Semester I

Course PHCT 1.1: Mathematical Methods in Physical Sciences

Teaching hours per week: 4
No. of credits: 4

Unit I

Special functions: Beta and gamma functions. Solution of differential equation using power series-Frobenius method.

Legendre functions: Legendre polynomials, Rodrigue's formula; generating function and recursion relations; Orthogonality and normalization; associated Legendre function, special harmonics.

Bessel functions: Bessel functions of the first kind, recursion relations and orthogonality.

Hermite functions: Hermite polynomials, generating function, recursion relations; Orthogonality.

Laguerre functions: Laguerre and associated Lauguerre polynomials, recursion relations; Orthogonality.

Applications of special functions to problems in physics.

12 Hours

Unit II

Matrices: Orthogonal, Hermitian, and unitary matrices; eigenvectors and eigenvalues, diagonalization of matrices, Matrix representation of linear operators, eigenvalues and eigenvectors of operators, simultaneous eigen vectors and commutativity, applications to physical problems

Tensors: Types of tensors, contravariant and covariant tensors, symmetric and antisymmetric tensors, Tensor algebra : equality, addition and subtraction, tensor multiplication, outer product; contraction of indices, inner product, quotient theorem, Kronecker delta, metric tensor, Christoffel symbols. Tensors in physics. Problems.

12 Hours

Unit III

Group Theory: Groups, subgroups and classes; homomorphism and isomorphism, group representation, reducible and irreducible representation, Schur's Lemmas, orthogonlity theorem, character of a representation, character tables, decomposing a reducible representation into irreducible representations, construction of representations, lie groups, rotation groups SO(2) and SO(3). Problems

12 Hours

Unit IV (Newly Added)

Monte Carlo methods: Introduction, definitions, Illustration of the use of Monte Carlo Methods, Examples on Particles in a Box and Radioactive Decay, Probability Distribution Functions, Multivariable Expectation Values, The Central Limit Theorem, Definition of Correlation Functions and Standard Deviation, Random Numbers and properties, Improved Monte Carlo Integration, Change of Variables, Importance of Sampling, Acceptance Rejection Method, Monte Carlo Integration of Multidimensional Integrals, Brute Force Integration, Importance of Sampling, Classes for Random Number Generators. Metropolis algorithm and detailed balance, Ising model. Examples and problems.

12 Hours

Text Books

1. Mathematical Methods for Physicists (4th edition): George Arfken& Hans J. Weber, Academic Press, San Diego (1995).
2. Mathematical Methods in Physical Sciences (2nd edition): Mary L. Boas, John Wiley & Sons, New York (1983).
3. Mathematical Physics: P. K. Chatopadhyay, Wiley Eastern Ltd., New Delhi (1990).
4. Introduction to Mathematical Physics: Charlie Harper, Prentice Hall of India Pvt. Ltd., New Delhi (1995).
5. Matrices and Tensors in Physics (3rd edition): A.W. Joshi, New Age International (P) Ltd. Publishers, New Delhi (2000).
6. Elements of Group Theory for Phyicists(3rd Edition): A.W.Joshi.,Wiley Eastern limited (1982).
7. Monte Carlo Methods, , 2nd Edition, M.H. Kalos, P.A. Whitlock, Wiley VCH

Reference Books

1. Mathematical Methods for Physics and Engineering: K. F. Riley, M. P. Hobson and S. J. Bence, Cambridge Univ. Press Cambridge (1998).
2. Advanced Mathematics in Physics and Engineering : Arthur Bronwell, Mc Graw Hill Book Company, New York (1953).
3. Group theory and its Applications to Physical Problems: M.Hammermesh, Addision Wesley, Mass (1962).
4. Schaum's Outline Series: Programming with FORTRAN : Seymour Lipschutz& Arthur Poe, McGraw Hill company, Singapore (1982).
5. Schaum's Outline Series: Vector Analysis and Introduction to Tensor Analysis: M.R. Speigel, McGraw Hill Company, Singapore (1983).
6. Mathematical Physics A. K. Ghatak, I. C. Gayal and S. J. Chua, Trinity Publications, 2017.
7. Computational Physics. J. M. Thijssen , Cambridge - 2007.
8. Understanding Molecular simulations , D. Frenkel and B. Smith, Academic press, 2002.

9. Steven E Koonin and D C Meredith, Computational Physics [fortran version], Perseus Books.
10. Numerical Recipes, Cambridge Univ. Press.

Course PHCT 1.2: Classical Mechanics

Teaching hours per week: 4
No. of Credits: 4

Unit I

Lagrangian Mechanics: Generalized coordinates, constraints, Lagrange equation,. Hamilton's principle, Derivation of Lagrange's equation from Hamilton's Principle. Symmetry and conservation laws: momentum conservation, cyclic co ordinates, angular momentum conservation and conservation of energy.

Motion in central force field: Equivalent one body problem, motion in central force field, Equation of orbit. Elliptic orbits, hyperbolic orbits and parabolic orbits. Elastic scattering in central force field, Rutherford scattering. Problems

12 hours

Unit II

Motion of Rigid body: Fixed and moving co ordinate systems. Coriolis force, Coriolis force acting on falling body Euler theorem. Euler angle, angular momentum and kinetic energy of a rigid body. Inertia tensor, Euler's equations of motion. Torque free motion. Motion of symmetric top – Nutational motion, Problems.

12 hours

Unit III

Hamiltonian Mechanics and Brackets: Legendre transformation and Hamilton equations of motion: conservation theorem and physical significance of Hamiltonian. Derivation of Hamilton's equation from a variation principle: principle of least action.

Lagrange and Poisson brackets, Equation of motion in Poisson bracket notation.

Hamilton Jacobi Theory: Hamilton Jacobi equation of motion for Hamilton's principle and characteristic functions, Harmonic oscillator problem as example of Hamilton Jacobi method. Problems

12 hours

Unit IV (Newly Added)

Rocket Dynamics: Introduction equation of motion for variable mass – performance of single stagerocket; exhaust velocity, structure factor and mass ratio. Exhaust speed parameter, effect of gravity; expression for height attained by single stage rocket, performance of single stage rocket optimization of multi stage rocket Launch site selection problems

12 hours

Text Books

1. Classical Mechanics: H.Goldstein, Narosa Publishing Pvt. Ltd. (1998).
2. Introduction to Classical Mechanics: R. G. Takwale& P. S. Puranik. Tata McGraw Hill, New Delhi (1997).

Reference Books

1. Classical Mechanics: H.Goldstein, C.Poole & J.Safko. Third Edition. Pearson Education Asia (2002).
2. Classical Mechanics: N. C. Rana and P. S. Joag, Tata McGraw Hill, New Delhi (1991).
3. Classical Dynamics of Particles and Systems: J. B. Marion, Academic Press (1964).
4. Classical Mechanics of Particles and Rigid Bodies: Kiran. C. Gupta, New Age International (1998).
5. Classical Mechanics: Dr. J. C. Upadhyaya, Himalaya Publishing House, Revised Edition (2009.
6. Classical mechanics: K. Sankara Rao, P. H. E Learning Private Limited (2008)

Course PHCT1.3: Electronics (General)

Teaching hours per week: 04
No. of credits: 04

Unit I

Operational amplifier: Introduction to Op Amp, Basic op amp circuit, 741 IC Op-Amp, open loop op-amp configurations – inverting, non inverting and differential amplifiers, feedback configurations, voltage follower, non inverting amplifier, Inverting amplifier, Op-Amp parameters Input output voltages, common mode rejection ratio, slew rate and frequency limitations. Summing, difference, scaling and averaging amplifier. DC and AC Voltmeter, instrumentation amplifier, Integrator and differentiator, Differentiator and Integrator design and performance, Precision half wave and full wave rectifier, Clipper and Clamping circuits, Peak detector, Sample and hold Circuit.

12 hours

Unit II

Op-amp applications and specialized ICs: Active filters – types, All pass phase shifting circuits, first and second order active low and high pass filter. Band pass filter, band stop filter.

Oscillators – basic principles, phase shift oscillator, Wein bridge oscillator, triangular and rectangular wave generator. Comparators and converters – basic comparator, zero crossing detector, Inverting and non inverting Schmitt trigger, Astable and monostable multivibrator. Precision voltage regulator (fixed and adjustable). IC 565 Phase locked loop, characteristics, Frequency multiplier, AM and FM demodulator.

12 hours

Unit III

Optical fiber communications: Introduction, optical fiber wave guide, ray theory transmission total internal reflection, acceptance angle, numerical aperture, skew rays, Electromagnetic mode theory, Modes in planar guide, Phase and group velocity, Types of fibers, step index fiber, graded index fiber, single mode fiber, mode field diameter and spot size, effective refractive index, photonic bandgap fibers. Intrinsic and extrinsic absorption losses, Rayleigh scattering, fiber bend loss, material dispersion and scattering effects. Preparation of optical fibers, liquid phase (melting) techniques, Plasma activated chemical vapor deposition. Structure and characteristics of multimode step index fibers, graded index fibers, single mode fibers and plastic clad fibers, optical fiber connectors, fiber alignment and joint loss, fiber splices. Light sources for OFC, LED and laser diodes, detectors p-n, p-i-n and avalanche photodiodes.

12 hours

Unit IV

Digital Electronics: Boolean operations and expressions, Boolean analysis of logic gates, simplification of Boolean expression. Karnaugh map: two, three and four variable map.

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, parity generators and checkers, comparators, decoders, BCD to seven segment decoder, encoders, code conversion, multiplexers, demultiplexers.

Sequential circuits: Latches, flip flops, SR, D, JK, Master Slave JK,T flip flops, counters, synchronous and asynchronous counters, ripple counters, mod n counters, mod 3, mod 5 and mod 10 counters, registers, shift registers, timing sequences, memory units, random access memory (RAM).

12 hours

Text books

1. Operational Amplifier and Linear IC's: Robert F. Coughlin and Frederick F. Driscoll, PHI publications (1994).
2. Op Amps and linear Integrated Circuits: R. Gayakwad, PHI publications, New Delhi (2000).

3. Digital Principles and Applications: A.P. Malvino and D. Leach, TMH Publications (1991).
4. Digital fundamentals – 10th Edition: Thomas L Floyd, Pearson Education (2003).
5. Optical Fiber Communication Principles & Practice, John M. Senior, Prentice Hall International Ltd, London (1992).

Reference Books

1. Microelectronics Circuits: Adel S. Sedra and Kenneth C. Smith, Oxford University Press (1991).
2. Digital Computer fundamentals, Thomas C. Bartee, McGraw Hill Ltd. (1977).
3. Digital Logic and Computer Design: Morris Mano. Prentice Hall of India Pvt.Ltd New Delhi (2000).
4. Logic Circuit Design: Alan W. Shaw, Sanders College Publication Company (1999).

Course PHCT 1.4 Condensed Matter Physics

Teaching hours per week: 4
No. of credits: 4

Unit I

Crystal structure: Lattice translational vectors and lattices, basis and crystal structure, primitive and non primitive cells, fundamental types of lattices, Miller indices. Symmetry elements, point groups and space groups. Examples of simple crystal structures.

Crystal diffraction and reciprocal lattice: Bragg law, reciprocal lattice vectors, diffraction conditions, Laue equations, Brillouin zones. Atomic form factor, structure factor and its calculations in simple cases. Experimental methods of X-ray diffraction, details of powder X ray diffraction of crystal structure determination. (Newly Added)

12 Hours

Unit II

Crystal binding: Crystals of inert gases: Van der Waals London interaction, repulsive interaction, cohesive energy, compressibility and bulk modulus.

Ionic Crystals: Madelung energy, Born Mayer Model, evaluation of Madelung constant for an infinite line of ions. The nature of binding in covalent, metal and hydrogen bonded crystals.

Lattice vibrations and thermal properties: Elastic waves, density of states of a continuous medium, Theories of specific heat: Classical, Einstein and Debye models. Vibration of one dimensional monatomic and diatomic lattices, properties of lattice waves, phonons. Lattice thermal conductivity.

12 Hours

Unit III

Free electron model of metals: Free electron gas and formulation of free electron theory of metals, electrical conductivity and origin of collision time, electrical conductivity versus temperature, Mattheissen's rule. Heat capacity of free electrons, Fermi Dirac distribution, the concept of Fermi surface, the effect of Fermi surface on electrical conductivity. Thermal conductivity: Wiedemann Franz law.

Energy bands in solids: Origin and magnitude of energy gap. Bloch functions. Kronig Penney model (qualitative). Number of states in a band. Distinction between metals, insulators and semiconductors. Velocity of the Bloch electron, electron dynamics in an electric field, concept of hole, dynamic effective mass of electrons and holes.

12 Hours

Unit IV

Semiconductors: Intrinsic and extrinsic semiconductors. Intrinsic and extrinsic carrier concentrations, position of Fermi level, electrical conductivity and mobility and their temperature dependence. Hall effect in semiconductor.

Superconductivity: Experimental survey, qualitative ideas about BCS theory, high temperature superconductors and their applications.

Magnetic properties: Classification of magnetic materials, quantum theory of paramagnetism Curie law; Weiss' molecular field theory of ferromagnetism, Curie – Weiss law.

Defects in solids: Types of imperfections, Schottky and Frenkel defects and their concentrations.

12 Hours

Text Books

1. Introduction to Solid State Physics: C.Kittel. Wiley Eastern Ltd., Bangalore (1976).
2. Elementary Solid State Physics: M.A. Omar.Addison Wesley Pvt.,Ltd.,New Delhi (1993).
3. Solid State Physics: A.J. Dekker, Macmillan India Ltd., Bangalore, (2000).
4. Solid State Physics: F.W.Ashcroft & N.D. Mermin. Saunders College Publishing, New York (1976).

Reference Books

1. Introduction to Solids: L.V. Azaroff. McGraw Hill inc, New york (1960).
2. Solid State and Semiconductor Physics: J.P.McKelvey. Harper and Row, Newyork (1966).
3. Elements of Solid State Physics (2nd Ed): J.P. Srivastava, PHI Learning Pvt. Ltd., New Delhi (2009).

Course PHCP 1.5: Practical I: Electronics and Condensed Matter Physics

Contact hours per week: 4
Number of credits: 4

1. Op-Amp 741 as an adder, subtractor, differentiator and integrator.
2. Wien bridge oscillator using Op-Amp 741.
3. Triangular wave generator using op-amp 741.
4. Low pass, high –pass and band pass active filters using Op Amp 741.
5. Simplification of Boolean expressions and implementation using 2 input NAND gate IC7400.
6. Fortran Programming using Fortran 77.
7. Analysis of X ray diffraction pattern.
8. Thermister characteristics
9. Determination of energy gap of semiconductor by resistivity measurement (4 probe method).
10. Developing of X ray pattern for a given substance using x ray diffractometer and determination interplanar spacing.
11. Structure factor calculation of simple crystal structures.

