when required.

References

1. Electronic devices and circuits by R.Boylstead and Nashalsky
2. Electronics principles by A.P.Malvino
3. Operational amplifiers and linear IC's by F.Robert Coughlin and Frederick F Driscoll.
4. Any other book suggested by the course teacher

M.Sc. Physics (Semester I) CBCS

PRACTICAL II: GENERAL AND COMPUTATIONAL LAB I (PH HCP 160)

LIST OF EXPERIMENTS:

1. Error Analysis: computations
2. Ultrasonic velocity studies in liquids
3. Verification of Fresnels laws
4. Blackbody radiation-Stefan’s constant determination (electrical method)
5. Excitation and Ionisation potentials
6. Determination of h/e by photocell method
7. Constant Deviation spectrometer
8. Study of Beer’s law
9. Production and measurement of vacuum
10. Verification of Bionomial and Gaussian distributions
    (Do experiment with identical coins for BD and lengths of nails for GD)
11. Solution of quadratic equation : Computer programming
12. Newton’s forward and backward interpolations: Computer programming
13. Linear least square fitting: Computer programming
    (Provide x and y data and ask to write program for determining slope and intercept)
    With the permission of BOS, new experiments may be added to the list whenever they are developed.

Note: Minimum of six experiments and three computations must be carried out.

Experiments may be added as and when required.

References

1. Advanced practical physics by Worsnop anf Flint, 9th Edition
2. Experiments in modern Physics by A.C.Melissons
3. Taylor manual of advanced laboratory experiments in Physics by Ed.T.Brown
4. Optics by A.K.Ghatak
5. Instrumental methods of analysis by HH Willard, LL Merrit, FA Settle, JK Jain
6. Any other book suggested by the course teacher.

M.Sc. Physics (Semester I) (CBCS)

COURSE: ASTROPHYSICS (PH SCT 141)

Unit 1 **Basic concepts** 14 hrs

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, modern telescopes like Gemini, KECT etc.

Unit 2 **Properties of stars** 14 hrs

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, mass luminosity relation, white dwarfs, pulsars, magnetars, neutron stars and black holes, variable stars.

Unit 3 **The solar system** 14 hrs

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 object and Oort cloud, theories of formation of solar system.

Unit 4 **Star clusters, galaxies and the universe** 14 hrs

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 law, Olber's paradox, big bang theory and the origin of the early universe, nucleosynthesis, cosmic microwave background radiation and evolution of the universe.

References

1. Introduction to Stellar Astrophysics, E. Bohm-Vitense, 3rd Volume, CUP, 1989
2. Astrophysics and Stellar Astronomy, T.L. Swihart, Wiley 1968
3. Introduction to Cosmology, J.V. Narlikar, CUP, 1993
4. Priciples of Physical Cosmology, P.J.E. Peebles, Princeton U.P. 1993
5. Galaxies; their Structure and Evolution, R.J. Taylor, CUP, 1993
6. Solar System Astrophysics, J.C. Brandt and Hodge, McGraw-Hill, 1964
7. Introduction to Modern Astrophysics, Ostlie and Carroll, Addison Wesley, 1997
8. An Introduction to Astrophysics Baidyanath Basu, PHI
9. A Text book of Astrophysics and Cosmology, V.B.Bhatia, New Age
10. Stars and Galaxies, K.D. Abhyankar, University Press
11. Pulsar Astronomy, A.G. Lyne and G. Smith, Cambridge Univ.

M.Sc. Physics (Semester II) (CBCS)

COURSE: MATHEMATICAL PHYSICS II (PH HCT 210)

Unit 1	**Complex analysis** Properties of analytic functions, Cauchy's integral theorem, singularities, Cauchy's residue theorem, evaluation of definite integrals. **Vector analysis** Cartesian and curvilinear coordinate systems; Review of vector algebra; Vector differentiation and integration; Line, surface and volume integrations, some examples; Gauss and Stock theorems, some physical applications.	14 hrs
Unit 2	**Group theory** Groups, subgroups, classes. Homomorphism and isomorphism. Group representation. Reducible and irreducible representations. Character of a representation, character tables. Construction of representations. Representations of groups and quantum mechanics. Lie groups. The three dimensional rotation group SO(3). The special unitary groups SU(2) and SU(3). The irreducible representations of SU(2). Representations of SO(3) from those of SU(2). Some applications of group theory in physics.	14 hrs
Unit 3	**Numerical techniques** Numerical methods. Solutions of algebraic and transcendental equations: Bisection, iterative and Newton-Raphson methods. Interpolation: Newton's and Lagrange's methods. Curve fitting: Method of least squares. Differentiation: Newton's formula. Integration: Trapezodal rule, Simpson's 1/3 and 3/8 rules. Eigen values and eigen vectors of a matrix. Solutions of ordinary differential equations: Euler's modified method and Runge-Kutta methods. Numerical computing. Computer programming for above numerical methods using C Language.	14 hrs
Unit 4	**Computational Physics** Programming in C for solution of problems in physics-examples from atomic and molecular physics, nuclear physics, mechanics, electrodynamics, quantum mechanics, solid state physics. **PC based instrumentation** PC interface for instrumentation, Programming for PC-interface-Languages for standard GPIB, Programming GPIB in basics, visual basic. PC based analytical instruments.	14 hrs

References

1. Mathematical Physics by P K Chattopadhyay, Wiley Eastern Ltd., Mumbai.
2. Introduction to Mathematical Physics by C Harper, PHI.
3. Mathematical Physics by Satya Prakash, S Chand and Sons, New Delhi
4. Introductory Methods of Numerical Analyes: S. S. Sastry, PHI, 1995
5. Fundamentals of Computers by V. Rajaraman, PHI
6. Programming in Basic by balagurswamy TMH
7. Programming with C by Venugopal and Prasad, TMH
8. Numerical Methods: E. Balagurswamy (TMH, 2001)
9. Instrumentation measurement analysis, Nakra and Chaudhury

M.Sc. Physics (Semester II) (CBCS)

COURSE: QUANTUM MECHANICS II (PH HCT 220)

Unit 1 **Time-dependent phenomena** 14 hrs

Perturbation theory for time evolution, first and second order transition amplitudes and their physical significance. Application of first order theory: constant perturbation, wide and closely spaced level-Fermi's golden rule, scattering by a potential. Harmonic perturbation: interactions of an atom with electromagnetic radiation, dipole transitions and selection rules; spontaneous and induced emission, Einstein A and B coefficients. Sudden approximation.

Unit 2 **Identical particles and spin**

Indistiguishability of identical paricles. Symmetry of wave function and spin, Bosons and Fermions. Pauli exclusion principle. Siglet and triplet state of He atom and exchange integral spin angular momentum, Pauli matrices.

Angular momentum

Definition, eigenvalues and eigenvectors, matrix representation, orbital angular momentum. Addition of angular momenta, Clebsch-Gordon coefficients for simple cases.–j_1= ½, j_2 =½ and j_1= 1, j_2 = ½.

Symmetry principles

Symmetry and conservation laws, symmetry and degeneracy. Space-time symmetries.

Unit 3 **Relativistic wave equations** 14 hrs

Schrodinger's relativistic equation: free particle, electromagnetic potentials, separation of equations, energy level in a coulomb field.

Dirac's relativistic equation: free particle equation, Dirac matrices, free particle solutions, charge and current densities. Electromagnetic potentials. Dirac's equation for central field: spin angular momentum, approximate reduction, spin orbit energy. Separation of the equation. The Hydrogen atom, classification of energy levels and negative energy states.

Unit 4 **Quantization of wave fields** 14 hrs

Classical and quantum field equations; coordinates of the field, classical Lagrangian equation, functional derivative; Hamilton's equations, quantum equations for the field; Quantization of non-relativistic Schrodinger wave equation: classical Lagrangian and Hamiltonian equations. Second quantization.