(New experiments may be added)

References

1. Microelectronics Circuits: Adel S. Sedra and Kenneth C.Smith, Oxford University Press (1991).
2. Electronic devices and circuits: R.Boylstead and Nashalsky: PHI publications (1999).
3. Electronics Principles: A.P. Malvino, TMH Publications (1984).
4. Operational Amplifier and Linear IC's: Robert F. Coughlin and Frederick F. Driscoll, PHI publications (1994).
5. Op-Amps and Linear Integrated Circuits: R. Gayakwad, PHI publications, New Delhi (2000).
6. Elementary Solid State Physics: M.A.Omar, Addison Wisley Pub.Ltd. New Delhi (1993).
7. X ray Diffraction: B.D. Cullity, Addison Wisley Ltd. New York (1972).
8. Introduction to Solid State Physics: C. Kittel, Wiley Eastern Ltd. Bangalore (1976).
9. Laboratory Manuals

Course PHCP 1.6: Practical II: Atomic & Molecular Physics and Nuclear & Particle Physics (General)

Contact hours per week: 4
Number of credits: 4

1. Study of Interference and Diffraction by means of He-Ne laser.
2. Determination of ionization potentials in atoms by the Franck-Hertz experiment.
3. Study of Zeeman Effect: Determination of e/m for an electron.
4. Study of dispersion of a Grating Spectrograph.

5. Spectroscopy Assignments in Computer Lab.
6. Study of the performance of G.M. Counter and Proportional counter.
7. Study of the performance of Scintillation detector and scintillation spectrometers.
8. Study of the random nature of radioactive decay.
9. Study of the absorption of beta particles.

(New experiments may be added)

References

1. Advanced Practical physics: (9th Edition) B.C.Worsnop & H.T. Flint Methuen & Co. Ltd. London (1951).
2. Instrumental Methods of Analysis : (6th Edition) H.H. Willard, L.L.Merrit, J.A. Dean & F.A. Settle, J.K. Jain for CBS Publishers (1986).
3. Optics (2nd Edition) A.K. Gathak Tata Mc Graw Hill Pub. Comp.Ltd New Delhi (1977).
4. Experimental Spectroscopy (3rd ed): Ralph A.Sawyer, Dover Pub, N.Y. (1950).
5. Lab Manuals/Books/Charts.
6. Experiments in Modern Physics: A.C. Melissions academic press (NY)(1966).
7. Experiments in Nuclear Science, ORTEC Applications Note. ORTEC,(1971) (Available in Nuclear Physics Laboratory).
8. Practical Nucleonics: F.J.Pearson., and R.R. Dsborne, E7 F.N. Spon Ltd(1960).
9. The Atomic Nucleus: R.D. Evans, Tata McGraw Hill Pub.comp.Ltd(1960).
10. Nuclear Radiation Detectors: S.S.Kapoor and V.S. Ramamurthy, Wiley Eastern Limited (1986).
11. Experimental Nucleonics: E. Bleuler and G.J. Goldsmith, Rinehart & Co. Inc. (NY). (1958).

Semester – II

Course PHCT 2.1: Quantum Mechanics – I

Teaching hours per week: 4
No. of Credits: 4

Unit I

Basic Principles: Hermitian operators, observables; Eigenfunctions, eigenvalues and orthonormalization of eigenfunctions, completeness. State functions as probability amplitude and the principle of superposition. Momentum, Hamiltonian and energy operators, Schrodinger equation. Probability density and probability current density, expectation value, Ehrenfest's theorem; basic postulates of quantum mechanics.

Simple Applications: Eigenvalues and eigenfunctions of free particle, particle in infinite square well and of simple harmonic oscillator by polynomial method, barrier transmission: leakage of free particle through a thick rectangular potential barrier and transmission and reflection coefficients.

12 hours

Unit II

Hydrogen atom: Particle in spherically symmetric potential, Reduction of two body problem to a single particle problem. Center of mass and relative motions; eigenvalues and eigenfunctions. Hydrogen like atom, eigenvalues of energy and eigenfunctions.

Angular momentum: The expression for the three Cartesian components and the square of the angular momentum, their commutation relations, expression for the operators in polar coordinates, eigenvalues and eigenfunctions in terms of polar coordinates; eigenvalues and eigenfunctions of the square and z component of angular momentum.

12 hours

Unit III

Time Independent Perturbation Theory: Eigenvalue of energy and eigenfunction in the first order approximation (the case of a system with non degenerate energy levels). Application to anharmonic oscillator and to the ground state of Helium atom.

Time Dependent Perturbation Theory: Concept of the theory, transition from one discrete level to the other, to a continuum states: Fermi's Golden rule. The harmonic perturbation, resonance transitions. Semi classical theory of Einstein's A & B coefficients. Interaction of radiations with a system of atoms, transition dipole moment, selection rules.

12 hours

Unit IV

Elastic Scattering: Differential and total cross section, phase analysis. Significance of the partial waves and phase shifts, S wave scattering from a square well potential. The Born approximation, derivation of the expression for differential scattering cross section, condition for validity of the approximation: application to square well potential and screened coulomb potential.

12 hours

Text Books

1. Quantum Mechanics – Theory & Applications (3rd Ed): A.K. Ghatak & S. Loknathan, MacMillan India Ltd. 91984).
2. A Text of Quantum Mechanics: P.M. Mathews &K. Venkatesan, Tata McGraw Hill, New Delhi (1982).
3. Quantum Mechanics (2nd ed): G. Aruldhas, Prentice Hall India Pvt.Ltd.,New Delhi (2009).
4. Quantum Physics (3rd ed): S. Gasiorowicz, Wiley India (P) Ltd., New Delhi (2007).

Reference Books

1. Introduction to Quantum Mechanics: L. Pauling & E. Bright Wilson, McGraw Hill, N.Y.(1935).
2. Quantum Mechanics(3rd ed): L.I. Schiff, McGraw Hill, N.Y.(1968).
3. Quantum Mechanics: E. Merzbacher, 2nd ed., Wiley, N.Y.(1970).
4. Quantum Mechanics (2nd Ed): V.K. Thankappan, new Age International (P) Ltd.(1993).

Course PHCT 2.2: Atomic & Molecular Physics (General) (Modified or Improved)

Teaching hours per week: 4
Number of credits: 4

Unit I

Atomic spectra and structure: Overview of the salient features of optical spectra due to alkalis, Boron group and IIA and IIB group of elements (as in Periodic Table). Spin orbit interaction due to single valence electron atoms and its doublet spectra. Vector model for two valence electron atoms: Determination of spectral terms (singlets, doublets, triplets, etc); derivation of interaction energies in LS and jj couplingschemes; the Lande interval rule; singlet and triplet splitting. Normal and anomalous Zeeman Effect of singlets and doublet states(qualitative). Stark effect in hydrogen (qualitative).

12 Hours

Unit II

Laser Physics: Laser principles: Einstein coefficients, optical pumping, population inversion, the threshold condition– the Schawlow Townes condition for laser oscillations. Three level and four level laser systems. The Ruby laser and He Ne Laser: energy level diagrams, excitation mechanism, construction and working. Shape and width of spectral lines: mechanisms; Natural, Doppler, Collision/pressure and Stark broadenings. Laser cooling: basic concepts, trapping techniques of neutral atoms, the Bose Einstein condensation. Atom lasers: basic ideas with illustrations.

12 Hours

Unit III

Diatomic rotational spectra and structure: General features of observed spectra of typical diatomic molecules in Far IR(microwave) and due to Raman scattering; empirical series for the observed wave numbers in both IR and Raman spectra. Diatomic molecule as rigid and non rigid rotator models: energy levels, eigenfunctions, selection rules, IR spectra and correlation with empirical series and illustrations. Raman scattering and spectra due to the rigid and non rigid rotator: energy levels, eigenfuntions, selection rules, spectra and correlation with empirical series and illustrations.

12 Hours

Unit IV

Diatomic vibrational spectra and structure: General features of observed spectra of typical diatomic molecules in Near IR and due to Raman scattering; empirical series for the observed wave numbers in both IR and Raman spectra. Diatomic molecule as Harmonic and Anharmonic oscillator models: energy levels, eigenfunctions, selection rules, IR spectra and correlation with empirical series and illustrations. Raman scattering and spectra due to Harmonic and Anharmonic oscillator models: energy levels, eigenfuntions, selection rules, spectra and correlation with empirical series and illustrations. The vibrating rotator model: energy levels, selection rules, IR and Raman spectra, IR fine structure spectrum of a rotation vibration band and correlation with empirical series.

12 Hours

Text Books

1. Introduction to Atomic Spectra : H.E. White, McGraw – Hill, Tokyo (1934)[Free soft copy available on Net].
2. Atomic Spectra: H.G.Kuhn, Longmans, Green & Co.Ltd, London & Harlow (1962) [Free soft copy available on Net].
3. Molecular Spectra & Molecular Structure(Vol I; 2nd ed): G.Herzberg, D. Van Nostrand Inc. N.Y. (1950) [Free soft copy available on Net].
4. Spectroscopy (Vol. 3):S. Walker & B. P. Strauhghan, Chapman & Hall, London (1976)
5. Fundamentals of Molecular Spectroscopy : C. N. Banwell and E.M. McCash, Tata Mc Graw-Hill Co., (4th revd Ed; 9th reprint, 2000)
6. Lasers and Non-Linear Optics : B. B. Laud, Wiley Eastern Ltd., New Delhi (1991).
7. Laser Fundamentals: William T. Silfvast, Cambridge Univ Press, 1999.

Reference Books

1. Fundamentals of Spectroscopy (2nd ed): B. Narayan, Allied Publishers Ltd., New Delhi (1999).
2. Physics of Atoms and Molecules – 2nd Ed., Bransden B.H. and Joachain C.J., Pearson Education, India (2006).
3. Modern Spectroscopy (4th Ed): J.M. Hollas, John Wiley & Sons Ltd. UK 2004[Free soft copy available on Net]
4. Laser Electronics: Joseph T. Verdeyen, Prentice-Hall of India Pvt. Ltd. New Delhi (1989).
5. Lasers: Theory & Applications: K. Thyagarajan & A. Ghatak, MacMillan India, New Delhi (1981).

Course PHCT 2.3: Nuclear & Particle Physics (General)

Teaching hours per week: 4
Number of credits: 4

Unit I

Basic Properties: Binding Energy and separation energy. Radius of nucleus by scattering of high energy neutrons, by X rays from muonoic atom and by high energy electron scattering method.

Nuclear spin and magnetic moment: Spin and magnetic moment of odd A nucleus. Experimental determination of magnetic moment by Rabi's atomic beam method.

Nuclear quadrupole moment: Electric quadrupole moment of nucleus (Prolate and Oblate) qualitative

Nuclear models: Liquid drop model, stability against beta decay, stability against spontaneous fission, Fermi gas model, Fermi energy and kinetic energy, nuclear shell model and magic numbers.

12 Hours

Unit II

Alpha decay: Gamow's theory of alpha decay, quantum mechanical tunneling, relation between mean life and decay energy. Hindrance factor.

Beta decay: Energetics of beta decay, continuous beta ray spectrum, neutrino hypothesis, Fermi's theory of beta decay (derivation), Fermi Kurie plot, non conservation of parity in beta decay

Gamma decay: Gamma transitions in nuclei and classifications. Internal conversion(qualitative)

Detectors: Gas filled detector, proportional counter, NaI(Tl) scintillation gamma ray spectrometer, semiconductor detector for detection of X ray and gamma radiation.

12 Hours

Unit III

Nuclear Reaction: Types of nuclear reactions. conservation laws, laboratory and center of mass systems. Q value of a nuclear reaction and relation between Q value and energy of outgoing particle, threshold energy. Compound nucleus model and its experimental verification. Briet Wigner formula (qualitative).

Reactor Physics: Condition for controlled chain reaction, four factor formula, thermal reactor, fast breeder reactor.

Elementary particles: Fundamental interactions and their general features, conservation laws, classification of elementary particles as leptons, mesons and baryons. Quark model (Qualitative).

12 Hours

Unit IV (Modified or Improved)

Interactions of gamma rays and charged particles with matter: Photoelectric effect, Compton effect and pair production, Mass attenuation co efficient of gamma rays. Mossbauer effect; Resonance scattering of gamma rays, experimental technique, simple applications. Energy loss of heavy charged particles; ionization, radiation processes, Bethe Bloch formula, applications. Energy loss of fast electrons; ionization, excitation and radiation process (Bremsstrahlung).

Application of Nuclear Physics: Trace elemental analysis and alpha decay applications, applications of radioisotopes in cancer treatment, agriculture and industry.

12 Hours

Text Books

1. Nuclei and Particles : E. Segre –The Benjamin Publishing, Pvt Ltd (1977).
2. Introductory Nuclear Physics : K.S. Krane John Wiley & Sons (1987).
3. Atomic and Nuclear Physics: Vol. II S.N.Goshal S. Chand and Company (1996).
4. Nuclear Physics: D.C.Tayal Himalaya Publishing House(2009)
5. Nuclear and Partilce Physics: S.L.Kakani, ShubhraKakani Vira Books(2008)
6. Environmental radioactivity: Eisenbud M, Academic Press (1987)

Reference Books

1. The Atomic Nucleus : R.D. Evans – Tata McGraw Hill New Delhi (1992).
2. Physics of Nuclei and Particles: Marmer and E.Sheldon,Vol.II Academic press (1970).
3. Physics of Nuclear Reactors: S.Garag, F.Ahmed and L.S. Kothari. – Tata McGraw Hill New Delhi (1986).
4. Introductory Nuclear Physcis : Samuel Wong Prentice Hall (1996).
5. Fundamentals of Nuclear Physics : N.A.Jelly Cambridge University Press (1990).
6. Introduction to Nuclear Physics : Harald A. Enge Addison –Wiseley (1996).
7. Introduction to Nuclear and Particle Physics: V.K.Mittal, R.C. Verma, S.C. Gupta PHI Learning Limited (2009)
8. Radiation detectors: Kapoor S S and Ramamurthy V S Wiley Eastern (1986)

Course PHET 2.4: Open Elective Course – I Modern Physics
(for students of other departments)
Syllabus is given at the end

Course PHCP 2.5: Practical III: Electronics and Condensed Matter Physics

Contact hours per week: 4
Number of Credits: 4

1. Study of triggered SR, JK and D-flip-flops.

2. Ripple counter and Shift Register using JK flip-flop.
3. Regulated power supply using 78xx integrated circuits.
4. R 2R ladder network D/A converter
5. Fortran Programming using Fortran 77.
6. Hall Effect and Hall mobility in semiconductors.
7. Determination of energy gap by reverse saturation current of pn-junction.
8. Computer programming using Fortran 77.
9. Developing of X-ray pattern for a cubic lattice using X-ray diffractometer and indexing of the pattern.