References

1. Quantum Mechanics: L. I. Schiff (McGraw-Hill, 1968)
2. Quantum Mechanics: F. Schwabl (Narosa, 1995)
3. A Text Book of Quantum Mechanics: Mathews and K Venkateshan.
4. Quantum Mechanics: V.K. Thankappan (Wiley Eastern, 1980)
5. Quantum Mechanics:B.K.Agarwal and Hariprakash (P-H, 1997)

M.Sc. Physics (Semester II) (CBCS)

COURSE: ELEMENTS OF SOLID STATE PHYSICS (PH SCT 230)

Unit 1 **Crystal structure** 14 hrs

Crystal systems, crystal classes, Bravais lattice. Unit cell: Wigner-Seitz cell. Notations of planes and directions. Atomic packing: packing fraction, Co-ordination number. Examples of simple crystal structures: NaCl, ZnS and diamond. Symmetry operations, point groups and space groups.

X-ray diffraction

X-ray diffraction, Bragg law. Laue equations, Atomic form factor and structure factor. Concept of reciprocal lattice and Ewald's construction. Experimental diffraction methods: Laue rotating crystal method and powder method.

Unit 2 **Crystal binding** 14 hrs

Types of binding. Van der Waals-London interaction, repulsive interaction. Modelung constant. Born's theory for lattice energy in ionic crystals and comparison with experimental results. Ideas of metallic binding, Hydrogen bonded crystals.

Lattice vibrations

Vibrations of monoatomic and diatomic lattices. Optical and acoustical branches, Quantization of lattice vibration-Concept of phonon, phonon momentum. Specific heat of lattice (qualitative).

Unit 3 **Energy bands in solids** 14 hrs

Formation of energy bands. Free electron model: free electron in one and three dimensional potential wells, electrical conductivity, heat capacity, paramagnetism, Fremi-Dirac distribution, density of states, concept of Fermi energy. Kroning-Penny model.

Defects in solids

Point defects: Schottky and Frenkel defects and their equilibrium concentrations. Line defects: Dislocations, multiplication of dislocations (Frank-Read mechanism). Plane defects: grain boundary and stacking faults.

Unit 4 **Semiconductors** 14 hrs

Intrinsic and extrinsic semiconductors: concept of majority and minority carriers. Statistics of electrons and holes, electrical conductivity, Hall effect in both intrinsic and extrinsic semiconductors, Experimental determination of energy gap of a semiconductor

Superconductors

Superconductivity, zero resistance, Meissner effect, critical field, classification into Type I and Type II, thermodynamics of superconducting transition, electrodynamics of superconductors.

References

1. Elementary Solid State Physics: Principles and applications, M. A. Omar, Addison-Wesley.
2. Introduction to Solid State Physics, C. Kittel, Wiley Eastern.
3. Solid State Physics, A. J. Dekkar, Prentice Hall Inc.
4. Semiconductor Physics, P. S. Kireev, MIR Publishers.

M.Sc. Physics (Semester II) (CBCS)

COURSE: ELEMENTS OF NUCLEAR PHYSICS (PH SCT 240)

Unit 1	**Basic properties of nucleus** Nuclear constitution. The notion of nuclear radius and its estimation from Rutherford's scattering experiment; the coulomb potential inside the nucleus and the mirror nuclei. The nomenclature of nuclei and nucleon quantum numbers. Nuclear spin and magnetic dipole moment. Nuclear electric moments and shape of the nucleus. **Nuclear forces** General features of nuclear forces. Bound state of deuteron with square well potential, binding energy and size of deuteron. Deuteron electric and magnetic moments-evidence for non-central nature of nuclear forces. Yukawa's meson theory of nuclear forces.	14 hrs
Unit 2	**Nuclear reactions** Reaction scheme, types of reactions and conservation laws. Reaction kinematics, threshold energy and Q-value of nuclear reaction. Energetics of exoergic and endoergic reactions. **Nuclear models** The shell model; Evidence for magic numbers, energy level, scheme for nuclei with infinite square well potential and the ground state spins. The liquid drop model: Nuclear binding energy, Bethe-Weizsacker's semi empirical mass formula.	14 hrs
Unit 3	**Nuclear decays** Alpha decay: Quantum mechanical barrier penetration, Gammow's theory of alpha, half-life systematics. Beta decay: Continuous beta spectrum, neutrino hypothesis and Fermi's theory of beta decay, beta comparative half-life systematics. Gamma decay: Qualitative consideration of multipole character of gamma radiation and systematics of mean lives for gamma multipole transitions. **Interaction of radiation with matter** Interaction of charged particles with matter, ionization energy loss, stopping power and range energy relations for charged particles. Interaction of gamma rays; photoelectric Compton and pair production processes. Nuclear radiation detectors-G M counter and scintillation detector.	14 hrs
Unit 4	**Nuclear energy** Fission process, fission chain reaction, four factor formula and controlled fission chain reactions, energitics of fission reactions, fission reactor. Fusion process, energitics of fusion reactions; Controlled thermonuclear reactions; Fusion reactor. Stellar nucleo synthesis. **Fundamental interactions and elementary particles** Basic interactions and their characteristic features. Elementary particles, classification; Conservation laws in elementary particle decays. Quark model of elementary particles.	14 hrs

References

1. The Atomic Nucleus: R D Evans (TMH)
2. Nuclear and Particle Physics: W.E. Burcham and M. Jobes (Addison Wesley, 1998, ISE)
3. Nuclear Physics: R R Roy and B P Nigam (Wiley Eastern)
4. Physics of Nuclei and Particles: P Mermier and E Sheldon (Academic Press)
5. Subatomic Physics-Nuclei and Particles: L Valantin
6. Nuclei and Particles: E Serge (Benjamin)
7. Nuclear Physics: D C Tayal (Himalaya)
8. Nuclear Physics: R C Sharma (Khanna)
9. Introduction to Nuclear Physics: S B Patel (Wiley Eastern)
10. Introductory Nuclear Physics: Kenneth S Krane (Wiley)
11. Atomic and Nuclear Physics: S N Ghoshal (S. Chand)

M.Sc. Physics (Semester II) CBCS

PRACTICAL III: Optics lab (PH HCP 260)

LIST OF EXPERIMENTS:

1. Wavelength of Laser light by single slit diffraction method.
2. Wavelength of Laser light by double slit interference method
3. Talbot bands
4. Diffraction halos (Lycopodium powder particle size determination)
5. Wavelength of sodium light using Michelson's Interferometer
6. Ultrasonic Interferometer
7. Constant deviation Spectrometer
8. Study of interference and diffraction by means of He-Ne Laser
9. Fresnel's laws of reflection

Note: Minimum of eight experiments must be carried.
Experiments may be added as and when required.

References

1. Electronic devices and circuits by R.Boylstead and Nashalsky
2. Electronics principles by A.P.Malvino
3. Microelectronics circuits by Adel S.Sedra and Kenneth C Smith
4. Digital principles and applications by A.P.Malvino and D.Leach
5. Any other book suggested by the course teacher

M.Sc. Physics (Semester II) CBCS

PRACTICAL IV: GENERAL AND COMPUTATIONAL LAB II (PH HCP 270)

LIST OF EXPERIMENTS: Combination of Nuclear and solid state experiments

1. Modes of vibration of a fixed bar
2. Material constant of a semiconductor
3. Determination of doublet separation by using Michelson's Interferometer
4. Verification of Hartman's formula
5. Cornu's method for elastic constants
6. Thermionic emission
7. Calibration of thermocouple
8 Refractive Index and thickness of reflecting surface using Laser source
9. Velocity of light by Kerr cell method

10. Study of Zeeman effect: determination of (e/m) of electron
11. Euler's method of interpolation: Computer programming

12. Numerical integration by Simpson's 1/3 and 3/8 rules: Computer programming.
13 Numerical integration by Trapezoidal rule: Computer programming.
14. Least square fit : Computer programming
    (Provide data from the experiments and ask to work out fit coefficients)

Note: Minimum of six experiments and three computations must be carried out.
Experiments may be added as and when required.

References

1. Advanced practical physics by Worsnop anf Flint, 9th Edition
2. Experiments in modern Physics by A.C.Melissons
3. Taylor manual of advanced laboratory experiments in Physics by Ed.T.Brown
4. Optics by A.K.Ghatak
5. Instrumental methods of analysis by HH Willard, LL Merrit, FA Settle, J Jain
6. Any other book suggested by the course teacher.