(New experiments may be added)

Reference books

1. Microelectronics Circuits: Adel S.Sedra and Kenneth C.Smith, Oxford University, Press (1991).
2. Electronic devices and circuits: R. Boylstead and Nashalsky : PHI publications (1999).
3. Electronic Principles: A.P. Malvino, TMH Publications (1984).
4. Operational Amplifier and Linear IC's: Robert F. Coughlin and Frederick F. Driscoll, PHI publications (1994).
5. Op Amps and Linear Integrated Circuits: R. Gayakwad, PHI publications, New Delhi (2000).
6. Elementary Solid State Physics: M.A. Omar, Addison Wesley Pub. Ltd. New Delhi (1993).
7. X ray Diffraction: B.D. Cullity, Addison Wesley, Ltd. New York (1972).
8. Introduction to Solid State Physics: C. Kittel, Wiley Eastern Ltd. Bangalore (1976).
9. Laboratory Manuals.

Course PHCP 2.6: Practical IV Atomic & Molecular Physics and Nuclear & Particle Physics

Contact hours per week: 4
Number of credits: 4

1. Study of Elliptically Polarized Light
2. Study of Beer's law
3. Study of Dispersion of a Glass Prism Spectrograph.
4. Stefan's constant of Radiation : High resistance by leakage method
5. Study of gamma ray spectrum obtained in Nal (TI) detector spectrometer.
6. Study of attenuation of gamma rays in matter.
7. computer programming using Fortran 77

(New experiments may be added)

References

1. Advanced Practical Physics: (9th Edition) B. C Worsnop & H.T. Flint, Methuen & Co. Ltd. onion (1951)

2. Instrumental Methods of Analysis : (6th Edition) H. H. Willard, L. L. Merit, J. A. Dean & F. A. Settle, J. K. Jain for CBS Publishers (1986)
3. Optics: (2nd Edition) A. K. Gathak Tata Mc Graw Hill Pub. Comp. Ltd New Delhi (1977)
4. Lab Manuals / Books / Charts.
5. Experiments in Modern Physics: A C. Melissions, Academic press (N.Y.) (1966).
6. Experiments in Nuclear Science ORTEC Application Note ORTEC, (1971) (Available in Nuclear Physics Laboratory)
7. Practical Nucleonics: F.J. Pearson., and R.R. Osborne, E & F.N. Spon Ltd., London (1960)
8. The Atomic Nucleus : R.D. Evans Tata Mc Graw Hill Pub. Comp. Ltd., (1960)
9. Nuclear Radiation Detectors: S.S. Kapoor and V.S. Ramamurthy, Wiely Eastern Limited (1986)
10. Experimental Nucleonics : E Bleuler and G.J. Goldsmith, Rinehart & Co, Inc. (NY) (1958)

Semester III

Course PHCT 3.1: Quantum Mechanics – II (shifted here From 4th sem 4.2)

Teaching hours per week: 04
Credits per week: 04

Unit I

Linear Vector Algebra: Linear Vectors space, Orthonormality, linear independence. Operators Eigenvalues, eigenvectors; Hermitian, Unitary and Projection operators. Bra and Ket notation for vectors. The elements of Representation Theory. Idea of Measurements, Observables and generalized uncertainty relation. Coordinate and momentum representations. Quantum Poisson Bracket.
Quantum Dynamics: Schrödinger and Heisenberg pictures; Interaction picture; the Heisenberg equation of motion. Linear harmonic oscillator problem by matrix method.

12 Hours

Unit II

Angular Momentum: Introduction, angular momentum operator and its representation, Eigen values and eigen functions of L^2, commutation relations, Angular momentum and rotations. Bra and Ket representation, Eigen values, ladder operators, Eigenvectors of $J^2$and J_z. Angular momentum matrices for j=1/2 and j=1. Pauli wavefunction and equation, Theory of addition of two angular momenta, Clebsch Gordan coefficients, allowed values of j, singlet and triplet states (qualitative).

12 Hours

Unit III

Approximation Methods: First order stationary perturbation theory for a degenerate case; the secular equation; applications: particle in a infinitely deep potential well subject to perturbing potential and, Stark effect in hydrogen atom; Second order perturbation theory and its application to a linear harmonic oscillator subject to a potential. W.K.B. approximation: Connection formulas; application to a potential well and alpha decay. The Variation method and its application to the ground state of hydrogen atom and helium atom.

12 Hours

Unit IV

Relativistic Quantum Mechanics: Klein–Gordon equation. Dirac's relativistic equation for a free particle: commutation relations and matrices for and ; free particle solutions; probability charge and current densities; positive and negative energy states; the spin of the Dirac particle, Zitterbewegung. Dirac equation in electromagnetic potentials and magnetic moment. Dirac equation for a central field; the hydrogen atom: energy levels and fine structure (without derivation).

12 Hours

Text Books

1. Quantum Mechanics (2nd Edition) : L. I. Schiff, McGraw – Hill Co, New York (1955)
2. Quantum Mechanics (Vol. I) : A. Messiah, North Holland Pub Co, Amsterdam (1962)
3. Quantum Mechanics – Theory and Applications (3rd Edition): A. Ghatak and S. Lokanathan, MacMillan India Ltd. New Delhi (1984)
4. A Text book of quantum Mechanics: P. M. Mathews and K. Venkateshan, Tata Mc Graw -Hill, New Delhi (1987).

Reference Books

1. The Principles of Quantum Mechanics (4th Edition) : P.A.M. Dirac, Oxford Univ Press, New York (1958)
2. Quantum Mechanics (1st Edition): V. K. Thankappan, New Age Intl. Pvt. Ltd., New Delhi (1985)
3. Quantum Mechanics : E. Merzbacher., John Wiley, New York (1970)
4. Modern Quantum Mechanics : J. J. Sakurai, Addison Wesley, Massachusetts (1994)
5. Applied Quantum Mechanics: A.F.J Levi, Cambridge Univ Press, 2003.

Course PHST 3.2: Electronics – I

Teaching hours per week: 04
No. of credits: 4

Unit I

Transmission lines: Line parameters, inductance and capacitance of open wire and coaxial line, line of cascaded sections, transmission line general solution, physical significance of the equations, the infinite line, wavelength, velocity of propagation, wave form distortion, distortion less line, telephone cable, induction loading of telephone cable, reflection of line not terminated with characteristic impedance, open and short circuited lines, insertion losses.

12 Hours

Unit II

Lines at RF: Parameters of open wire line at high frequencies, parameter of co axial cable at high frequencies, constants of lines of zero dissipation, voltage and current on dissipation less lines, standing wave ratio, impedance of open and short circuit lines, the ¼ wave line, ½ wave line, impedance matching of ½ wave line, single stub matching, Circle diagram for the dissipationless line and its applications..

12 Hours

Unit III

Waveguides: Solutions of wave equations in rectangular and cylindrical coordinates, TE and TM modes in rectangular and cylindrical wave guides, characteristics of rectangular and circular wave guides.

Antennas: Hertzian dipole, Current and voltage distributions Resonant antennas, radiation patterns, and length calculations, Nonresonant antennas, Antenna gain and effective radiated power, Radiation measurement and field intensity, Antenna resistance, Bandwidth, beam width, and polarization, Ungrounded antennas, Grounded antennas, Grounding systems, Effects of antenna height, loop antennas, phased arrays, antenna as aperture, different types of apertures, Principles of pattern multiplication, phased arrays, Yagi Uda antenna, helical antenna.

12 Hours

Unit IV

Satellite communication: Introduction, Kepler's laws, orbits, geostationary orbit. Power systems, attitude control, satellite station keeping, antenna look angles, limits of visibility, frequency plans and polarization, transponders, up link and down link power budget calculations, digital carrier transmission, multiple access methods, fixed and mobile satellite service, earth stations, INSAT.

12 Hours

Text books

1. Networks, Lines and Fields: J. D. Ryder, Prentice Hall India Pvt., Ltd., New Delhi (1995)
2. Electronic communications, 4th edition: Dennis Roddy and John Coolen, Prentice – Hall of India Pvt. Ltd. New Delhi (1997)

3. Electronic Communication systems – 4th edition: George Kennedy and Bernard Davis, Tata McGraw – Hill Publishing Company Ltd., New Delhi (1999).
4. Satellite communication – 3rd edition, Dennis Roddy, McGraw – Hill Publishing Company Ltd., New Delhi (2001)

References books

1. Communications Systems: Simon Haykin, Wiley Eastern Ltd., New Delhi
2. Radio Engineering: G. K. Mittal, Khanna Publishers, Delhi (1998)
3. Modern Communication Systems – Principles and Applications : Leon W. Couch II, Prentice Hall of India Pvt. Ltd. New Delhi (1998)

Course PHST 3.2: Condensed Matter Physics – I

Teaching hours per week: 4
No. of Credit: 4

Unit I

Periodic Structures: Reciprocal lattice and its properties, periodic potential and Bloch theorem, reduction to Brillouin 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 method, band width and effective mass in linear lattice and cubic lattices. APW and k.p. methods of band structure calculations.

12 Hours

Unit II

Fermi surface Studies: Extended, reduced and periodic zone schemes. Construction of Fermi surface in square lattice, Harrison construction, slope of bands 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 Hass-van Alphen effect, external orbits.

12 Hours

Unit III

Electrical Transport in Metals and Semiconductors: Boltzmann equation, relaxation time approximation, electrical conductivity, thermal conductivity, thermoelectric effects Calculation of relaxation time, scattering by impurities and lattice vibrations, Mattheisen’s rule, temperature dependence of resistivity, residual resistance.

12 Hours

Unit IV

Quantization of lattice vibrations and phonons: Potential and kinetic energies in terms of generalized coordinates and momenta, Hamiltons equations of motion, quantization of normal modes.

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.

12 Hours

Text Books

1. Principles of Theory of Solids: J. M. Ziman, Cambridge University Press, (1972).
2. Introduction to Solid State Physics : C. Kittel, Wiley Eastern Ltd, Bangalore (1976).
3. Lattice Dynamics: A. K. Ghatak and L. S. Kothari, Addison Wesley, Reading (1971).
4. Solid State Physics: J. D. Patterson and B.C. Bailey, Springer Verlag, Berlin (2007)

References Books

1. Physics of Solids: F. C. Brown, Benjamin Inc. Amsterdam (1967).
2. Elements of Solid State Physics (2nd Ed): J.P. Srivastava, PHI Learning Pvt. Ltd., New Delhi (2009)
3. Solid State Physics: N. W. Aschroft and A. D. Mermin, Saunders College Publishing New York (1976)

Course PHST 3.2: Atomic & Molecular Physics – I
(Atomic and Diatomic Molecular Spectra)

Teaching hours per week: 04
No. of credits per week: 04

Unit I

One electron atoms: Fine structure and Hyperfine structure Fine structure: of hydrogenic atoms (quantum mechanical treatment): energy shifts due to relativistic and spin orbit corrections, fine structure splitting (hydrogen atom), fine structure and intensities of spectral lines. The Lamb shift.

Hyperfine structure and isotope shifts: magnetic dipole hyperfine structure; energy shift, hyperfine structure multiplet, hyperfine transitions in hydrogen, isotope shift.

12 Hours

Unit II

Interaction of One electron Atoms with External Electric and Magnetic fields: (Quantum mechanical treatment) The Stark effect-first order correction to energy and eigen states: splitting of the degenerate level of hydrogen; the Zeeman effect: Normal Zeeman effect-magnetic interaction energy, selection rules, Lorentz triplet, polarization states; the Paschen-Back effect (qualititative); anomalous Zeeman effect magnetic interaction energy, selection rules, splitting of levels in hydrogen atom.

12 Hours

Unit III

Elementary discussion of electronic states: Electronic energy and Total energy, Born-Oppenheimer approximation. Symmetry properties of electronic eigen functions.

Vibrational structure of electronic bands; Progressions and Sequences, isotope effect, Deslandres' table; Intensity distribution in the vibrational structure of electronic bands; the Franck-Condon principle (absorption), Dissociation energy.
MO theoretical treatment of H_2^+ and H_2 electronic states and correlation of states.

12 Hours

Unit IV

Finer details about electronic states and electronic transitions: Coupling of Rotation and Electronic Motion:Coupling of rotation and electronic motion in diatomic molecules. Hund's coupling cases, Spin uncoupling, Lambda doubling, symmetry properties of rotational levels of Σ and Π electronic states.

Types of allowed electronic transitions; selection rules, Rotational structure of bands due to Σ–Σ, Π–Σ, Σ–Π and Π–Π transitions of singlet multiplicity, P,Q,R branches; the Fortrat diagram; combination relations; evaluation of rotational constants.

12 Hours

Text Books

1. Physics of Atoms and Molecules(2nd ed): Bransden B.H. and Joachain C.J.,Pearson Education, India (2006)
2. Atoms & Molecules : Mitchel Weissbluth, Academic Press, N. Y. (1982)
3. Molecular Spectra & Molecular Structure(Vol I): G.Herzberg, D. Van Nostrand CoPrinceton, N.J. (1945)
4. Spectroscopy (Vol. 3):S. Walker & B. P. Strauhghan, Chapman & Hall, Lon (1976)

Reference Books

1. Introduction to Atomic Spectra : H.E. White, McGraw – Hill, Tokyo (1934)
2. Quantum Chemistry : Ira Levine, Prentice – Hall of India, New Delhi (1991)
3. Fundamentals of Spectroscopy (2nd ed): B. Narayan, Allied Publishers Ltd., NewDelhi, (1999).

4. Modern Spectroscopy (4th Ed): J.M. Hollas, John Wiley & Sons Ltd. UK 2004.

Course PHST3.2: Nuclear & Particle Physics – I

Teaching hours per week: 4
No.of Credits: 4

Unit I

Basic Properties: Scattering of high energy electrons by nucleus; Expression for Mott Scattering, differential cross section, form factor, charge distribution in nuclei.
Scattering of high energy electrons by nucleons; Expression for Rosenbluth formula, electric and magnetic form factors of protons, the magnetic form factor of neutron, their distribution in nucleon. . **(Modified)**

Electric quadrupole moment: Expression for axial quadrupole moment, quadrupole moment of spheroidal nucleus. Quadruple moment due to single nucleon is a state J.