M.Sc. Physics (Semester II) (CBCS)

COURSE: ATMOSPHERIC AND SPACE SCIENCE (PH SCT 241)

Unit 1 **Physical Meteorology and atmospheric pollution** 14 hrs

Scope of atmospheric science terminology and definitions: weather and climate, composition of the atmosphere: fixed and variable gases, VMR, mechanism of production and destruction of atmospheric constituents, structure of atmosphere, temperature variation in the boundary layer and free atmosphere, Chapman cycle, laws of thermodynamics of the atmosphere: Equation of state for dry air and moist air, virtual temperature. Role of meteorology on atmospheric pollution, atmospheric boundary layer-solar radiation, terrestrial radiation, soil temperature; Air stability, Local wind structure, aerosols.

Unit 2 **Optics of the atmosphere and atmospheric instrumentation systems** 14 hrs

Scattering – role of scattering, elements of radiometry and photometry-geometric considerations, radiometric quantities, response of eye, photometric quantities, Characteristic of scattering – types and nature of scattering processes, scattering in the atmosphere – angular scattering and polarization, total scattering and attenuation, transmittance and optical thickness, ground based instruments for the measurement of temperature – mechanical thermometers, electrical thermometers, wet and dry bulb thermometers, maximum and minimum thermometers; Humidity – relative humidity and absolute humidity, hygrometers; Pressure – barometer, wind – anemometers and rainfall rate – rain gauges.

Unit 3 **Orbital motion and space dynamics** 14 hrs

Coordinate and time systems, elements of orbits in space, motion, elements of reduction of observational data, review of two body problem: Kepler's law of orbital motion, Newton's laws of motion and gravitation, solution to two body problem: Elliptical, parabolic and hyperbolic orbits, orbit in space: f and g series, many body problem: Equations of motion, Lagrange's solutions, Lagrange's planetary equations (qualitative), artificial satellites, types of orbits-geostationary and geosynchronous orbits, sun synchronous orbits and satellites, weightlessness and artificial gravity. Forces acting on artificial satellites, atmospheric drag. Rocket motion: Motion of a rocket in a gravitational field and in atmosphere.

Unit 4 **Remote sensing** 14 hrs

Concepts of remote sensing, electromagnetic spectrum, source of electromagnetic radiation for remote sensing, fundamentals of radiometry and radiometric measurements, energy interaction with earth's surface, signatures of vegetation, soil and water bodies of the earth's surface (general discussion), classification of remote sensors, spectral, spatial and temporal resolution, IR and microwave sensors (qualitative), data reception and products (qualitative), application of remote sensing for earth's resource management (general discussion). Indian remote sensing programme.

References

1. Fundamentals of Atmospheric Modeling: Mark Z Jacobson, Cambridge University, 1999/2000
2. Optics of the Atomosphere: Earl J McCartney, John Wiley and Sons, 1976
3. Radar Meteorology by S Raghavan, Kulwer Academic Publishers, 2003
4. Dynamic Meteorology by Holton, J.R., 3rd edition, Academic Press N.Y. 1992
5. Meteorology for Scientists and Engineers: Roland B. Stull, Brookes/Cole (Thomson Learning), 2000
6. Atomospheric Physics: J.V. Iribrine and H.R. Cho, D. Reidel Publishing Co. 1980
7. The Physics of Atmosphere: John Hougton Cambridge University Press, 1976
8. Orbital Motion: A.E. Roy, Adam Hinglar Ltd. 2002
9. Fundamentals of Remote Sensing: George Joseph, University Press Pvt. Ltd. Hyderabad, 2002
10. Introduction to Remote Sensing: Singh and Sharma, Rawath Publications, New Delhi, 2004.
11. Basic Space Plasma Physics: W. Baumjohann and R.A. Treumann, Imperial College Press, 1997
12. Introduction to Ionosheric Physics: H. Rishberth and O.K. Garriot, Academic Press, 1969
13. Physics of Space Plasma, 2nd Edn.: G.K. Parks, Addison-Wesley, 1991

M.Sc. Physics (Semester II) (CBCS)

COURSE: MODERN PHYSICS (PH OET 250)

Unit 1 **Electronics** 14 hrs

AC, DC, resistance, capacitance, inductance fundamentals and applications. rectifiers, power supply and amplifiers. Microphones and speakers. Mobile communication (qualitative)

Unit 2 **Basic nuclear physics** 14hrs

Nucleus and its constitution, Basics of radioactivity, alpha, beta and gamma particles and their properties.

Astronomy

Solar system, evolution of stars, star birth, white dwarfs, neutron stars and holes. Newton's laws of gravitation, Kepler's laws of planetary motion. Basics of satellite.

Unit 3 **Basics of condensed matter physics** 14 hrs

Crystalline and non-crystalline solids, thin films and nano structures. X-rays production and detection, applications. conductors, semiconductors and superconductors.

Thermodynamics

Thermodynamic system. Laws of thermodynamics, entropy, carnot's cycles, non-reaching of 0 K.

14hrs

Unit 4 **Basics of optics**

Electromagnetic spectrum, reflection, refraction, diffraction, interference and polarization of light. Optical fibers and its structure.

Lasers

Lasers, characteristics of laser, laser applications.

References

1. Electronic Devices and Circuit Theory, R Boylestad and L Nashelsky, VIIIth Edi. (PHI, 2002)
2. Elements of X-ray Diffraction, B D Cullity and S R Stock, IIIrd Edi. (Prentice Hall, 2001)
3. Introduction to Solid State Physics, C Kittel, IVth Edi. (Wiley Eastern, 1974)
4. Thermal Physics, C Kittel and H Kroemer, IInd Edi. (CBS Publ., 1980)
5. Atomic and Nuclear Physics, S N Ghoshal, Vol. I and II (S Chand and Company, 1994).
6. Text book on spherical Astronomy by Smart W.M.
7. Observational Astronomy by Binney Scott D.
8. Optics by A.Ghatak

M.Sc. Physics (Semester II) (CBCS)

COURSE: GENERAL PHYSICS (PH OET 251)

Unit 1 **Mechanics** 14 hrs

Newton's laws of motion and their applications, energy and its conservation, rockets and satellites.

Heat

Definitions of heat and temperature, thermometers, different scales of temperature, specific heat, some common effects of heat.

Unit 2 **Electricity and magnetism** 14 hrs

Electrical charges, Coulomb's law, electrical current, electrical resistance, Ohm's law, magnetic field, electromagnetic induction, Faraday's law, electric generator, motors, transformers, some common applications pf electricity.

Unit 3 **Light** 14hrs

concept of light, reflection, refraction and dispersion of light, refractive index, plane concave and convex mirrors, dispersion by a prism, lenses and their properties, telescopes.

Unit 4 **Atomic and nuclear physics** 14hrs

Atomic size and structure, Bohr's theory of hydrogen atom (qualitative), atomic spectra, nuclear size and contents, binding energy of nuclei, nuclear fission, nuclear fusion, nuclear reactors.

References

1. Blackwood and Kelly, General Physics, John Wiley, 1955
2. T A Ashford, The Physical Sciences, Holt, Rinehart and Winston, 1967
3. Isaac Asimov, Understanding Physics, Bracket Books, 1966
4. Albert J Read, Physics-a descriptive analysis, Addison Wesley
5. J B Marion, Physics and the Physical Universe, John Wiley, 1971
6. George Gamow, Physics, Cleaveland

M.Sc. Physics (Semester III) CBCS

COURSE: CLASSICAL MECHANICS (PH HCT 310)

Unit 1 **Newtonian mechanics** 14 hrs

Single and many particle systems-Conservation laws of linear momentum, angular momentum and energy. Application of Newtonian mechanics: Two-body central force field motion. Kepler's laws of planetary motion. Scattering in a central force field, scattering cross section, The Rutherford scattering problem

Unit 2 **Lagrangian formalism** 14 hrs

Constrains in motion, generalised co-ordinates, virtual work and D'Alembert's principle. Lagrangian equation of motion. Symmetry and cyclic co-ordinates. Hamilton variational principle; Lagrangian equation of motion from variational priniciple. Simple applications.

Unit 3 **Hamiltonian formalism** 14 hrs

Hamilton's equations of motion- from Legendre transformations and the variational Principle. Simple applications. Canonical transformations. Poisson brackets-Canonical equations of motion in Poisson bracket notation. Hamilton-Jocobi equations.

Unit 4 **Relativistic mechanics** 14 hrs

Relativistic mechanics: Four-dimensional formulation- four-vectors, four-velocity and four-acceleration. Lerentz co-variant form of equation of motion.

Continuum mechanics

Basic concepts, equations of continuity and motion; Simple applications.

References

1. Classical Mechanics: H Goldstein, (Addision-Wesley, 1950)
2. Introduction to Classical Mechanics: R G Takwale and P S Puranik (TMH, 1979)
3. Classical Mechanics: N C Rana and P S Joag (Tata McGraw, 1991)
4. Mechanics: Landau L D and Lifshitz E M (Addition-Wesley, 1960)

M.Sc. Physics (Semester III) (CBCS)

COURSE: ELECTRODYNAMICS AND PLASMA PHYSICS (PH HCT 320)

Unit 1 **Electrostatics and Magnetostatics** 14 hrs

Gauss's law and applications, electric potential, Poisson's equations, work, energy in electrostatics, 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, Bio-Savart law and applications, Ampere's law and applications, magnetic vector potential, multipole expansion of the vector potential, magnetic field inside matter.

Unit 2 **Electrodynamics and Electromagnetic waves** 14 hrs

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 wave in rectangular wave guide.

Unit 3 **Electromagnetic Radiation** 14 hrs

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 Larentz transformations, magnetism as a relativistic phenomenon, transformation of eclectic and magnetic fields, the tensor, electrodynamics in tensor notation, potential formulation of relativistic electrodynamics.

Unit 4 **Plasma Physics** 14 hrs

Definition of plasma, Debye shielding, charge particle motion in electric and magnetic fields at right angles, time varying E and B field, adiabatic invariants, dielectric constant of a plasma, the equations of motion of a plasma fluid, drift velocities, plasma oscillations, plasma waves, propagation of electromagnetic waves in plasma.

References

1. Introduction to Electrodynamics, D.J. Griffths, PHI, 3rd Ed.
2. Electromagnetics, B.B. Laud, New Age International PVT. LTD (1987).
3. Electromagnetism, I.S. Grant and W.R. Phillips, John Wiley and Sons Ltd (1975).
4. Plasma Physics, R.A.Cairns, Blackie (1985).
5. Principles of Plasma Physics, N.A.Krall and A.W.Trivelpiece, McGraw Hill (1973).
6. The Theory of Plasma Wave, T.H.Stix, McGraw Hill (1962).
7. Magnetohydrodynamics, T.G.Cowling, Interscience (1957).
8. Basic Space Plasma Physics: W. Baumjohann and R.A. Treumann, Imperial College Press, 1997

M.Sc. Physics (Semester III) (CBCS)

COURSE: SOLID STATE PHYSICS I (PH SCT 330)

Unit 1	**Periodic structures** Reciprocal lattice and its properties. Periodic potential and Bloch theorem, reduction to Brillourin zone, Born-von Karman boundary conditions. Counting of states. **Electron states** Nearly free electron model, discontinuity at zone boundary, energy gap and Bragg reflection. Tight binding model, band width and effective mass in linear lattice and cubic lattices. APW and k.p.methods of band structure calculations.	14 hrs
Unit 2	**Quantization of lattice vibrations** Potential and kinetic energies in terms of generalized coordinates and momenta, Hamiltons equations of motion, quantization of normal modes. **Lattice waves** Lattice dynamics, properties of lattice waves using mono and diatomic lattices, lattice spectrum and Van Hove singularity, diffraction by crystal with and without lattice vibrations, phonons and Debye-Waller factor.	14 hrs
Unit 3	**Thermal properties** Density of states, thermal energy of harmonic oscillator. Lattice heat capacity: Dulong-Petit's classical theory, Einstein and Debye's theories, comparison of theory with experimental results. Anharmonicity and thermal expansion, phonon-phonon interaction. **Elastic properties of solids** Stress and strain tensors, elastic constants and Hooke's law, strain energy, reduction of elastic constants from symmetry, isotropy for cubic crystals, technical moduli and elastic constants. Propagation of long wavelength vibrations. Experimental determination of elastic constants by ultrasonic interference method.	14 hrs
Unit 4	**Fermi surface studies** Extended, reduced and periodic zone schemes. Construction of Fermi surface in square lattice, Harrison construction, slope of band at zone boundary, electron orbits, hole orbits and open orbits. Experimental methods: Electron dynamics in a magnetic field, cyclotron frequency and mass, cyclotron resonance. Quantization of orbits in a magnetic field, Landau quantization, degeneracy of Landau levels, quantization of area of orbits in k-space, de Has-van Alphen effect, extremal orbits.	14 hrs

References

1. Principle of the theory of solids: J.M. Ziman (Cambridge University Press)
2. Introduction to Solid State Physics: C. Kittel (Wiley Eastern)
3. Solid State Physics: A.J. Dekkar (Prentice Hall Inc)
4. Solid State Physics: N.W. Ashcroft and N.D. Mermin (Saunders College Publishing)
5. Elementary Solid State Physics: Principles and applications, M.A. Omar (Addison-Wesley)
6. Physics of Solids: F.C. Brown (Benjamin Inc. Amsterdam)
7. Introduction to Theory of Solid State Physics: J.D. Patterson (Addison-Wesley)

M.Sc. Physics (Semester III) (CBCS)

COURSE: NUCLEAR PHYSICS I (PH SCT 331)

Unit I **General Properties of Nucleus** 14 hrs

Properties of the nucleus: Nuclear size and shapes- estimation of nuclear radii by different methods, charge distribution in nuclei and nucleons by electron scattering experiment, nuclear shapes - nuclear moments - Magnetic dipole moment - molecular beam experiments for determination of nuclear moments.

Electric quadrupole moment: Expression for axial quadrupole moment, moment of spheroidal nucleus, quadrupole moment due to a single nucleon in a state j.

Beta decay: selection rules - classification of beta transitions into allowed and forbidden types - the shape factor – universal Fermi interaction.

Elementary theory of internal conversion and discussion of experimental results.

Unit 2 **Interaction of radiation with matter** 14 hrs

Interaction - stopping power - energy loss characteristics, particle range - energy loss in thin absorbers. Scaling laws. Interaction of fast electrons - specific energy loss. Electron range and transmission curves.

Interaction of gamma rays - interaction mechanisms - photoelectric absorption, Compton scattering and pair-production. Gamma ray attenuation - attenuation coefficients, absorber mass thickness, cross sections.

Interaction of neutrons - general properties - slow down interaction, fast neutron interaction, neutron cross sections. Radiation exposure and dose – dose equivalent.

Unit 3 **Nuclear detectors** 14 hrs

Gas filled counters (qualitative), Scintillation detectors - different types of scintillators - photomultiplier tubes, measurement with scintillation detectors - NaI(Tl), plastic scintillator - Scintillation spectrometer. Spectrum analysis.

Semiconductor detectors - semiconductor properties - physics of semiconductor detectors - diffused junction, surface barrier and ion-implanted detectors. Si(Li), Ge(Li) and HPGe detectors - semiconductor detector spectrometer. Pulse height analysis of spectrum, SSNTD, TLD, Superheated drop detectors.

Unit 4 **Nuclear electronics** 14 hrs

Preamplifier circuits, linear and pulse amplifier, pulse shaping, pulse stretching. Wilkinson type analog to digital converter. Pulse discriminators - coincidence and anticoincidence circuits - memories, single and multichannel analysers – on-line data processing - time to amplitude converter - charge sensitive amplifier. Basic principles of measurement techniques such as collimation, shielding, geometry and calibration.