Magnetic dipole moment: Nuclear g factor for neutron and proton, expression for g factor for a nucleon in a state J in special cases for odd proton and odd neutron on extreme single particle model, Schmidt limits.

12 Hours

Unit II

Nuclear forces: Characteristics of nuclear forces, deuteron problem, basic properties, ground state of deuteron for square well potential, relation between the range and depth of potential. Non-existence of excited states, basic properties of non central force, deuteron in mixture of S and D states using magnetic moment. Range of tensor interaction using quadrupole moment, saturation of nuclear forces. **(Modified)**

12 Hours

Unit III

Nucleon-Nucleon Scattering: n-p scattering, partial wave analysis, scattering of neutron by hydrogen molecules: ortho and para hydrogen, spin dependence of nuclear force, effective range theory for n-p scattering. Qualitative features of p p scattering, effect of Coulomb and nuclear scattering. High energy n-p and p-p scattering (qualitative). Meson theory of nuclear force: Yukawa and pseudo scalar theory, one pion exchange potential.

12 Hours

Unit IV

Elementary Particles: Pion-nucleon scattering and its resonances. Strange particles:associated

Production-strangeness quantum number, Gell–Mann and Nishijima formula, Kaons, lamda, sigma, omega hyperons. Symmetry classification of elementary particles: SU(3) symmetry and eight-fold way, Gell-Mann Okubo formula, Weight diagram, discovery of Ω^- particle.

Quark Model: fundamental representation of SU(3) and quarks, experimental support for quark model, quark structure of mesons and baryons, color quark and gluons, quark dynamics, charm, beauty and truth quarks, grand unification theory. **(Modified)**

12 Hours

Text Books

1. Introductory Nuclear Physics: Kenneth S. Krane, John Wiley and sons (1988)
2. Subatomic Physics: Nuclei and Particles (Volume II) : Luc Valentin North Holland (1981)
3. Physics of Nuclei and Particles: P. Marmier and E. Sheldon Academic press (1970)
4. Introduction to Particle Physics: M. P. Khanna Prentice Hall of India (1990)
5. Nuclear Physics: R. R. Roy and B.P. Nigam, Wiley Eastern (2014)

Reference Books

1. Subatomic Physics (Second Edition) : Hans Frauenfelder and E. M. Henley, Prentice Hall (1991)
2. Introduction Nuclear Physics : Herald. A. Enge., Addison Wesley (1983)
3. Introductory Nuclear Physics : Samuel S. M. Wong, Prentice – Hall (1996)
4. Atomic Nucleus : R. D. Evans, Tata Mc Graw –Hill (1982)
5. Theoretical Nuclear Physics Volume I : Nuclear structure : AmosdeShalit and Herman Feshbach, John Wiley (1974)
6. Nuclear and particle Physics : W. Burcham and M. Jobes, Addision wesley (1998)
7. Theoretical Nuclear Physics : J. M. Blatt and V. F. Weisskoff, Wiley (1962)
8. Inroduction to quantum electrodynamics and particle physics: Deep Chadra Joshi,
9. Modern Atomic and Nuclear Physics: A.B. Gupta Books and Allied (2009)
10. Nuclear Physics: S. N. Ghoshal, S Chand & Company (2014)
11. Nuclear Physics: D. C. Tayal, Himalaya Publishing House (5th ed.) (2013)
12. Introduction to Elementary Particles: D. Griffiths, John Wiley (1987)

Course PHST 3.3: Electronics – II

Teaching hours per week: 04
No. of credits: 04

Unit I

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

12 Hours

Unit II

Biomedical Instrumentation: Role of technology in medicine, Developments in biomedical instrumentation, physiological systems of the body, sources of biomedical signals, basic medical instrumentation system, performance requirements of medical instrumentation systems, intelligent medical instrumentation systems, consumer and portable medical equipment, implantable medical devices, micro-electro mechanical systems (MEMS), wireless connectivity in medical instruments, electrocardiograph(ECG), vector cardiograph (VCG), phonocardiograph (PCG), digital stethoscope, electroencephalograph (EEG), electromyography,magnetic resonance imaging (MRI),real-time ultrasonic imaging systems. pace makers, defibrillators.

12 Hours

Unit III

Continuous time signals: Classification of signals, continuous time signals, discrete time signals, standard test signals, operations on signals. Definition of a system,classification of system, examples of systems. Classification of system, Continuous time systems defined by an input/output differential equation, system modeling, zero input response zero state response and causality, unit impulse response, convolution, convolution integral and properties, system stability. Discrete time systems, difference equation, initial conditions and iterative solution, zeroinput response, unit impulse response, zero state response, discrete time convolution, properties of convolution sum, convolution examples, system stability, numerical convolutions.

12 Hours

Unit IV

Transform domain representation of signals: Fourier series representation of periodic signals, exponential form of the Fourier series, aperiodic signal representation, Fourier transform, transforms of some useful functions, properties, generalized Fourier transform. Computations of output response via the Fourier transform, analysis of ideal filters, amplitude modulation, angle modulation. Discrete time Fourier transform, discrete Fourier transform, system analysis via the DTFT and DFT.

12 Hours

Text books

1. Electronic Measurements and Measuring techniques: A. D. Helfrick and W.D. Cooper
2. Electrical and Electronic measurements and techniques: A. K. Shawney The educational and Technical Publications, New Delhi (1985)
3. Biomedical digital signal procession: William J. Tompkins, Prentice hall of India Pvt. Ltd. (2000)

4. Electronic Signals and Systems: Paul A. Lynn, English Language Book Society Macmillan (1986)

Reference books

1. Communication systems: Simon Haykin, Wiley eastern Ltd. New Delhi (1983)
2. Modern Communication Systems – Principles and Applications: Leon W. Couch II, Prentice Hall of India Pvt. Ltd., New Delhi (1998)
3. Discrete time Signal procession –2nd Edition, A.V. Oppenhiem, R. W. Schafer and J. R. Buck, Prentice Hall, New Jersey (1999).
4. Digital Signal Processing – A Computer Based approach : Sajith K. Mitra, Tata – McGraw Hill Publications, New Delhi (2000).
5. Principles of Electronic Instrumentation : A. J. Diefenderfer, and B.E. Hotton, Saunders college Publishing, London (1994).

Course PHST 3.3: Condensed Matter Physics – II

Teaching hours per week: 4
No of Credit: 4

Unit I

Ferromagnetism: Review of Weiss theory of ferromagnetism, its successes and failures, Heisenberg exchange interaction, exchange integral, exchange energy, spin waves (one dimensional case only), quantization of spin waves and magnons, density of modes, thermal excitation of magnons and Bloch $T^{3/2}$ law, specific heat using spin wave theory. Origin of ferromagnetic domains, hysteresis curve, magnetocrystalline anisotropy energy, Bloch wall formation.

Antiferromagnetism: Characteristic property of antiferromagnetic substance, Neutron diffraction experiment. Two sub lattice model molecular field theory of antiferromagnetism, Neel temperature, Susceptibility below and above Neel temperature.

Ferrimagnetism: Ferrimagnetic order, ferrites, Curie temperature and susceptibility of ferrimagnets.

12 Hours

Unit II

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, electron paramagnetic resonance and nuclear magnetic resonance.
Effect of crystal field on energy levels of magnetic ions (qualitative). Spin Hamiltonian, zero field splitting.

Novel Magnetic Materials and Devices: Magneto optic effect: Kerr and Faraday. The basic concepts of Giant Magnetoresistance (GMR) and Colossal Magnetoresistance (CMR), applications to memory storage, actuators and sensors.

12 Hours

Unit III

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

12 Hours

Unit IV

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

12 Hours

Text Books

1. The Physical Principles of Magnetism : A. H. Morrish, John Wiley & sons, New York (1965)
2. Solid State Physics : A. J. Dekker, Macmillan India Ltd., Bangalore (1981)
3. Introduction to Solid State Physics : 5th Edn C. Kittel, Wiley Eastern Ltd., Bangalore (1976)
4. Elementary Solid State Physics : M. A. Omar, Addison Wesley Pvt. Ltd., New Delhi (2000).
5. Elements of Solid State Physics, Second Edition, J.P. Srivastava, Eastern Economy Edition, PHI Learning Private Limited, New Delhi (2009).

Reference Books

1. Introduction to Magnetic Resonance: A. Carrington and A. D. Mclachlan, Harper & Row, New York, (1967).
2. Elements of Solid State Physics (2nd Ed): J.P. Srivastava, PHI Learning Pvt. Ltd., New Delhi (2009)

Course PHST 3.3: Atomic & Molecular Physics – II
(Spectroscopy Instrumentation Techniques)

Teaching hours per week: 4
No of Credits per week: 4

Unit I

Components of Optical Instruments: Sources of radiation for uv, visible and IR regions; types of prism and grating monochromators; Radiation detector types Photon (photovoltaic, vacuum phototube, PMT); Multichannel types Photodiode arrays, CID, CCD; Thermal detectors Thermocouples, Bolometer, Pyrroelectric types. Principles of FT optical measurements.

Atomic Spectroscopy
Atomic Absorption Spectrometry: Sources of flames; Instrumentation: Single and Double beam instruments. Sampling techniques. Simple applications.

Atomic Emission Spectrometry: Sources; Typical spectrometers; sampling techniques. Arc and spark sources; instrumentation.

12 Hours

Unit II

Luminescence Spectroscopy

UV Visible Absorption Spectrometry: The Beer's law and its limitations. Instrumentation: sources; single and double beam spectrometers; Solvent effects; Bathochromic and Hypsochromic shifts; Assignment of and transitions.

Fluorescence Spectrometry: Theory of Fluorescence and Phosphorescence (with energy level diagram); Transition types; quantum efficiency (yield). Instruments: Fluorometers and Spectrofluorometers; lifetime measurements, Radiative and Natural lifetime, Decay curves. Applications.

12 Hours

Unit III

Vibrational Spectroscopy

Infrared Spectrometry: Molecular vibrations and Group frequencies. IR sources; transducers. Instruments: Dispersive and FT based spectrometers; sample handling. Interpretation of spectra structure correlations.

Raman Spectrometry: Origin of Raman scattering (qualitative);comparison of vibrational Raman and infrared spectra; activity and intensity of Raman bands; depolarization ratio. Instrumentation; sources; dispersive and FT-based Raman spectrometers; sample handling. Simple applications.

12 Hours

Unit IV

NMR Spectroscopy

Proton NMR Spectrometry: Theory of NMR: Interaction between nuclear spin and magnetic moment; resonance condition; population of energy levels. Relaxation processes: spin lattice and spin-spin relaxations (qualitative). The chemical shift and its correlation with molecular structure. Typical NMR spectrometers (cw/FT); sample handling. Simple applications of 1H.NMR.

Photoelectron Spectroscopy

Photoelectron spectroscopy: Types UPS and XPS. Experimental method for UPS and XPS. Ionization processes and Koopmans' theorem. Interpretation of UP and XP spectra with applications.

12 Hours

Text Books

1. Instrumental Methods of Analysis: H. H. Willard, L. L. Merrit, J. A. Dean and F. A. Settle, J. K. Jain for CBS Publishers (1986)
2. Principles of Instrumental Analysis (5th Ed) : D. A. Skoog, F. J. Holler & T. A. Nieman, Harcourt Asia Pvt. Ltd. (1998)
3. Fundamentals of Molecular Spectroscopy : C. N. Banwell and E.M. McCash, Tata McGraw-Hill Co.,(4th revd Ed; 9th reprint, 2000).

Reference Books

1. Raman Spectroscopy: D. A. Long, McGraw Hill Intl. Co. (1977)
2. Modern Spectroscopy (4th Ed): J.M. Hollas, John Wiley & Sons Ltd, UK (2004)[Free soft copy available on Net].

Course PHST3.3: Nuclear & Particle Physics – II

Teaching hours per week: 4
No. of Credits: 4

Unit I

Nuclear Detectors: Scintillation detector, different types of scintillators, photomultiplier tubes; gain and types of photomultiplier tubes, Preamplifiers; charge sensitive, voltage sensitive and current sensitive preamplifiers, Amplifiers; linear and spectroscopy amplifiers, Single channel analyzers; integral, window and normal modes, Multichannel analyzer; various types of ADC, memory, linear gate and working, NaI(TI) gamma ray spectrometer; Calibration, photopeak, compton edge and back scattered peak, single escape and double escape peak. Role of thickness of the crystal for detecting the radiation.

Semiconductor Detector: Relation between applied voltage and depletion layer thickness, Lithium drifted germanium detector, High purity germanium detector, Lithium drifted silicon detector, position sensitive silicon detector. Principle and working of magnetic spectrometer and Cherenkov detector.

12 Hours

Unit II

Particle Accelerators and Applications: Basic components of accelerator, types of accelerations, principles of operation.
Ion sources: Duoplasmatron ion source and electron cyclotron resonance (ECR) ion source.
Accelerators: Principle and working of electrostatic accelerators, azimuthally varying field (AVF) cyclotron and pelletron accelerator, RIB accelerator, Microtron, Super Conducting Cyclotron, synchrotron source.
Application of ion beams: Rutherford Backscattering Spectroscopy (RBS), Elastic Recoil Detection (ERD), Nuclear Reaction Analysis (NRA).

12Hours

Unit III

X – ray Fluorescence Spectroscopy: X ray Fluorescence; Energy and wavelength dispersive X – ray fluorescence spectrometers. microXRF, Total XRF and their applications
Positron Annihilation Spectroscopy: Principles, positron sources and experimental arrangements, Angular correlation of annihilation radiation (ACAR),positron annihilation life time (PALT) measurement. Applications
Perturbed angular correlation (PAC): PAC sources, experimental arrangement, magnetic dipole interaction, electric quadruple interaction, applications.

12 Hours

Unit IV

Neutron Physics: Basic properties of neutron, production of neutrons, detection of slow and fast neutrons; BF3 counter and 3He based neutron detector, scintillation detectors for fast neutrons, detection of ultra high energy neutrons, cloud chamber as a neutron detector, the crystal monochromator, neutron diffraction (theory), powder and single crystal neutron diffraction, neutron diffraction from magnetic materials, neutron diffraction in fluids, reflection of neutrons, polarization of neutrons, small angle neutron scattering (SANS).

12 Hours

Text Books

1. Atomic and Nuclear Physics volume II : S. N. Goshal, S. Chand and company (1998)

2. Nuclear Radiation Detectors : S. S. Kapoor and V. S. Ramamurthy, Wiley Eastern Limited (1986)
3. Techniques for Nuclear and Particle : W. R. Leo, Springer Verlag (1987).
4. Radiation Detection and Measurement : Glenn. F. Knoll, John Wiley and sons (1989)
5. Principles of Charged Particle Acceleration : S. Humphris, John Wiley (1986)
6. Introduction to Neutron Physics: L. F. Curtis, East west press (1958)
7. Nuclear Electronics: P.W. Nicholson, John Wiley & Sons (1974)
8. Experimental neutron scattering: B.T.M. Willis & C.J. Carlie, Oxford University Press (2009)
9. Introduction to Neutron Physics: L.F. Curtiss, East West Press (1969)

Reference Books

1. Introduction to Nuclear Physics : Herald A. Enge, Addison – Wesley (1983)
2. Physics of Nuclei and Particles Vol II : P. Marmier and E. Sheldon, Academic Press (1969)
3. Nuclei and Particles (second edition) : E. Segre, Benjamin (1977)
4. Nuclear and Particle Physics : W. Burcham and M. jaobes, Addison Wesley (1998)
5. Physics of Nuclei and Particles : P. Marmier and E. Sheldon Academic press (1970)
6. Alpha, Beta and Gamma Spetroscopy : K Seighban Vol. I and II North Holland (1966)
7. Experimental Techniques in Nuclear Physics: Dorin N. Poenaru, Walter Greiner Walter de Gruyter, Berlin(1997)
8. Experimental Neutron Scattering: BTM Willis and C J Calile Oxford University Press (2009)
9. Quantitative X ray Fluorescence analysis: G. R. Lachance and F. Claisse John Wiley and sons (1995)
10. Ion Implantation Science and Technology: J. P. Ziegler, Academic Press (1988).
11. Nuclear electronics: Kowalski E., Springer Verlag, Berlin (1970)
12. Nuclear Physics Experimental and theoretical, Hans H.S., New Age International Publishers (2001)

Course PHET 3.4 Open Elective Course II
(for students of other departments)

PHET3.4a: Instrumental Methods

OR

PHET3.4b: Physics of Nanomaterials

(Any one of the above will be offered)
Syllabus is given at the end

Course PHSP3.5: Electronics Practical – I

Contact hours per week: 4
No. of Credit: 4

1. Square, triangular and ramp generation using op amp
2. Instrumentation amplifier gain, CMRR and input impedance
3. Active notch and twin T filter realization using Op Amp
4. Precision half wave and full wave rectifier using Op amp
5. 2's complement adder and subtractor
6. 4 – bit bidirectional shift register

(New experiments/assignments may be added)

References

1. Operational Amplifier and Linear IC's: Robert F. Coughlin and Frederick F. Driscoll, PHI publications (1994).
2. Op Amps and linear Integrated Circuits: R Gayakwad, PHI publications, New Delhi (2000).
3. Digital Principles and Applications: A.P. Malvino and D. Leach, TMH Publications (1991).
4. Digital fundamentals – 8th edition: Thomas L Floyd, Pearson Education (2003)
5. Microelectronics Circuits: Adel S. Sedra and Kenneth C. Smith, Oxford University Press (1991).
6. Digital Computer fundamentals, Thomas C. Bartee, McGraw Hill Ltd. (1977).
7. Digital Logic and Computer Design: Morris Mano. Prentice Hall of India Pvt.Ltd New Delhi (2000).
8. Logic Circuit Design: Alan W. Shaw, Sanders College Publication Company (1999).

Course PHSP3.5: Condensed Matter Physics Practical – I

Contact hours per week: 4
No of Credits: 4

1. Structure factor calculations
2. d spacing calculations
3. Indexing of cubic systems
4. Determination of Debye temperature by study of specific heat of metals
5. Assignment using FORTRAN programming
6. Calculation of relative integrated intensity
7. Indexing of tetragonal systems
8. Obtaining X ray pattern for a given substance using X ray diffractometer and indexing the pattern.

(New experiments/assignments may be added)

Reference Books

1. X ray diffraction: B.D. Cullity, Addison Wesley, New York (1972).
2. X ray diffraction procedures: H.P. Klug and L.E. Alexander, John Wiley and sons, New York.
3. Interpretation of X ray powder diffraction pattern: H.P. Lipson and H. Steeple, Macmillan, London (1968).
4. Introduction to Solid State Physics : 5th Edn C. Kittel, Wiley Eastern Ltd., Bangalore (1976)
5. Elementary Solid State Physics : M. A. Omar, Addison Wesley Pvt. Ltd., New Delhi (2000)
6. Introduction to magnetochemistry: A. Earnshaw, Academic press, London (1968).
7. Lab manuals.

Course PHSP 3.5 –Atomic & Molecular Physics Practical – I

Contact hours per week: 4
No of Credits: 4

1. Study of Constant Deviation Spectrograph
2. Study of Grating spectrograph
3. Study of Small Quartz Spectrograph
4. Vibrational analysis of CN violet bands
5. Study of Copper Spark Spectrum
6. Spectrochemical analysis of Mixture
7. Rotational analysis of HCl

(New Experiments / Assignments may be added)

Reference Books

1. Experimental Spectroscopy (3rd Edition): R. A. Sawyer. Dover Publication, Inc, New York (1963).
2. Atomic Spectra and Atomic Structure (2nd Edition) – G. Herzberg. Dover Publication New York (1944)
3. Atomic Spectra – H.E. White, Mc Graw –Hill, New York (1934).
4. A Course of Experiments with He-Ne Lasers (2nd Edition) : R. S. Sirohi. Wiley Eastern, New Delhi (1991).
5. Lab. Manuals.
6. Molecular Spectra & Molecular Structure Vol. I : G. Herzberg, D. Van Nostrand Co, New York (1950)
7. Instrumental Methods of Analysis : H. H. Willard, L. L. Merrit, J. A. Dean and F. A. Settle, J. K. Jain for CBS Publishers (1986)
8. The Identification of Molecular Spectra : R.W. B. Pears & A. G. Gaydon, Wiley, New York (1961).
9. Fiber Optic Laboratory Experiments: Joel Ng.

Course PHSP 3.5: Nuclear & Particle Physics I

Contact hours per week: 4
No of Credits: 4

1. Calibration of NaI(Tl) scintillation spectrometer
2. Attenuation beta particles I
3. Verification of Mosley's law
4. Positron annihilation
5. Multvibrator circuit using transistors and IC 555
6. Pulse generator using IC 4049
7. Attenuation gamma rays I
8. Calibration of X ray proportional counter spectrometer
9. Magnetic beta ray spectrometer I
10. Nuclear rotational studies
11. Regulated power supply using transistors and LM 309
12. R.C coupled amplifier

(New experiments/assignments may be added)

Reference Books

1. Experiments in Modern Physics : A. C. Melissions, Academic Press (NY) (1966)
2. Experiments in Nuclear Science, ORTEC Application Note. ORTEC, (1971)
3. (Available in Nuclear Physics Laboratory)
4. Practical Nucleonics : F. J. Pearson., and R. R.Osborne, E & F. N. Spon Ltd. London (1960)
5. The Atomic Nucleus: R. D. Evans, Tata Mc Graw Hill Pub. Comp. Ltd. (1960)
6. Nuclear Radiation Detectors : S. S. Kapoor and V. S. Ramamurthy, Wiely Eastern Limited (1986)
7. Experimental Nucleonics : E. Bleuler and G. J. Goldsmith, Rinehart & Co. Inc. (NY) (1958)
8. A manual of experiments in reactor physics : Frank A. Valente, Macmillan company (1963)
9. A practical introduction to electronic circuits : Martin Harthley Jones, Cambridge University Press (1977)
10. Integrated circuit projects : R. M. Marston, Newnes Technical Books (1978)
11. Semiconductor projects : R. M. Marston, A Newnes Technical Books (1978)
12. Waveform generator projects : R. P. Marston, A Newnes Technical Books (1978)

Course PHSP 3.6: Electronics Practical –II

Contact hours per week: 4
No. of Credit: 4

1. Crystal oscillator and frequency division circuits
2. Optical fiber experiments: Analog & digital

3. Phase locked loop ICs and characteristics
4. Dual power supply using IC regulators.
5. Staircase generator using 4-bit counters
6. Decade counter with 7-segment display

(New experiments/assignments may be added)

References

1. Operational Amplifier and Linear IC's: Robert F. Coughlin and Frederick F. Driscoll, PHI publications (1994).
2. Op Amps and linear Integrated Circuits: R Gayakwad, PHI publications, New Delhi (2000).
3. Digital Principles and Applications: A.P. Malvino and D. Leach, TMH Publications (1991).
4. Digital fundamentals – 8th edition: Thomas L Floyd, Pearson Education (2003)
5. Microelectronics Circuits: Adel S. Sedra and Kenneth C. Smith, Oxford University Press (1991).
6. Digital Computer fundamentals, Thomas C. Bartee, McGraw Hill Ltd. (1977).
7. Digital Logic and Computer Design: Morris Mano. Prentice Hall of India Pvt.Ltd New Delhi (2000).
8. Logic Circuit Design: Alan W. Shaw, Sanders College Publication Company (1999).

Course PHSP 3.6: Condensed Matter Physics Practical – II

Contact hours per week: 4
No. of Credits: 4

1. Hall effect and Hall mobility
2. Determination of e/kB
3. Susceptibility of paramagnetic substance by Gouy's method
4. Specific heat of metals
5. Magnetoresistance of semiconductors
6. Determination of Curie temperature of a ferromagnet.
7. Electron spin resonance
8. Resistivity by four probe method.
9. Determination of elastic constants.
10. Thermoluminescence studies of alkali halides by X ray irradiations
11. Size estimation of nanocrystals

(New experiments/assignments may be added)

Reference Books

1. X ray diffraction: B.D. Cullity, Addison Wesley, New York (1972).
2. X ray diffraction procedures: H.P. Klug and L.E. Alexander, John Wiley and sons, New York.

3. Interpretation of X ray powder diffraction pattern: H.P. Lipson and H. Steeple, Macmillan, London (1968).
4. Introduction to Solid State Physics : 5th Edn C. Kittel, Wiley Eastern Ltd., Bangalore (1976)
5. Elementary Solid State Physics : M. A. Omar, Addison Wesley Pvt. Ltd., New Delhi (2000)
6. Introduction to magnetochemistry: A. Earnshaw, Academic press, London (1968).
7. Lab manuals.

Course PHSP 3.6 –Atomic & Molecular Physics Practical – II

Contact hours per week: 4
No. of Credits: 4

1. Determination of screening constants for sodium doublets
2. Vibrational analysis of AlO bands
3. Zeeman Effect (Photographic method):
4. Vibrational Analysis of I2 absorption bands
5. Verification of Lande's interval rule
6. Verification of Beer's law using USB spectrometers
7. Optical fiber attenuation

(New Experiments / Assignments may be added)

Reference Books

1. Experimental Spectroscopy (3rd Edition): R. A. Sawyer. Dover Publication, Inc, New York (1963).
2. Atomic Spectra and Atomic Structure (2nd Edition) – G. Herzberg. Dover Publication New York (1944)
3. Atomic Spectra – H.E. White, Mc Graw –Hill, New York (1934).
4. A Course of Experiments with He-Ne Lasers (2nd Edition) : R. S. Sirohi. Wiley Eastern, New Delhi (1991).
5. Lab. Manuals.
6. Molecular Spectra & Molecular Structure Vol. I : G. Herzberg, D. Van Nastrand Co, New York (1950)
7. Instrumental Methods of Analysis : H. H. Willard, L. L. Merrit, J. A. Dean and F. A. Settle, J. K. Jain for CBS Publishers (1986)
8. The Identification of Molecular Spectra: R.W. B. Pears & A. G. Gaydon, Wiley, New York (1961).
9. Fiber Optic Laboratory Experiments: Joel Ng.

Course PHSP3.6: Nuclear & Particle Physics –II

Contact hours per week: 4

No of Credits: 4

1. Attenuation beta particles II
2. Half life of Indium
3. Attenuation gamma rays II
4. Compton Scattering
5. Study of emitter follower circuit
6. FET amplifier
7. Magnetic beta ray spectrometer I I
8. X ray fluorescence studies
9. Rutherford scattering
10. Pulse stretch and pulse delay using IC 74121
11. Pulser: variable width and frequency using LM 310
12. Scale of two circuit

(New experiments/assignments may be added)

Reference Books

1. Experiments in Modern Physics : A. C. Melissions, Academic Press (NY) (1966)
2. Experiments in Nuclear Science, ORTEC Application Note. ORTEC, (1971)
3. (Available in Nuclear Physics Laboratory)
4. Practical Nucleonics : F. J. Pearson., and R. R.Osborne, E & F. N. Spon Ltd. London (1960)
5. The Atomic Nucleus : R. D. Evans, Tata Mc Graw Hill Pub. Comp. Ltd. (1960)
6. Nuclear Radiation Detectors : S. S. Kapoor and V. S. Ramamurthy, Wiely Eastern Limited (1986)
7. Experimental Nucleonics : E. Bleuler and G. J. Goldsmith, Rinehart & Co. Inc. (NY) (1958)
8. A manual of experiments in reactor physics : Frank A. Valente, Macmillan company (1963)
9. A practical introduction to electronic circuits : Martin Harthley Jones, Cambridge University Press (1977)
10. Integrated circuit projects : R. M. Marston, Newnes Technical Books (1978)
11. Semiconductor projects : R. M. Marston, A Newnes Technical Books (1978)
12. Waveform generator projects : R. P. Marston, A Newnes Technical Books (1978)

Semester – IV

Course PHCT 4.1: Classical Electrodynamics

Teaching hours per week: 04
Number of Credits: 04

Unit I

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

12 Hours

Unit II

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

12Hours

Unit III

Electrodynamics: Faraday law of induction, displacement current, Maxwell's equations. Vector and scalar potentials. Gauge transformations, Lorentz gauge, Coulomb gauge. Continuity equation, Poynting's theorem, momentum, Maxwell's stress tensor, conservation of energy and momentum in electromagnetic fields.

Electromagnetic Waves: Propagation of waves in linear media, reflection and transmission at normal and oblique incidence, Electromagnetic waves in non conducting and conducting medium, skin depth, reflection at conducting surface.

Wave guides: Fields at the surface and within a conductor, modes in rectangular wave guide,TE waves in a rectangular wave guide, Co axial transmission line and cylindrical cavities.

12 Hours

Unit IV

Electromagnetic radiation: Retarded Potentials, Lenard Wiechert potentials, fields of a moving point charge.Electric dipole radiation, Magnetic dipole radiation,Power radiated by a point charge, Larmor formula, Power radiated by a point charge with collinear velocity and acceleration, Bremsstrahlung radiation, radiation from a charged particle moving in a circular orbit, cyclotron and synchrotron radiation.