References

1. Physics of Nuclei and Particles: P Mermier and E Sheldon (Academic Press)
2. Nuclear Physics: R R Roy and B P Nigam (Wiley Eastern)
3. Subatomic Physics-Nuclei and Particles: L Valantin
4. The Structure of Nucleus: M A. Preston and R K Bahaduri
5. Emilio Segre: Nuclei and Particles, II Edn. (Benjamin, 1977)
6. Nuclear and Particle Physics: W.E. Burcham and M. Jobes (Addison Wesley, 1998, ISE)
7. Nuclear Physics: D C Tayal (Himalaya)
8. Atomic and Nuclear Physics: S N Ghoshal (S. Chand)
9. Kenneth S Krane: Introductory Nuclear Physics (John Wiley, 1986)
10. Knoll G F: Radiation Detection and Measurement, II Edn. (John Wiley, 1989)
11. Evans R D: Atomic Nucleus (Tata McGraw Hill, 1972)
12. Delaney: Electronics for Physicists.

M.Sc. Physics (Semester III) (CBCS)

COURSE: SOLID STATE PHYSICS II (PH SCT 340)

Unit 1 **Transport properties of metals** 14 hrs

Boltzman equation, electrical conductivity, calculation of relaxation time. Impurity scattering, ideal resistance. General transport coefficients, thermal conductivity, thermoelectric effects, lattice conduction, phonon drag.

Transport properties of semiconductors

Thermal conductivity. Thermoelectric and magnetic effects. Hot electron and energy relaxation times. High frequency conductivity. Acoustic (deformation and piezoelectric) and optical (polar and non polar) scattering by electrons.

Unit 2 **Dielectric properties** 14 hrs

Macroscopic description of static dielectric constant, electronic, ionic and orientational polarization, Lorentz field, dielectric constant of solids, complex dielectric constant and dielectric losses. Theory of electronic polarization and optical absorption.

Ferroelectricity

General properties, classification, dipole theory and its drawbacks, thermodynamics of ferroelectric transitions, ferroelectric domains.

Unit 3 **Magnetic properties** 14 hrs

Classification, Langevin theory of diamagnetism, quantum theory of paramagnetism.

Ferromagnetism: concept of domains, thermodynamics, thickness of Bloch wall, molecular field concept, Weiss theory, Heisenberg exchange interaction, Ising model, spin waves dispersion relation (one dimensional case), quantization of spin waves, concept of magnons and thermal excitation of magnons, Bloch $T^{3/2}$ law for magnetization.

Antiferromagnetism: Two sublattice model. Ferrimagnetism in the context of iron garnets.

Unit 4 **Superconductivity** 14 hrs

Review of basic properties, classification into type I and type II. Energy gap and its temperature dependence. Super current and critical currents.

London’s phenomenological equations, penetration depth. Cooper pairs, coherence length. Instability of Fermi surface and cooper pairs. BCS theory and comparison with experimental results. Ground state energy of superconductor. Quantization of magnetic flux. Josephson effects (AC and DC) and applications

High T_c materials: Structure and properties, some applications

References

1. Principle of the theory of solids: J.M. Ziman (Cambridge University Press)
2. Introduction to Solid State Physics: C. Kittel (Wiley Eastern)
3. Solid State Physics: A.J. Dekkar (Prentice Hall Inc)
4. The physical principles of solids: A.H. Morish
5. Introduction to Superconductivity: M. Tinkham (McGraw-Hill, International Edition)
6. Semiconductor Physics: P.S. Kireev (MIR Publishers)
7. Solid State Science: K. Seeger (Springer Verlag)

M.Sc. Physics (Semester III) (CBCS)

COURSE: NUCLEAR PHYSICS II (PH SCT 341)

Unit 1	**Nuclear spectroscopy** Experimental determination of beta interaction. The shape of beta spectra. The rest mass of neutrino - neutrino recoil experiment. Inverse beta decay. Double beta decay. **Gamma ray spectroscopy:** Qualitative discussion of multiple radiation, selection rules, determination of gamma decay transition probability for single particle transition in nuclei- Weisskopf's estimates – comparison with experimental values. life time measurements. gamma-gamma, beta-gamma angular correlation studies, decay schemes, angular distribution of gamma rays from oriented nuclei, polarization of gamma rays.	14 hrs
Unit 2	**Nuclear techniques:** Basic principles, instrumentation and application of X-ray fluorescence (XRF), Neutron activation analysis- Principle, Instrumentation and application, Proton induced X-ray emission (PIXE)- Principle, Experimental details and applications, Positron annihilation-Principle, Sources, Experimental details, angular correlation of annihilation radiation and Fermi momentum of conduction electron in metals, Positron lifetime and lattice defects in metals, Ion beam analysis- Rutherford back scattering, Channeling, Nuclear reaction analysis.	14 hrs
Unit 3	**Review of deuteron problem and nuclear forces** Review of ground state properties of deuteron, Deuteron as mixture of S and D states - admixture in the deuteron wave function - magnetic and electric quadrupole moment of deuteron from S and D mixture. Ground state wave function of deuteron. Expression for Pd. **Review of nuclear forces** - charge independence, Symmetry, spin-dependence, tensor character, exchange character. Pseudoscalar meson theory. General survey of non-central forces. Two body potential, three body and many body potentials.	14 hrs
Unit 4	**Nucleon-nucleon scattering** Free n-p and p-p scattering - n-p scattering formalism - partial wave analysis - theory of S wave neutron scattering by free protons - scattering length - spin dependence of n-p scattering. Effective range theory of n-p scattering - significance of sign of scattering length - coherent and incoherent scattering. Coherent scattering from hydrogen molecules and sign of scattering lengths. Cross sections for ortho and para hydrogen - comparison with experiment. The optical theorem. Low energy scattering of protons by protons. Mott's modification of Rutherford formula. Experimental results. Effective range theory for p-p scattering. Analysis of n-p and p-p scattering at low energy. High energy n-p and p-p scattering and experimental results. Photo disintegration of deuteron - dipole approximation cross-section for photo disintegration - photoelectric disintegration cross section and angular distribution studies.	14 hrs

References

1. Roy R R and Nigam B P: Nuclear Physics – Theory and Experiment (Wiley Eastern Ltd., 1993)
2. Emilio Segre: Nuclei and Particles, II Edn. (Benjamin, 1977)
3. Ghoshal S N: Atomic and Nuclear Physics, Vol. II (S Chand & Company, 1994)
4. Singru R M: Experimental Nuclear Physics’ (Wiley Eastern, 1972)
5. Curtis L F, ‘Introduction to Neutron Physics’
6. Wong, `Introduction to Nuclear Physics’ (Prentice Hall, 1997)
7. Ponearu D N and Greiner W (ed) ‘Experimental Techniques in Nuclear Physics’ (Walter de Gruyter Berlin, 1997).
8. Glaston S, ‘Introduction to Thermonuclear Reactions’
9. Kenneth S Krane, ‘Introductory Nuclear Physics’ (John Wiley, 1986)
10. Enge H, ‘Introduction to Nuclear Physics’ (Addison Wesley, 1988)
11. Paul E B, ‘Nuclear and Particle Physics’ (North Holland, 1969)
12. Evans R D, ‘Atomic Nucleus’ (Tata McGraw Hill, 1972)
13. Kapoor S S and Ramamoorthy V S, ‘Radiation Detectors’ (Wiley Eastern, 1986)
14. Burcham W E, ‘Nuclear Physics’, II Edn. (Longman, 1963)
15. Siegbahn Kai, Alpha, Beta & Gamma Spectroscopy’, Vol. I, II (North Holland, 1979)
16. Marmier D and Sheldon E, ‘Nuclear Physics’, Vol. I, II (Academic Press, 1969)

M.Sc. Physics (Semester III) CBCS

PRACTICAL V: SOLID STATE PHYSICS LAB I (PH HCP 350)

LIST OF EXPERIMENTS:

1. Determination of interplanar spacing using X-ray powder pattern
2. Magnetic Susceptibility of liquid by Quinke's method
3. Measurement of resistivity of a semiconductor by four probe method (fixed temperature)
4. Determination of Debye's temperature of Lead or Tin
5. Structure factor determination: Computations
6. Specific heat of metals
7. Ultrasonic velocity in solids
8. Activation energy of point defects in metals: Experiment/Computation
9. Fermi energy of metals: Experiment/Computation
10. Thermal expansion coefficient in solids
11. Thermoelectric power of Ferrites
12. Energy gap of a pn-junction diode/LED
13. Thermistor characteristics

Note: Minimum of eight experiments must be carried.
Experiments may be added as and when required.