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

12 Hours

Text Books

1. Classical Electrodynamics: J.D.Jackson , Wiley Eastern Ltd., Bangalore (1978)
2. Introduction to Electrodynamics: D.J.Griffiths, Prentice Hall of India, Ltd., New Delhi (1995).

Reference Books

1. Electromagnetics: B.B. Laud. Wiley Eastern Ltd., Bangalore (1987)
2. Classical Electromagnetic Radiation: J.B. Marion, Academic press, NewYork (1968).
3. Classical Electrodynamics; S P Puri, Tata McGraw Hill Publishing Company Ltd., New Delhi, (1990).

Course PHCT 4.2: Statistical and Thermal Physics

Teaching hours per week: 04
No. of Credits: 04

Unit I

Classical Statistics: Basic postulates of statistical mechanics, phase spaces, Liouville equation; concept of ensembles, postulate of equal a proiri probability; microstates and macrostates; general expression for probability; canonical ensemble: most probable distribution of energies, thermodynamic relations in canonical ensemble; canonical partition function; micro canonical ensemble; grand canonical ensemble, grand partition function.Partition function for the system and for the particles, translational partition function; Gibbs paradox: Sackur-Tetrode equation; Boltzmann equipartition theorem; rotational partition function; vibrational contribution to thermodynamic quantities; electronic partition function.

12 Hours

Unit II

Quantum Statistics: Postulates of quantum statistical mechanics, ideal quantum gases, quantum statistics in classical limit, symmetric and antisymmetric wave functions for indistinguishable particles; Bose-Einstein and Fermi-Dirac distributions, ideal Bose and Fermi gases, their properties at high temperature and densities, weak and strong degeneracy of perfect gases, Bose-Einstein condensation, black body radiation, phonons and specific heats of solids.

12 Hours

Unit III

Fluctuations and Brownian motion: Fluctuations in canonical, grand canonical and microcanonical ensembles, number fluctuations in quantum gases. Brownian motion: Langevin equation, random walk problem. Diffusion: Einstein relation for mobility. Time dependence of fluctuations: power spectrum, spectral density; persistence and correlation of fluctuations; Wiener-Khinchin theorem, Johnson noise, Nyquist theorem; shot noise; Fokker-Planck equation.

12 Hours

Unit IV

Irreversible thermodynamics: Reversible and irreversible processes, Onsager reciprocity relations and their derivations; thermoelectric phenomena, linear response theory, Kubo relations, fluctuation dissipation theorem; Saha theory of ionisation.

Liquid helium: phase diagram, superfluid properties, two fluid model, thermo-mechanical, fountain and mechano-caloric effects, quantum theory of superfluid ^{3}He and mixture of ^{3}He-^{4}He.

12 Hours

Text books

1. Statistical mechanics and properties of matter: Theory and applications: E.S.R. Gopal, John Wiley & Sons, New York (1974).
2. Statistical mechanics (3rded.): B.K.Agarwal and M. Eisner, New Age International (P) Ltd. Publishers, New Delhi (2013).

Reference Books

1. Fundamentals of statistical and thermal Physics: F.Reif, McGrawHill Ltd., New Delhi (1965).
2. Elementary statistical physics: C. Kittel, John Wiley & Sons, New York (1958).
3. Statistical mechanics; Theory and applications; S.K.Sinha, TMH Pub. Ltd., New Delhi(1990).
4. Statistical Thermodynamics: M.C. Gupta, New Age Publishers (2nd ed.) (2010)
5. Statistical Mechanics, R.K. Pathria& Paul D. Beale, Bufferworgh Heinemann (2nded.) (2012)
6. Fundamentals of Statistical Mechanics: B.B. Laud, New Age International (2012)

Course PHST 4.3: Electronics – III

Teaching hours per week: 4
No. of credits: 4

Unit I

Microprocessor Architecture: Introduction, microprocessor and its operations, architecture of 8085 microprocessor, memory, input and output devices, basic interfacing concepts, memory interfacing, interfacing input and output devices.

12 Hours

Unit II

Programming of 8085: Introduction, instruction classification, instruction format, over view of instruction set of 8085, data transfer operations, arithmetic operations, logic operations, branch operation; Instructions for Looping, counting, and indexing, additional data transfer instructions, 16-bit arithmetic operation, logic operations: rotate, compare; stack, subroutine, conditional call and return instructions.

12 Hours

Unit III

Interfacing peripherals and applications: The 8085 interrupt, multiple interrupts and priorities, additional 8085 interrupts: TRAP, RST 7.5, 6.5 and 5.5, triggering levels, additional I/O concepts, DMA; Interfacing A/D and D/A converters, handshaking and polling, the 8155 multipurpose programmable interfacing device; interfacing 7-segment display, the 8259 timer as square wave generator.

12 Hours

Unit IV

Microcontroller: 8051 architecture: 8051 microcontroller hardware-I/O pins, ports and circuits-External memory-Counter and Timers-Serial data I/O Interrupts. 8051 programming: instruction syntax-moving data-logical operations-arithmetic operations- branching instructions.

12 Hours

Text books

1. Microprocessor Architecture, Programming, and Applications with 8085/8080 A: Ramesh S. Gaonkar, New Age International Publishers Ltd.
2. The 8051 Microcontroller, Architecture, Programming and Applications, Kenneth J Ayala, International Thompson Publishing.

References books

1. Microcomputer theory and Applications: Rafiquzzaman Mohamed, John Wiley and Sons, New York (1987)
2. Introduction to Microprocessors (3rd Edition): Aditya P. Mathur, Tata – Mc Graw – Hall Publishing Company Ltd., New Delhi (1989)
3. The 8051 Microcontroller and Embedded systems: M.A. Mazidi, J.G. Mazidi, Pearson, Prentice Hall (2005)

Course PHST4.3: Condensed Matter Physics – III

Teaching hours per week: 4
No. of Credit: 4

Unit I

Semiconductors: General properties of semiconductors, Elemental and compound semiconductors, band structure of real semiconductors.
Intrinsic semiconductors: Carrier concentration, Fermi energy, extrinsic semiconductors: Binding energy of impurity, impurity levels, Population of impurity levels, carrier concentration, Fermi energy and its dependence on impurity concentration and temperature.

12 Hours

Unit II

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.

12 Hours

Unit III

Low-dimensional semiconductor structures: Metal-oxide-semiconductor junction, Inversion layer, quantum well. Modulation doping, quantum well wire, quantum dot and superlattice. Two – dimensional electron gas, energy levels and density of states. Quantum Hall effect (qualitative)

Thin Film Physics: Preparation : Thermal evaporation spray pyrolysis and spin coating.Epitaxial growth and Chemical vapor deposition, methods. MBE, MOCVD, Thickness measurements: Electrical methods, (resistivity and capacitance measurements), Optical methods (optical absorption and interference) and vibrating quartz crystal method.

12 Hours

Unit IV

Semiconductor Devices: p-n junction in e Metal-oxide-semiconductor junction quilibrium : Space charge region, barrier potential, barrier thickness, contact field, junction capacitance and its determination, potential diagram of p-n junction.
p-n junction in non – equilibrium: generation and recombination current. Continuity equations, current voltage relation, saturation current, tunnel diode, Gunn diode, semiconductor lasers, LED and photocell.

12 Hours

Text Books

1. Solid State and Semiconductor Physics : J. P. McKelvey, Harper and Row, New York (1966)
2. Solid State Physics: N. W. Aschroft and A. S. Mermin, Saunders College Publishing, New York (1976).
3. The Physics of Low Dimensional Semiconductors: J. H. Davies. Cambridge University press, (1998).
4. Elementary Solid State Physics: M.A. Omar, Addison – Wesley Pvt.Ltd., New Delhi (1993).
5. Thin Film Phenomena: K. L. Chopra. Mc Graw – Hill Book Company, New York (1969).

Reference Books

1. Elements of Solid State Physics (2nd Ed): J.P. Srivastava, PHI Learning Pvt. Ltd., New Delhi (2009)
2. Physics of Thin Films: L. Eckertova, Cambridge University Press, Cambridge (1998).

Course PHST 4.3: Atomic and Molecular Physics - III
(Molecular Spectroscopy of Polyatomic molecules)

Teaching hours per week: 4
No. of credits: 4

Unit I

Molecular Symmetry: Point Groups, symmetrically equivalent atoms.
Rotational Spectra: Classification of molecules as rotors: Linear, Symmetric top, Spherical top, Asymmetric top molecules. Energy levels: thermal distribution, symmetry properties and statistical weights of rotational levels, Spectrum; IR and Raman spectra.

12 Hours

Unit II

Molecular Vibrations: Separation of rotational and vibrational motions; the secular equation for small vibrations (classical treatment). Normal modes of vibration. Normal coordinates. Simple illustrations. Internal coordinates, symmetry co-ordinates, determination of number of normal co ordinates (symmetry species). Potential energy functions and force fields.

12 Hours

Unit III

Vibrational Energy levels and Selection Rules: The Schrodinger's vibrational wave equation. Energy levels, Vibrational Spectra and Degeneracy. Symmetry properties of wave functions, overtones, combinations, components of electric dipole moment, and the polarizability. Selection

Rules for Infrared and Raman Spectra. The rule of mutual exclusion. Group frequencies; the Product rule; Fermi resonance.

12 Hours

Unit IV

Electronic Structure & Spectra: Classification of Electronic States based on angular momentum, spin, multiplet components. Types of electronic transitions; Allowed transitions, general selection rules, spin selection rules. Forbidden transitions: Magnetic and electric quadrupole transitions.

12 Hours

Text Books

1. Molecular Vibrations: E. Bright Wilson, J. C. Decius, P. C. Cross, Dover Pub., Inc., N.Y. (1955)
2. Introduction to the theory of Molecular Vibrations and Vibrational Spectroscopy: L A Woodward, Clarendon Press, Lon, (1976)
3. Vibrational Spectroscopy – Theory and Applications : D. N. Sathyanarayana, New Age International Pub., New Delhi (1996)
4. Fundamentals of Molecular Spectroscopy: C. N. Banwell, Tata Mc Graw-Hill, New Delhi (1983)
5. Molecular Spectra and Molecular Structure(Vol.III)-Electronic Spectra & Electronic Structure of Polyatomic Molecules : G. Herzberg, D. van Nostrand & Co. N. J. (1966)

Reference Books

1. Molecular Spectra and Molecular Structure(Vol.II)-Infrared & Raman Spectra of Polyatomic Molecules : G. Herzberg, D. Van Nostrand & Co. N. J. (1945)
2. Atoms & Molecules : Mitchel Weissbluth, Academic Press, N. Y. (1978)
3. Raman Spectroscopy: D. A. Long, McGraw-Hill, NY (1977).
4. Introduction to Infrared and Raman Spectroscopy: N.B. Colthup, L. H. Daly and S.E. Wiberley, Academic Press, N. Y. (1975)
5. Vibrating Molecules : P. Gans, Chapman & Hall, London (1971)
6. Vibration Spectra and Structure Vol. 4 : (Ed) J. R. Durig, Elsevier Sci. Pub. Co. N. Y. (1975).
7. Microwave Spectroscopy: C.H.Townes and Arthur Schawlow, McGraw Hill, 1955.

Course PHST - 4.3: Nuclear & Particle Physics – III

Teaching hours per week: 4
No of Credits: 4

Unit I

Nuclear Models

Shell model: evidences for nuclear shell structure-energy levels according to the infinite square well potential and harmonic oscillator potential, effect of spin orbit interaction, prediction of ground state spin – parity of odd A nuclei and odd-odd nuclei – Nordhiem's rules,

Collective Model: Evidences for collective motion, vibrational energy levels of even nuclei. Rotational energy levels of deformed even-even nucleus, moment of inertia-rigid body value, back bending, spectrum of odd A nuclei,

Nilsson model: Calculation of energy levels and prediction of ground state.

12 Hours

Unit II

Nuclear Reaction I: Comparison of features of compound nucleus model and direct reaction model. Partial wave analysis of nuclear reactions, expressions for scattering and reaction cross sections and their interpretation – shadow scattering – resonance theory of scattering and absorption – overlapping and isolated resonance – Briet –Wigner formula for scattering and reaction shape of cross section curve near a resonance. Inverse nuclear reactions – principle of detailed balance–optical model–mean free path – optical potential and its parameters for elastic scattering.

12 Hours

Unit III

Nuclear Reaction II: Transfer reactions – semi-classical description – plane wave Born approximation (PWBA) – its predictions of angular distributions – distorted wave Born approximation (DWBA)- spectroscopic factors – transfer reactions and the shell model.
Heavy ion reactions: Importance of heavy ion reactions, Elastic scattering; critical angle, deflection function, Rainbow scattering and diffraction.. Nuclear and Coulomb scattering and its experimental results, compound nucleus formation, formation of nuclear molecule, fusion of heavy ions and formation of super heavy nuclei in heavy ion reactions.

12 Hours

Unit IV (Newly Added)

Particle Physics: Weak interactions Weak decays, neutral Kaons, the Ko Ko systems, regeneration of short lived component of neutral kaons, lifetimes and cross sections, Feynman diagrams, leptonic, semi leptonic and non leptonic processes, verification of electromagnetic and weak interactions intermediate vector bosons, quark flavour changing interactions with examples, muon decay – Fermi's four particle coupling and modern perspective with a mediating vectorboson, W and Z bosons; their masses and range of weak interactions. Charged weak interactions of quarks: Cabibbo factor, GIM mechanism (Glashow Iliopoulos Miani mechanism) Neutral kaons: CP as a symmetry, CP violation in neutral kaon decay (Fitch Cronin experiment), CPT theorem (qualitative),evolution of a neutral kaon beam with time, regeneration experiments.