References

1. Introduction to Solid State Physics by C.Kittel
2. X.Ray diffraction by B.D.Cullity
3. Physics of Solids by F.C.Brown
4. Interpretation of X-ray powder diffraction pattern by H.P.Lipson and H.Steeple
5. Any book suggested by the course teacher

M.Sc. Physics (Semester III) CBCS
PRACTICAL V: NUCLEAR LAB I (PH HCP 351)

LIST OF EXPERIMENTS:

1. Nuclear counting statistics: Verification of Poisson Distribution
2. GM counter characteristics: Operation voltage determination
3. Determination of dead time of GM counter – single source
4. Verification of inverse square law for nuclear radiation
5. Attenuation of β-rays in aluminium
6. Attenuation of γ-rays
7. Half life of K-40
8. Coincidence circuit
9. Analysis of stopping power and energy loss
10. Nuclear radius calculation
11. Semiempirical mass formula and binding energy analysis
12. Analysis of β-spectrum and half life systematic

    With the permission of BOS, new experiments may be added to the list whenever they are developed.

Note: Minimum of eight experiments must be carried.
Experiments may be added as and when required.

References

1. Experiments in Nuclear Science, ORTEC Applications Note. ORTEC (1971)
2. Practical Nucleaonics by F.J.Pearson and R.r.Dsborne
3. Experimental Nucleaonics by E.Bleuler and G.J.Goldsmith, Rinehart
4. The Atomic Nucleus by R.d.Evans
5. Any other book suggested by the course teacher

M.Sc. Physics (Semester III) CBCS

PRACTICAL VI: SOLID STATE PHYSICS LAB II (PH HCP 360)

LIST OF EXPERIMENTS:

1. Magnetic susceptibility by Gouy's method
2. Temperature variation of resistivity of a semiconductor: four probe method
3. Curie temperature of a ferromagnetic material
4. Hall effect in semiconductors
5. Electron spin resonance: g factor determination
6. Dielectric studies in some solids
7. Ionic conductivity of an alkali halide crystal
8. Temperature variation of conductivity in a glass
9. Study of creep
10. Determination of yield point and yield strength
11. Determination of elastic constants
12. Intensity calculations of X-ray powder pattern

Note: Minimum of eight experiments must be carried.
Experiments may be added as and when required.

References

1. Introduction to Solid State Physics by C.Kittel
2. X.Ray diffraction by B.D.Cullity
3. Physics of Solids by F.C.Brown
4. Interpretation of X-ray powder diffraction pattern by H.P.Lipson and H.Steeple
5. Any book suggested by the course teacher

M.Sc. Physics (Semester III) CBCS

PRACTICAL V: NUCLEAR LAB II (PH HCP 361)

LIST OF EXPERIMENTS:

1. Dead time of GM counter by double source method
2. Nuclear electronics: linear amplifier, single channel analyzer, coincidence ircuits
3. Study of scintillation detector (NaI)
4. Γ-ray spectrum using scintillation detector: multi channel analysis

5. B-ray spectrum using scintillation detector
6. Half life of Indium-116

7. Study of Bremsstrahlung radiation
8. Positron annihilation

9. Study of solar cells

10. Study of solar panels
11. Energy transfer efficiency in liquid scintillators

12. Nuclear models and nuclear structure analysis

Note: Minimum of eight experiments must be carried.

Experiments may be added as and when required.

References

1. Experiments in Nuclear Science, ORTEC Applications Note. ORTEC (1971)
2. Practical Nucleaonics by F.J.Pearson and R.r.Dsborne
3. Experimental Nucleaonics by E.Bleuler and G.J.Goldsmith, Rinehart
4. The Atomic Nucleus by R.d.Evans
5. Any other book suggested by the course teacher

M.Sc. Physics (Semester IV) (CBCS)

COURSE: STATISTICAL MECHANICS (PH HCT 410)

Unit 1 **Basic thermodynamic and statistical concepts** 14 hrs

The laws of thermodynamics and their implications. Thermodynamic potentials, Maxwell's relations and their applications. phase space, ensembles, Ergodic hypothesis and Liouville's theorem. Probability, probability distribution and the most probable distribution. The probability distribution and partition function. Microcanonical, canonical and grand canonical ensembles, thermodynamic potentials and the partition function.

Unit 2 **Classical statistics** 14 hrs

Partition function of a system of particles. The translation partition function, Gibbs paradox and Boltzmann equipartition theorem. Rotational and vibrational partition function. Einstein relation and electronic partition function. Various other partition functions and the corresponding thermodynamic potentials. Maxwell-Boltzmann distribution and its physical applications.

Unit 3 **Quantum statistics** 14 hrs

The symmetry and anti symmetry of the wave functions, Bosons and Fermions, Bose-Einstein and Fermi-Dirac distributions. Ideal Bose and Fermi gases-their properties at high and low temperatures and densities. Bose-Einstein condensation. Blackbody radiation and photons. The phonons and specific heat of solids-Einstein and Debye's theories.

Unit 4 **Fluctuations** 14 hrs

Fluctuations in canonical, grand canonical and microcanonical ensembles. The Brownian motion and Langevin equation. Random walk, diffusion and the Einstein relation for mobility. Fockker-Plank equation. Johnson noise and shot noise.

Irreversible thermodynamics

Onsager reciprocity relations. Thermoelectric phenomena. Non-equilibrium phenomenon in liquid helium-fountain effect. Gibbs entropy for non-equilibrium states. The entropy and information.

References

1. Statistical Mechanics: K Huang (Wiley Eastern)
2. Statistical Mechanics and Properties of matter: E S R Gopal (Macmillan)
3. Elementary Statistical Physics: C Kittel (John Wiley)
4. Fundamentals of Statistical and Thermal Physics: F Reif (McGraw Hill)
6. Thermodynamics of irreversible Processes: S R de Groot
7. Statistical Physics: L D Landau and E M Lifshitz (Pergamon)

M.Sc. Physics (Semester IV) (CBCS)

COURSE: ANALYTICAL TECHNIQUES AND INSTRUMENTATION
(PH HCT 420)

Unit 1 **Spectrophotometry** 14 hrs

Ultra-violet, visible, infrared, raman, fluorescence and atomic absorption spectrophotometry.

Thermal analyses

Differential Thermal Analysis (DTA); Differential Scanning Calorimetry (DSC); Thermo Gravimetric Analyses (TGA).

X-ray spectrometry

X-ray Diffraction (XRD) techniques and associated instrumentation.

Unit 2 **Electron and ion spectroscopy** 14 hrs

Auger Electron Spectroscopy (AES), Scanning Electron Microscopy (SEM); Transmission Electron Microscopy (TEM). Scanning Tunnelling Electron Microscopy (STEM). Ion Spectroscopy, Secondary Ion Mass Spectroscopy (SIMS), Ion Scattering Spectroscopy (ISS).

Unit 3 **Optical techniques** 14 hrs

Refractometry, palarimetry.

Electric and dielectric techniques

Impedance, dielectric constant and dielectric loss measurements using impedance analyzers.

Magnetic resonance spectroscopy

Nuclear Magnetic Resonance (NMR), Electron Paramagnetic Resonance (EPR), Electron Spin Resonance (ESR).

Unit 4 **Nuclear techniques** 14 hrs

Nuclear activation analysis, isotope tracer methods, Mossbauer spectroscopy, neutron diffraction, positron annihilation.

Low temperature techniques

Production and measurement of low temperatures: liquification of gases (H_2, N_2 and O_2), cryostats, refrigerators.

Vacuum techniques

Production and measurement of vacuum.

References

1. Handbook of Analytical Instruments, R.S.Khandpur, Tata McGraw-Hill.
2. Istrumental method of analysis, Willard, Merritt, Dean and Settle, CBS Publishers and Distributors, Delhi.
3. Instruments methods of Chemical analysis, Chatwal and Anand, Himalaya Publishing House.
4. Methods of Experimental Physics Vol. 14 A and B, edited by Dudley.
5. Experimental Spectroscopy by Sawyer.

M.Sc. Physics (Semester IV) (CBCS)

COURSE: SOLID STATE PHYSICS III (PH SCT 430)

Unit 1	**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.	14 hrs
Unit 2	**Optical Properties of Semiconductors:** Interband and intraband absorption, fundamental absorption, absorption edge, exciton absorption, free carrier absorption, impurity involved absorption. Photoconductivity, luminescence. **Low-dimensional semiconductor structures:** Inversion layer, quantum well. Modulation doping, quantum well wire, quantum dot and superlattice. wTwo – dimensional electron gas, energy levels and density of states. **Amorphous Semiconductors:** Classification, band structure, electronic conduction, optical absorption, switching.	14 hrs
Unit 3	**Elastic properties:** Elastic, anelastic and viscoelastic behaviours; Fracture of materials: ductile and brittle fracture, fatigue fracture, fracture toughness, ductile-brittle transition, methods of protection against fracture; Plastic deformation: tensile stress-strain curve, plastic deformation by slip, shear strength of perfect and real crystals, mechanism of creep. **Liquid crystals:** Classification. Structure and texture. Orientational and translational order. Mechanical, optical, magnetic and electrical properties. Liquid crystal displays.	14 hrs
Unit 4	**Properties of Ferrites**: Intrinsic and Extrinsic properties of Ferrites Magnetic Properties under consideration, mixed ferrites for Property Optimization, Temperature Dependence of Initial Permeability, Time Dependence Initial Permeability (Disaccomodation), Chemistry Dependence Low Field Losses (Loss Factor), Chemistry Considerations for Hard Ferrites Saturation Induction Microwave Ferrites and Garnets Ferrites for Memory and Recording Applications. **AC Properties of Ferrites:** Introduction AC Hysteresis Loops Eddy Current Losses Permeability Disaccomodation Core Loss Microwave Properties Microwave Precessional Modes Logic and Switching Properties of Ferrites.	14 hrs

References:

1. Structure Determination from Powder Diffraction Data Ed By W.I.F. David , Shankland, L.B.McCusker and Ch. Baerlocher.
2. Electron beam analysis of materials, M.H.Loretto.
3. Science of Engineering materials, Srivastava and Srinivasan.
4. The Science and Engineering of materials, Askeland.
5. The Physics of Low Dimensional Semiconductors: J. H. Davies. Cambridge University press, (1998).
6. The Physical Principles of Magnetism : A. H. Morrish, John Wiley & sons, New York (1965).
7. Introduction to Magnetic Resonance: A. Carrington and A. D. Mclachlan, Harper & Row, New York, (1967).
8. Elements of Solid State Physics (2nd Ed): J.P. Srivastava, PHI Learning Pvt. Ltd., New Delhi (2009) .
9. Amorphous Semiconductors: D. Adler, CRC, London, (1972).
10. Solid State and Semiconductor Physics : J. P. McKelvey, Harper and Row, New York (1966)

M.Sc. Physics (Semester IV) (CBCS)

COURSE: NUCLEAR PHYSICS III (PH SCT 431)

Unit 1 **Nuclear models** 14 hrs

Fermi gas model: Fermi energy of nucleons, Fermi momentum and level density; nuclear matter. kinetic energy for the ground state-asymmetry energy - nuclear evaporation.

Shell model: Evidances for shell structure, motion in mean potential, energy levels according to harmonic oscillator potential and infinite square well potential - effect of spin-orbit interaction.

Shell model Prediction of ground state spin, parity of odd-A nuclei and odd-odd nuclei - Nordheim's rules, magnetic moments of odd-A nuclei Schmidt limits.and quadrupole moment.

Unit 2 **Nuclear shell model** 14 hrs

Shell model for one nucleon outside the core-configurations for the excited states. Model for two nucleons outside the core. Residual interaction - ^{18}O Spectrum (qualitative) for two particles in $d_{5/2}$ orbit and in $d_{5/2}$ - $s_{1/2}$ orbits.

Collective model: Nuclear deformations and collective motions of nucleons. Vibrational model- Vibrational excitation and vibrational energy levels for even-even nuclei, β and ϒ vibrations for permanently quadropole deformed nuclei, rotational model- Nuclear rotational motion and rotational energy spectra for even-even and odd A nuclei. Nuclear quadrupole moments. Nilsson model - calculation of energy levels - prediction of ground state spin. Nuclear moments.

Unit 3 **Nuclear Reactions I** 14 hrs

Background information for nuclear reaction - reaction mechanisms-comparison of features of compound nucleus model and direct reaction model. Theory of stripping and pickup reaction.

Partial wave approach: partial wave analysis of nuclear reactions-expressions for scattering and reaction cross sections and their interpretations - shadow scattering. Resonance theory of scattering and absorption. Overlapping and isolated resonance. Breit-Wigner formulae. Shape of cross section curve near a resonance.

Unit 4 **Nuclear Reactions II** 14 hrs

Nuclear reaction cross section - its behaviour near threshold - inverse reactions - principle of detail balance.

Optical model - mean free path - optical potential and its parametrisation for elastic scattering. Optical model at low energy, Kapur-Pierls dispersion formula for potential scattering and experimental results.

Transfer reactions - semiclassical description. Plane wave Born approximation (PWBA) - its predictions of angular distributions - modifications - distorted wave Born approximation (DWBA) - spectroscopic factors and their significance.

Heavy ion physics: Special features of heavy ion reactions. Qualitative treatment of remote electromagnetic interaction Coulomb excitations; close encounters, grazing collisions and particle transfer. Direct and head on collision, compound nucleus and quasi molecule formation.

References

1. Segre E, ‘Nuclei and Particles’, II Edn. (Benjamin, 1977)
2. Preston M A and Bhaduri R K, ‘Structure of the Nucleus’ (Addison Wesley, 1975)
3. Ghoshal S N, ‘Atomic and Nuclear Physics’, Vol. I & II (S Chand & Company, 1996)
4. Roy R K and Nigam P P, ‘Nuclear Physics - Theory and Experiment’ (Wiley Eastern Ltd., 1993)
5. Enge H, ‘Introduction to Nuclear Physics’ (Addison Wesley, 1988)
6. Sachler G R, ‘Introduction to Nuclear Reactions’, II Edn. (Macmillan Press, 1990)
7. Marmier D and Sheldon E, ‘Physics of Nuclei and Particle’, Vol. I & II (Academic Press, 1969)
8. Blatt J M and Weisskopf V F, ‘Theoretical Nuclear Physics’ (John Wiley, 1952)
9. Krane K S, ‘Introductory Nuclear Physics’ (John Wiley, 1987)
10. Perkins D H, ‘Introduction to High Energy Physics’, II Edn. (Addison Wesley, 1982)
11. Soodak H and Campbell B C, ‘Elementary Pile Theory’ (John Wiley, 1950)

M.Sc. Physics (Semester IV) (CBCS)

COURSE: SOLID STATE PHYSICS IV (PH SCT 440)