12 Hours

Text Books

1. Nuclear Physics : Theory and Experiment : R.R.Roy and B. P. Nigam, Wiley Eastern Publications (1986)
2. Atomic and Nuclear Physics volume II : S. N. Goshal, S. Chand and company (1998)
3. Introductory Nuclear Physics : K. S. Krane, Wiley and sons (1988)
4. Nuclear Reaction with heavy Ions : Reiner Bass, Springer – Verlag (1980)
5. Heavy Ion Reaction : R. A. Broglia and Aage Winter, Addison Wesley (1991)
6. Nuclear reaction : R. Sing and S. N. Mukherjee, New Age International (1996)
7. Nuclear Physics Experimental & Theoretical: H.S. Hans, New Age International, (2001)

Reference Books

1. Subatomic Physics : Nuclei and Particles (Volume II) : Luc Valentin North Holland (1981)
2. Subatomic Physics (Second Edition) : Hans Frauenfelder and E. M. Henley, Prentice Hall (1991)
3. Introduction to Nuclear Physics : Herald. A. Enge Addison-Wesley (1983)
4. Introduction to Nuclear Physics : Samuel S. M. Wong Prentice – Hall (1996)
5. Atomic Nucleus : R. D. Evans, Tata McGraw-Hill (1982)
6. Theoretical Nuclear Physics Volume I : Nuclear structure : Amos de Shalit and Herman Feshbach, John Wiley (1974)
7. Nuclear and Particle Physics: W. Burcham and M. Jobes, Addison – Wesley (1998).
8. Introduction to Elementary Particles, D. Griffiths: John Wiley, 1987.
9. Quarks and Leptons, F. Halzen&A.D. Martin, John Wiley & Sons, New York, 1984.
10. Unitary Symmetry and Elementary Particles, D. B. Lichtenberg:2nd edition, Academic Press, 1978.
11. Elementary Particles, J. M. Longo:II edition, Mc Graw-Hill, New York, 1973.
12. Particles and Nuclei: Povh, Rith, Scholz, Zetsche, Springer (1999)
13. Subatomic Physics: Hans Frauenfelder and Ernest M. Henley, Prentice Hall (1991)
14. Introduction to High Energy Physics: Donald H. Perkins, Addison Wesley Publishing, (1987)

Course PHST 4.4: Electronics – IV

Teaching hours per week: 4
No. of credits: 4

Unit I

Amplitude Modulation: Amplitude Modulation, Theory, Frequency spectrum of the AM wave, Representation of AM, Power relations in the AM wave, Generation of AM, Basic requirements, Modulated transistor amplifiers, Single Sideband Techniques, Evolution and Description of SSB, Suppression of Carrier, Effect of nonlinear resistance on added signals, balanced modulator, Suppression of unwanted Sideband, filter system, phase shift method, The "third" method, System evaluation and comparison, Vestigial sideband transmission, AM transmitter and receiver, TRF and super heterodyne receivers, SNR in DSBSC and SSBSC systems.

12 Hours

Unit II

Frequency Modulation: Theory of Frequency and Phase Modulation, Description of Systems, Mathematical Representation of FM, Frequency Spectrum of FM Wave, Phase Modulation, Intersystem Comparisons, Noise and Frequency Modulation, Effects of Noise on Carrier Noise Triangle, Pre emphasis and De emphasis, Comparison of Wideband and Narrowband FM, Stereophonic FM Multiplex System, Generation of Frequency Modulation, Direct Methods, Stabilized Reactance Modulator AFC, Indirect Method, Basic FM demodulators

12 Hours

Unit III

Analog Pulse Modulation: Sampling theorem for band pass signals, Pulse Amplitude modulation: generation and demodulation, PAM/TDM system, PPM generation and demodulation, PWM, Spectra of Pulse modulated signals, SNR calculations for pulse modulation systems. Waveform coding: quantization, PCM, DPCM, Delta modulation, Adaptive delta modulation Design of typical systems and performance analysis.

12 Hours

Unit IV

Pulse Shaping, Nyquist criterion for zero ISI, Signaling with duobinary pulses, Eye diagram, Equalizer, Scrambling and descrambling. Signal space concepts: geometric structure of the signal space, L2 space, distance, norm and inner product, orthogonality Base band pulse data transmission: Matched filter receiver, Inter symbol interference, Gram Schmidt Orthogonalization Procedure.

Digital modulation schemes: Coherent Binary Schemes: ASK, FSK, PSK, MSK. Coherent M-ary Schemes, Calculation of average probability of error for different modulation schemes.

12 Hours

Text books

1. Electronic communications, 4th edition: Dennis Roddy and John Coolen, Prentice – Hall of India Pvt. Ltd. New Delhi (1997)
2. Modern Communication Systems – principles and applications: Leon W. Couch II, Prentice Hall of India Pvt. Ltd. New Delhi (1998).
3. Electronic Communication systems – 4th edition: George Kennedy and Bernard Davis, Tata McGraw – Hill Publishing Company Ltd., New Delhi (1999).

4. Communication Systems, 3rd ed., Simon Haykin, John Wiley & Sons.
5. Modern Digital and Analog Communication, 3rd Ed., B.P. Lathi, Oxford University Press.

Reference books

1. Communication Systems: Simon Haykin, Wiley Eastern Ltd., New Delhi (1978).
2. Radio Engineering: G. K. Mittal, Khanna Publishers, Delhi (1998).

Course PHST 4.4: Condensed Matter Physics – IV

Teaching hours per week: 4
No of Credits: 4

Unit I

Superconductivity: Occurrence of superconductivity, destruction of superconductivity by magnetic field, heat capacity and energy gap, microwave and infrared properties, type I and type II superconductors, high Tc superconductors (qualitative ideas only).
Thermodynamics of superconductivity, London equations, coherence length, flux quantization in superconducting ring, duration of persistent current.

12 Hours

Unit II

BCS Theory: Attraction between Cooper – pairs, accomplishments of BCS theory.
Tunneling: Basic concepts of tunneling, metal-insulator tunneling, metal insulatorsuperconductor tunneling, supercondutror-insulator-superconductor tunneling, Cooper-pair tunneling, A. C. and D. C. Josephson effect, macroscopic quantum interference.

12 Hours

Unit III

Amorphous Semiconductors: Preparation of amorphous semiconductors, classification, band structure, electronic conduction, optical absorption, electrical switching (Ovonic diode).

Polymers: Basic concepts, classification of polymers, effect of temperature, mechanical properties of general polymers. Conducting polymers, classes, synthesis, charge transport mechanism.

Liquid crystals: Classification, orientational order and inter-molecular forces, magnetic effects, optical properties and general applications.

12 Hours

Unit IV

Nanostructured materials: Introduction, electronic and optical properties: quantum confinement effect. Synthesis of nanoparticles: gas phase and colloidal synthesis. Carbon based nanomaterials: qualitative ideas of carbon nanotubes and graphene. Magnetic nanostructures. Applications of nanomaterials.

Characterization techniques: X-ray diffraction, optical spectroscopy,scanning electron and transmission electron microscopies. The basic concepts of scanning tunneling and atomic force microscopies.

12 Hours

Text Books

1. Introduction to Solid State Physics: C. Kittel, Editions: 2,5,6,7, Wiley Eastern Ltd., Bangalore.
2. Elementary Solid State Physics: M.A. Omar Addison-Wesley Pvt. Ltd., New Delhi, (2000).
3. Amorphous Semiconductors: D. Adler, CRC, London, (1972).
4. Introduction to Nanotechnolgy: C.P. Poole Jr. and F.J. Owens, John Wiley and Sons, Singapore (2006).
5. Nano: The Essentials: T. Pradeep, Tata McGraw-Hill Publishing New Delhi (2007).

Reference Books

1. Solid State Physics : A. J. Dekker, Macmillan India Ltd., Bangalore (1981)
2. Solid State Physics: F. W. Aschroft and N. D. Mermin, Saunders College Publishing, New York, (1976).
3. Electronic processes in Non-Crystalline Materials : N. F. Mott and E. A. Davis, Clarendon press, Oxford, (1979).
4. Nanoscale Materials – (Ed) L.M. Liz-Marzan and P.V.Kamat, (Kluwer, 2003)
5. Nanostructured Materials and Nanotechnology, (Ed) H.S.Nalwa, (Academic,2002)
6. Elements of Solid State Physics (2nd Ed): J.P. Srivastava, PHI Learning Pvt. Ltd., New Delhi (2009)
7. Solid State Physics, J.D. Patterson and B.C. Bailey, Springer Verlag, Berlin (2007)

Course 4.4: Atomic & Molecular Physics IV
(Lasers, Nonlinear Optical Effects and Laser Spectroscopy)

Teaching hours per Week: 4
No. of Credits: 4

Unit I

Laser Amplifiers: Requirements for population inversions for Two , Three and Four level systems:necessary and sufficient conditions for laser action, threshold requirements for laser action with and without cavity, rate equations. Pumping requirements and techniques.

Laser Resonators: Longitudinal and transverse modes: Fabry Perot resonator, its cavity modes. Properties of modes: spatial dependence, frequency dependence and mode competition. Spherical, Plane parallel, confocal resonator and unstable resonators. Stability stability criteria, properties of Gaussian beams. Q switching and mode locking:general techniques and examples.

12 Hours

Unit II

Lasers with low density gain media: General description, laser structure, excitation mechanism and applications of Copper vapor laser, Helium-Cadmium laser, Argon and Krypton ion lasers. Nitrogen laser, Carbon-dioxide laser, Excimer laser, X-ray laser, and Free Electron laser.

12 Hours

Unit III

Lasers with high density gain media: General description, laser structure, excitation mechanism and applications of Dye lasers, Neodymium YAG and Glass lasers, Alexandrite laser, Titanium sapphire laser, Fiber lasers and semiconductor diode lasers(homo and hetero junction and quantum well lasers)

12 Hours

Unit IV

Nonlinear Optical Effects: Wave propagation in an anisotropic crystal, Second harmonic generation, Phase matching, Parametric oscillation, Self focusing light.

High Resolution Spectroscopy: Idea of hole burning, the Lamb dip, Inverse Lamb dip, stabilization of frequency. Doppler free and Doppler limited Spectroscopy. Two photon spectroscopy.

Laser Raman Spectroscopy: Hyper Raman spectroscopy, Stimulated Raman effect, Inverse Raman effect, CARS (Coherent Anti Stokes Raman Spectroscopy).

12 Hours

Text Books

1. Laser and Non Linear Optics: B.B.Laud, Wiley Eastern Ltd., New Delhi(1991)
2. Laser Electronics: Joseph T. Verdeyen, Prentice Hall of India Pvt Ltd. New Delhi.
3. Introduction to Fiber Optics: A. Ghatak & K. Thagarajan, Cambridge Univ. Press (1999)
4. Lasers: Theory of Applications: A. Ghatak & K. Thagarajan, MacMillan India (1981)
5. Modern Spectroscopy (4th ed), J.Michael Hollas, John Wiley, 2004.

6. Optical Fiber & Communication Principles & Practice: John M. Senior, Prentice Hill Intl. Ltd. London (1992)
7. Laser Fundamentals: W. Silfvast, Cambridge Univ. Press.

Reference Books

1. Principles of Lasers: O. Svelto, Plenum Press, N.Y(1982)
2. Introduction to Gas Lasers Population Inversion Mechanisms: C.S.Willet, Permon Press, Oxford (1974)
3. High Resolution Spectroscopy: K. Shimoda, Springer Verlag, Berlin (1976)
4. Raman Spectroscopy: D.A. Long, McGraw Hill Intl. Book Co (1977)
5. Laser Principles & Applications: J. Wilson & J.F.B. Hawkes, Prentice Hall Intl. Inc.(1983)
6. Encyclopedia of Lasers & Optical Technology: Robert A. Meyers, Academic Press, Cal.(1991)
7. Laser Spectroscopy: H. Walther, Springer Verlag, Berlin (1976)

Course PHST 4.4: Nuclear & Particle Physics – IV

Teaching hours per week: 4
No of Credits: 4

Unit I

Nuclear Fission: Bohr-Wheeler theory of nuclear fission, saddle point, scission point, barrier penetration, shell correction to the liquid drop model, Strutinsky's smoothing procedure, evidence for the existence of second well in fission isomers. Nuclear fission with heavy ions. Nuclear fission-fission time scale.
Nuclear Fusion: Basic fusion processes, characteristics of fusion, fusion in stars. Controlled thermonuclear reactions. magnetic pressure, pinch effect, magnetic confinement systems for controlled thermonuclear fusion.

12 Hours

Unit II

Slowing down of Neutrons: Slowing down of neutrons by elastic collisions, – logarithmic decrement in energy, number of collisions for thermalization, slowing down power, moderating ratio.

Neutron diffusion: Elementary theory of diffusion of neutrons, spatial distributions of neutron flux (I) in an infinite slab with a plane source at one end (II) in an infinite medium with point source at the center – reflections of neutrons – albedo.

Reactor Theory: 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 – Classification of reactors – thermal neutron and fast breeder reactors.

12 Hours

Unit III

Beta decay: Classification of beta transition on the basis of ft values, selection rules and shapes of beta spectra. Universal fermi interaction.. The neutrino in beta decay-inverse beta decay processes- detection of neutrino; Cowan and Reins experiment, determination of neutrino mass, different types of neutrinos, Symmetry breaking in beta decay- parity operation: relevance of psedoscalar quantities. The Wu-Ambler experiment and fall of parity conservation. Discovery of W and Z bosons. Double beta decay, beta delayed nucleon emission .Elementary theory of K-electron capture.

12 Hours

Unit IV

Gamma decay: 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. Elementary theory of internal conversion and discussion of experimental results. Lifetime measurements, the angular correlation for dipole-dipole transitions, gamma-gamma correlation studies. Polarization of gamma radiation.

12 Hours

Text Books

1. Structure of the Nucleus: M. A. Preston and R.K. BhaduriAddision – Wesley (1975).
2. Nuclear Physics Vol. II: S. N. Goshal. S. Chand and Company (2013).
3. Introductory Nuclear Physics : Kenneth S. Krane, John Wiley and sons (1998)
4. SubatomicPhysics: Nuclei and Particles (Volume – II): Luc Valentin North Holland (1981).
5. Introduction to Neutron Physics: L. F. Curtis, East west press (1958).
6. Nuclear Reactor Engineering: Glasstone S and Sesonske A, CBS, Delhi, (1994)

Reference Books

1. Theoretical Nuclear Physics: J. M. Blatt and V. F. Weisskoff, Wiley (1992).
2. Subatomic Physics (Second Edition) : Hans Frauenfelder and E.M.Henley, Prentice Hall (1991)
3. Introduction to Nuclear Physics: Herald. A. Enge, Addison-Wesley (1983).
4. Introductory Nuclear Physics: Samuel S. M. Wong, Prentice – Hall (1996).
5. Reactor Physics: Zweifel P F, International student Edn. (McGraw Hill, 1973)

Course PHSP – 4.5: Electronics Practical – III

Contact hours per week: 4
No. of Credits: 4

(8085 Interfacing)

1. Stepper motor interface
2. ADC and DAC circuit interfacing

(8085 programming)

1. Mathematical operations, block transfer and sorting of 8-bit data
2. Mathematical operations with 16-bit data
3. Code conversion methods
4. 8085 Interrupts and subroutines

(New experiments /Assignments may be added)

References books

1. Microprocessor Architecture, Programming, and Applications with 8085/8080 A: Ramesh S. Gaonkar, New Age International Publishers Ltd.
2. Microcomputer theory and Applications: Rafiquzzaman Mohamed, John Wiley and Sons, New York (1987)
3. Introduction to Microprocessors (3rd Edition): Aditya P. Mathur, Tata – Mc Graw – Hall Publishing Company Ltd., New Delhi (1989)
4. Modern Digital and Analog Communication, 3rd Ed., B.P. Lathi, Oxford University Press.