Unit 1	**Transport in Semiconductors:** Electrical conductivity and mobility, their dependence on temperature and scattering mechanisms, energy gap determination. Diffusion, Einstein relation, diffusion equation and diffusion length. **Magnetic Field Effects:** Hall effect, Hall resistance, magnetoresistance (qualitative), cyclotron resonance and effective mass determination. **Optical Properties:** Interband and intraband absorption, fundamental absorption, absorption edge, exciton absorption, free carrier absorption, impurity involved absorption. Photoconductivity, luminescence.	14 hrs
Unit 2	**Semiconductor devices:** introduction, p-n junction, the junction transistors, tunnel diode, MIS Tunnel diode. IMPATT diode. Gunn diode semiconductor lasers, field effect transistor, the semiconductor lamp and other devices, integrated circuits and microelectronics (qualitative), MODFET, quantum Hall effect, heterojunctions, quantum wells and super lattices (qualitative)	14 hrs
Unit 3	**Photovoltaic converters:** Interaction of solar radiations with semiconductors, photovoltaic effect, types of solar cell, equivalent circuit diagram of a solar cell, determination of series resistance (Rs) and shunt resistance (Rsh), ideal properties of semiconductor for use its solar cell, carrier generation and recombination, dark and illuminated characteristics of solar cell, carrier generation and recombination, dark and illuminated characteristics of solar cell, solar cell output parameters: RL, Voc, Isc, Pm, FF, efficiency, performance dependence of a solar cell on band gap energy, diffusion length and carrier life time, Types of heterojunction, construction of energy band diagram of heterojunctions, origin of capacitance in a heterojunction, expression for junction capacitance, Mott-Schottky relation.	14 hrs
Unit 4	**Physics of Nanomaterials**, Different form of nanostructures, idea of 2-d, 1-d and 0-d nanostructures; Hetrostructures Band bending, depletion width and capacitance, inversion layer, 2-d electron gas in triangular well potential, sub band, density of states, surface electron density; exciton, quantum size effect, electron confinement strong and weak limit, spherical well, effect of confinement; **Different methods of preparation of nanomaterials** Top down: UV and electron beam lithography, Ball milling; Bottom up: Atom manipulation by SPM, Dip pen nanolithography, Cluster beam evaporation, Ion beam deposition, chemical bath deposition with capping techniques, Self assembled mono layers. Characterization nano materials by TEM, XRD pattern and light scattering experiments.	14 hrs

References:

1. Charles Kittel, Introduction to Solid State Physics (V edition), Wiley, 1976.
2. A.J. Dekker, Solid State Physics, Prentice Hall, (1957).
3. N.W.Ashcroft and N.D.Mermin, Solid State Physics, Saunders College publishing (1976).
4. J.S. Blakemore, Solid State Physics,(II edition), Cambridge University Press,(1974).
5. Harald bath and Hans Luth ,Solid State Physics, Springer International Student editon, Narosa Publishing House, (1991).
6. M.A. Omar, Elementary Solid State Physics, Addison Wesley, New Delhi,(2000).
7. S.O. Pillai, Solid State Physics, New Age International Publication,(2002).
8. M.A.Wahab, Solid State Physics, Narosa Publishing House, New Delhi,(1999).
9. H.C.Gupta, Solid State Physics, Vikas Publishing House, New Delhi,(2002).
10. J.H. Fendler: Nanoparticles and Nanostructure Films: Preparation,Characterization and Applications 1998 WILEY-VCH Verlag GmbH 15 Dec 2007
11. S. Raimes: Many Electron Theory. Published by North-Holland Pub. Co (1972)
12. O. Madelung: Introduction to Solid State Theory. Springer Series in Solid-State Sciences Softcover reprint of the original 1st ed. 1978.
13. H. Ibach and H. Luth: "Solid State Physics: An Introduction to Theory and experiments: Edition: 4th ed. 2009
14. J.M. Ziman: Principles of the Theory of Solids. Cambridge University Press second edition 1972
15. Puri and Jaganathan, Material science Nova Science Publishers, 2001
16. A.S Edestein,R.C. Cammarata: Nano materials application and synthesis. Edited by *A. S. Edelstein* and *R. C. Cammarata*, Institute of Physics Publishing, Bristol, UK 1996
17. Dieter-Vollath Nano materials an introduction to synthesis properties and applications. 2 ed Wiley.VCH
18. Charles.P.Pole jr, Frank.J.Owens: introduction Nano technology. John Wiley & Sons, 30-May-2003
19. S.M. Lindsay: Introduction to Nano science, Oxford Univ. press, 2009
20. A.K.Bandyopdhyay ,Nano Materials :New age International (P) limited publishers), 2008
21. Juh Tzeng Lue, Encyclopedia of Nanoscience and Tech.; Physical properties of nano materials: Ed: H.S.Nalva, Vol. X, Page:1-46. 2007.
22. Ryan Richards and Helmut Bonnemann, Nanofabrication towards biomedical applications: Synthetic approach to metallic Nanomaterials :Editors: CSSR Kumar, J.Hormes, WILEY:VCH, 2005.

M.Sc. Physics (Semester IV) (CBCS)
COURSE: NUCLEAR PHYSICS IV (PH SCT 441)

Unit 1 **Neutron physics** 14 hrs

Classification of neutrons according to their energy - neutron sources. Ultrafast neutrons, Neutron detectors, Neutron detection from nuclear reactions. BF_3 counters, ^3He counters, fission detectors, activation method for neutron flux measurement. Recoil counters, neutron time of flight technique. Slow neutron detection through nuclear reaction and induced radio activity, slow neutron cross section measurements, neutron monochromators.

Nuclear fusion, basic fusion processes, characteristics of fusion, fusion in stars. Controlled thermonuclear reactions. Hydromagnetic equations. Magnetic pressure, pinch effect, magnetic confinement systems for controlled thermonuclear fusion

Unit 2 **Reactor physics** 14 hrs

Fundamentals of nuclear fission – fission fuels. chain reaction , multiplication factor. Condition for criticality – Breeding phenomena. Different types of reactors , Slowing down of neutrons by elastic collisions - logarithmic decrement in energy - number of collisions for thermalisation.

Elementary theory of diffusion of neutrons - spatial distribution of neutron flux (1) in an infinite slab with a plane source at one end and (2) in an infinite medium with point source at the centre. Reflection of neutrons - Albedo.

Slowing down density - Fermi age equation. Correction for absorption - resonance escape probability. The pile equations - Buckling. Critical size for spherical and rectangular piles.

Condition for chain reaction - the Four-factor formula. Thermal neutron reactor - Fast breeder reactor.

Unit 3 **Particle physics** 14 hrs

Conservation laws and symmetry principles

Fundamental interactions and their basic features. Elementary particles and their classification based on fundamental interactions.
Conservation laws in elementary particle and antiparticles,
symmetry principles; Space-time symmetries, internal and gauge symmetries; Time reversal symmetry

Leptons - neutrinos, muon production and decay - muon capture, spin and magnetic moments of muons.

Pions - the Yukawa interaction, spin of pions - intrinsic parity - isotopic spin of pions. Pion-nucleon scattering and resonance. Nuclear collision, production and photo production of Pions. Rho, Omega and Eta mesons.

Unit 4 **Strange particles and unified model** 14 hrs

Strange particles: associated production – strangeness quantum number; GellMann-Nishijima formula – Kaons and Lambda, Sigma, Xi and Omega hyperons.

The Quark model – quark composition of particles. The eight fold way; meson and baryon multiplets; Gellmann-Okubo mass formula. Broken symmetry. Qualitative discussions on unification of basic interactions

Weak interactions:. the parity and its non-conservation in weak interaction; neutral Kaons. The K° - K° systems. Charge conjugation invariance; isotopic parity; C P invariance; C P violation and its analysis.; C P T invariance and its consequences Standard model, GUTs and proton decay; Super symmetry.

References

1. Goshal S N, `Atomic & Nuclear Physics', Vol. II (S Chand & Company, 1994)
2. Wong, `Introduction to Nuclear Physics' (Prentice Hall, 1997)
3. Marmier D and Sheldon E, 'Physics of Nuclei and Particles', Vol. I, II (Academic Press, 1969)
4. Zweifel P F, 'Reactor Physics', International student Edn. (McGraw Hill, 1973)
5. Emilio Segre, 'Nuclei and Particles', II Edn. (Benjamin, 1977)
6. Kenneth S Krane, 'Introductory Nuclear Physics' (John Wiley, 1986)
7. Glasstone S and Sesonske A, 'Nuclear Reactor Engineering' (CBS, Delhi, 1986)
8. Little field T A and Thorley N 'Atomic and Nuclear Physics', II Edn. (Nostrand Co., 1988)

M.Sc. Physics (Semester IV) (CBCS)

COURSE: PROJECT

1. Project work must be carried out at the rate of 8 hours per week under the guidance of a course teacher. Through project work, students are expected to acquire some skills in research (theory or experiment). At the end of the study every student shall have to submit a written project report which would be assessed for 200 marks (Internal assessment for 50 marks plus project report for 100 marks plus viva-voce examination for 50 marks).

   Both project report and viva-voce examinations must be assessed by two examiners drawn from the panel of examiners prepared by the BOS.