Course PHSP 4.5: Condensed Matter Physics Practical – III

Contact hours per week: 4
No. of Credits: 4

1. Indexing of hexagonal systems.
2. Precise parameter determination:
    a. Extrapolation method.
    b. Cohen's method
3. Structure determination of CdTe.
4. Universal curves for ferromagnets
5. Determination of skin depth
6. Phase transition in ferroelectric crystals
7. Temperature dependence of susceptibity of a paramagnetic substance
8. Characteristics of a solar cell
9. Defect formation energy in metals
10. Diamagnetic susceptibility of water molecule.
11. Fermi energy of copper
12. Dielectric constant of non polar liquids (benzene)

13. Dipole moment of organic molecule (acetone)
14. BH curve using integrator

(New experiments/assignments may be added)

Reference Books

1. X ray diffraction: B.D. Cullity, Addison Wesley, New York (1972).
2. X ray diffraction procedures: H.P. Klug and L.E. Alexander, John Wiley and sons, New York.
3. Interpretation of X ray powder diffraction pattern: H.P. Lipson and H. Steeple, Macmillan, London (1968).
4. Introduction to Solid State Physics : 5th Edn C. Kittel, Wiley Eastern Ltd., Bangalore (1976)
5. Elementary Solid State Physics : M. A. Omar, Addison Wesley Pvt. Ltd., New Delhi (2000)
6. Introduction to magnetochemistry: A. Earnshaw, Academic press, London (1968).
7. Solid State Physics : A. J. Dekker, Macmillan India Ltd., Bangalore (1981)
8. Solid State Physics : N. W. Aschroft and A. D. Mermin, Saunders College Publishing New York (1976)

Course PHSP 4.5 –Atomic & Molecular Physics Practical – III

Contact hours per week: 4
No. of Credits: 4

1. Rotational analysis of (0, 0) band of BeO:
2. Study of Spatial and Temporal Coherence of He-Ne Laser:
3. Determination of refractive index of the material using He-Ne Laser
4. Study of Absorption spectra on a Single Beam Spectrophotometer
5. Fiber Optic Sensors
6. Vibrational analysis of emission bands of N2.
7. Rotational spectral analysis of N2
8. Measurements of Emission spectra on USB Spectrometer
9. Vibrational Analysis of Emission band spectrum of C2

(New Experiments / Assignments may be added)

Reference Books

1. Experimental Spectroscopy (3rd Edition) : R. A. Sawyer. Dover Publication, Inc, New York (1963).
2. Atomic Spectra and Atomic Structure (2nd Edition) – G. Herzberg. Dover Publication New York (1944)
3. Atomic Spectra – H.E. White, Mc Graw –Hill, New York (1934).
4. A Course of Experiments with He-Ne Lasers (2nd Edition): R. S. Sirohi. Wiley Eastern, New Delhi (1991).
5. Principles of Lasers: Svelto. O, Plenum Press New York (1982).

6. Lab. Manuals.
7. Molecular Spectra & Molecular Structure Vol. I : G. Herzberg, D. Van Nostrand Co, New York (1950)
8. Instrumental Methods of Analysis : H. H. Willard, L. L. Merrit, J. A. Dean and F. A. Settle, J. K. Jain for CBS Publishers (1986)
9. The Identification of Molecular Spectra: R.W. B. Pears & A. G. Gaydon, Wiley, New York (1961).
10. Fiber Optic Laboratory Experiments : Joel N.G

Course PHSP 4.5: Nuclear & Particle Physics Practical III

Contact hours per week: 4
No of Credits: 4

1. Z dependence of external bremsstrahlung
2. Anthracene crystal beta ray spectrometer
3. Electron capture transition energy using internal bremsstrahlung
4. Coincidence circuit
5. Si(Li) beta ray spectrometer
6. Digital to analog converter circuits
7. Half life of 40K
8. Gamma gamma angular correlation
9. Nuclear reaction analysis
10. Schmidt trigger circuit using transistors and IC 555
11. Charge sensitive pre amplifier using LF 357
12. Function generator using IC 741

(New experiments/assignments may be added)

References

1. Experiments in Modern Physics: A.C. Melissions, Academic Press (NY) (1966).
2. Experiments in Nuclear Science, ORTEC Application Note. ORTEC, (1971)
3. (Available in Nuclear Physics Laboratory).
4. Practical Nucleonics: F. J. Pearson., and R. R. Osborne, E & F. N. Spon Ltd., London (1960).
5. The Atomic Nucleus: R. D. Evans, tata Mc Graw Hill Pub. Comp. Ltd. (1960).
6. Nuclear Radiation Detectors: R. D. Kapoor and V. S. Ramamurthy, Wiely Eastern Limited (1986).
7. Experimental Nucleonics : E. Bleuler and G. J. Goldsmith, Rinehart & Co. Inc. (NY)
8. (1958)
9. A manual of experiments in reactor physics: Frank A. Valente the Macmillan company
10. (1963).
11. A practical introduction to electronic circuits: Martin Harthley Jones Cambridge University Press (1977).
12. Integrated Circuit Projects: R. M. Marston Newnes Technical Books (1978).

13. Semiconductor Projects: R. M. Marston A Newnes Technical Books (1978).
14. Linear Integrated Circuits: D. Roy Choudhary and Shail Jain, New Age International (1995).
15. Op-Amps and Linear Integrated Circuits: Ramakanth A Gayakawad, Prentice-Hall of India (1995).
16. Op-Amps and Linear Integrated Circuits: Ramakanth A Gayakawad, Prentice Hall of India (1995).

Course SPJ4.6 – Project

Contact hours per week: 6
No of Credits: 6

Course SPJ4.6 – Project in Electronics

Topic(s) for the project may be selected in consultation with the project supervisor.

Reference/Text books to be recommended by the Course Teacher

Course PH SPJ 4.6: Project in Solid State Physics

Topic(s) for the project may be selected in consultation with the project supervisor.

Reference/Text books to be recommended by the Course Teacher

Course PHSPJ 4.6 – Project in Atomic & Molecular Physics

Topic(s) for the project may be selected in consultation with the project supervisor.

Reference/Text books to be recommended by the Course Teacher

Course PHSPJ 4.6Project in Nuclear and Particle Physics

Topic(s) for the project may be selected in consultation with the project supervisor.

Reference/Text books to be recommended by the Course Teacher

OPEN ELECTIVE COURSES IN PHYSICS

Course PHET 2.4: Elective I – Modern Physics

Teaching hours per week: 04
No. of Credits per week: 04

Unit I

Blackbody Radiation: Nature of Blackbody spectrum; classical radiation laws and their limitations; Planck's radiation law and quantum hypothesis. Simple examples/problems.

The Photoelectric Effect: Apparatus used to study the Photoelectric Effect; laws of Photoelectric Effect; Einstein Photoelectric Equation. Simple examples.

X-Rays: Nature and production of X rays; the Bragg law; Bragg X ray crystal spectrometer.

The Compton Effect: X ray Compton scattering from an electron; experimental set up for Compton scattering. Simple problems.

12 Hours

Unit II

Atomic Structure: Hydrogen spectrum; the Bohr model; experimental measurement of the Rydberg constant; Franck Hertz experiment.

Matter Waves: The de Broglie wavelength and its relation with the Bohr model; Davisson Germer experiment. Heisenberg Uncertainty principle: Momentum position and Energy time relations. Simple examples.

Quantum Physics: Idea of wave function and probability. One dimensional Schrödinger wave equation: Its application to the particle in a box and Hydrogen atom; energies and wave functions.

Vector Model: Space quantization: Orbital angular moment and magnetic moment; Spin angular moment and magnetic moment; Stern Gerlach experiment. States of Hydrogen in terms of n, l, ml. The normal Zeeman Effect; experimental set up for Zeeman effect. Simple problems.

12 Hours

Unit III

Statistical Physics: Distinguishability and Indistinguishability; Maxwell Boltzmann distribution for gas molecules; vrms; Equipartition theorem. Quantum statistics: F D and B E distributions.

Molecular Structure: Bonding mechanisms: Ionic bonds; Covalent bonds; the Hydrogen bond; Van der Waals bonds. Molecular vibration and rotation spectra. Molecular orbitals: Hydrogen molecular ion and molecule; bonding in complex molecules.

Solid State Physics: Ionic solids; covalent solids; metallic solids; molecular crystals; amorphous solids. Classical models of electrical and heat conductivities in solids; Ohm's Law; Wiedemann Franz law; the quantum view point.

Lasers: Absorption, Spontaneous and Stimulated emissions; Population inversion; laser action;

typical gas (He Ne/CO_2) characteristics.

12 Hours

Unit IV

Magnetism; Magnetic moment; Magnetization. Magnetic materials: Diamagnetic, paramagnetic and ferromagnetic materials. Superconductivity phenomenon.

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

Nuclear Fission / Fusion: Fission – Basic process; a simple model; a typical nuclear reactor. Fusion: basic process; stellar energy.

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

12 Hours

Text Books

1. Modern Physics (2nd Ed) Serway, Moses and Moyer, Saunders College Pub, 1997.
2. Fundamentals of Physics extended with Modern Physics (4th Ed) Halliday, Resnick and Walker, John Wiley, 1993.

Course PHET 3.4 Elective II
Course PHET 3.4a: Instrumental Methods

Teaching hours per week: 4
No. of Credits per week: 4

Unit I

Electronic instruments for measurement – Single and dual power supply units. Digital voltmeter principles of electronic multimeter, digital multimeter, Q meter, Power meter, Electronic LCR meter, Frequency & time interval counters. Electronic instruments for signal generation & analysis – Function generators, Pulse generators, Frequency synthesizer, Principles & applications of cathode ray oscilloscope.

12 Hours

Unit II

UV/Visible Absorption Spectrometry: Concept of electronic energy levels, transitions, Beer's law and its limitations. Instrumentation: Components of Colorimeter, Single beam spectrometer, Double beam spectrophotometer; principle, construction and working, sampling technique; Applications.

Infrared Absorption Spectrometry: Concept of molecular vibrational energy levels, transitions. Instrumentation: Components of single beam and double beam spectrometers; principle, construction, working, sampling technique; Applications

12 Hours

Unit III

Fluorescence Spectrometry: Fluorescence and Phosphorescence phenomena(with energy level diagram). quantum yield, fluorescence quenching, rate parameters, radiative and natural lifetime. Fluorimeter: Basic components, principle, construction, working, sampling technique; Applications.

Nuclear Magnetic Resonance Spectrometry: Principle of resonance; the chemical shift. Components of NMR spectrometer: principle, construction, working, sampling technique; Applications.

12 Hours

Unit IV

Radioactivity and its Applications
Radioactivity: Unit of radioactivity, source strength, production and decay of radioactivity, alpha decay, beta decay, gamma decay, natural and artificial radioactivity, Geiger counter, NaI(Tl) detector.
Applications of Nuclear Physics: Trace element analysis, mass spectrometry with accelerators. Alpha decay application, diagnostic nuclear medicine, therapeutic nuclear medicine, food preservation, plant metabolism.

12 Hours

Text Books

1. Cooper W. Electronic Instrumentation & Measurement Technique – Prentice Hall of India.
2. George C. Barney, Intelligent Instrumentation – Prentice Hall India
3. Instrumental Methods of Analysis : H. H. Willard, L. L. Merrit, J. A. Dean and F. A. Settle, J. K. Jain for CBS Publishers (1986)
4. Principles of Instrumental Analysis (5th ed) : D. A. Skoog, F. J. Holler & T. A. Nieman, Harcourt Asia Pte. Ltd. (1998)
5. Fundamentals of Molecular Spectroscopy : C. N. Banwell and E.M. McCash, Tata Mc Graw Hill Co., 4th revised edition, (9th reprint, 2000).
6. Introductory Nuclear Physsics: Kenneth s Krane, John Wiley and Sons (2005).

Course PHET 3.4 Elective II:

Course PHET 3.4b: Physics of Nanomaterials

Teaching hours per week: 4
No. of Credits per week: 4

Unit I

Basics of nanoscience: The nanoscale, historical background, quantum confinement, size dependent properties, types of nanomaterials, fullerenes, nanowires, nanotubes, thin film.

Basic quantum mechanics: Wave particle duality, Heisenberg uncertainty principle Schrödinger equation solution of one dimensional time independent equation, particle in a one dimensional box; density of states for zero , one , two and three dimensional box; particle in a coulomb potential. Tunneling of a particle through potential barrier

12 Hours

Unit II

Synthesis of nanomaterials: Physical methods mechanical ball milling, melt mixing; evaporation ion sputtering, laser ablation, laser pyrolysis, chemical vapour deposition, molecular beam epitaxy.

Chemical methods: colloidal synthesis and capping of nanoparticles. Types of nanoparticles metals, semiconductors, graphene, carbon nano tubes etc.

12 Hours

Unit III

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

12 Hours

Unit IV

Properties of nanomaterials: Mechanical; Electrical classification metals semi conductors, insulators, band structures; mobility, resistivity, Hall effect, magneto resistance; Optical optical absorption and transmission, photoluminescence, electro luminescence, thermoluminescence; Magnetic magnetism and types of magnetic materials dia , para , ferro , antiferro ; nano magnetism.

12 Hours

Text books

1. Nanotechnology: Principles and practices, S. K Kulkarni, Capital Publ. Co., New Delhi (2007)

2. Nanocrystals : Synthesis, Properties and Applications, C.N.R.Rao, P. John Thomas and G.U. Kulkarni, Springer series in Materials Science 95, Springer Verlag, Berlin, Heidelburg (2007).

Reference books

1. Quantum Mechanics – Vol 1 & 2, Cohen, Tannoudji
2. The Physics and Chemistry of Solids, Stephen Elliot & S.R. Elliot
3. Solid State Physics A.J. Dekker
4. Introduction to Nanotechnology Charles P.Poole Jr and Franks J. Owens
5. Electronic Transport in macroscopic systems, Supriyo Datta
6. Nanotubes and Naowires CNR Rao and A Govindaraj, RCS Publishing.
7. From Atom to Transistor Supriyo Datta
8. Encyclopedia of Nanotechnology Hari singh Nalwa