Detailed Syllabi

Semester I

PD-101 Physics I (L2-T0-P1-CH4-CR3)

Coordinate systems, elements of vector algebra in plane polar, cylindrical, spherical polar coordinate systems,

Gradient, divergent, curl, line integrals, Stoke's theorem, Gauss' theorem,

Dimensional analysis, solutions for one-dimensional equation of motion in various forms, Frames of reference, relative velocity and accelerations, Elements of special theory of relativity, postulates, Galilean and Lorentz transformations, equivalence of mass and energy, Time dilation, length contraction, Doppler effect, twin paradox, mass energy equivalence, general theory of relativity,

Work-energy theorems, energy diagrams, Conservation of linear and angular momentum and collisions, central forces, motion in non-inertial frames, centrifugal and Coriolis forces, derivations of Kepler's law, hyperbolic, elliptic and parabolic orbits,

Elementary rigid body dynamics, variable mass problems,

Elasticity: Young's, bulk and shear moduli.

Textbooks:

1. Kleppner, D. and Kolenkow, R., *Introduction to Mechanics,* (McGraw-Hill Book Co., Inc, 1973)
2. Resnick, R., *Introduction to Special Relativity,* (Wiley)
3. Mathur, D. S., *Mechanics,* (S Chand & Co Ltd, 2000)

Reference Books:

1. Simon, K. R., *Mechanics,* 3rd edition, (Addison-Wesley Pub. Co., 1971)
2. Kittel, C., Knight, W. D. and Ruderman, M. A., *Mechanics,* 2nd edition, (McGraw-Hill Book Co., Inc., 1973)
3. Chow, T. L., *Mathematical Methods for Physicists: A concise introduction*, 1st edition, (Cambridge Univ. Press, 2000)
4. Riley, K. F., Hobson, M. P. and Bence, S. J., *Mathematical Methods for Physics and Engineering*, 3rd edition, (Cambridge, 2006)
5. Young, H. D. and Freedman, R. A., *University Physics,* 12th edition, (Pearson, 2009)

Laboratory component:

1. Laboratory related Instructions:
    a. Laboratory safety measures; handling of chemicals; electrical and electronics items & instruments; handling of laser and laser related instruments and experiments; handling of Radioactive samples and related instruments; general safety measures etc.
    b. Management and maintenance of laboratory room, equipment etc.
    c. Techniques of data collection, data analysis, measurement of error and error analysis etc.
    d. Technique/ method of notebook record.
    e. To calculate mean, standard deviation for a given measurement data
2. Familiarization with equipment and components:
    a. Familiarization of different Electrical and Electronic components and hence identification & determination of values of unknown components
    b. Familiarization of different Optical components and hence show different optical behaviour & pattern by using different optical components and optical sources (white light, laser, sodium light etc.)
    c. Familiarization of Microsoft excel, Origin and other software for data analysis
    d. Soldering & de-soldering of components in a circuit board
3. Use of equipment:

a. Multimeter and its uses
b. Function generator and its uses
c. CRO and its use to measure the wavelength, frequency, amplitude etc. of a given electrical signal

4. To study the variation of time period with distance between centre of suspension and centre of gravity for a bar pendulum and to determine: (a) Radius of gyration of the bar about an axis through its C.G. and perpendicular to its length, (b) The value of g in the laboratory.
5. Determine the value of the acceleration due to gravity (on Earth) by using Kater's pendulum.
6. To determine the surface tension of the given liquid (water/ CCl4) by capillary tube method.
7. Design a LCR circuit with the given components and to measure the resonance frequency of the circuit.
8. Determine the moment of the given bar magnet and horizontal component of Earth's magnetic field by magnetometers.
9. To measure the focal length of a given lens using (a) Bessel's method, and (b) Magnification method.
10. To obtain the refractive index and dispersion of the material of a 60^0 prism using a spectrometer.

Semester II

PD-102 Physics-II (L2-T0-P1-CH4-CR3)

Electrostatics in vacuum: Coulomb's law, Electric field due to a system of charges, Gauss's law in differential and integral forms, The electric dipole, its electric field and potential, The capacitance of parallel plate, Cylindrical and spherical capacitors,

Magnetic effects in the absence of magnetic media: the Biot-Savart law, the force on a current and on moving charges in a B-field, the magnetic dipole,

The couple and force on, and the energy of, a dipole in an external electric field and in an external magnetic field,

Physics of diodes and transistors, Zener Diodes, Breakdown Mechanism,

Digital Electronics: Number systems, 2's complement method, Boolean algebra, Gates, Universal gates and their applications

Textbooks:

1. Horowitz, P. and Hill, W., *The Art of Electronics*, 2nd edition, (Cambridge University Press, 1995)
2. Milliman, J. and Halkias, C. C., *Integrated Electronics,* (Tata McGraw Hill, 2004)
3. Tocci, R. J. and Moss, G.L. *Digital Systems: Principles and Application,* (Pearson, 2009)
4. Rakshit, P.C. and Chattopadhaya, D., *Electricity and Magnetism,* (New Central Book Agency, 2012)

Reference Books:

1. Malvino A. P., *Electronic Principles*, (McGraw-Hill Education (India) Pvt Limited, 2007)
2. Boylestad, R. and Nashelsky, L., *Electronic Devices and Circuit Theory*, 8th edition, (Pearson Education, India, 2004)

Laboratory component:

1. Determination of Young's modulus of the given wire by torsional oscillation (Searl's) method.
2. Determination of the co-efficient of viscosity of water by Poiseulle's method.
3. Measurement of frequency of an unknown tuning fork using a sonometer.
4. Determine the coefficient of linear expansion of the given metal sample by optical lever method.
5. Study of Lissajous figure of two different waves using CRO and find out the unknown frequency of an electrical signal.

6. Determine the wavelength of the given source of light using Fresnel's biprism.
7. Determination and plot I-V characteristics of a LED.
8. To study elastic and inelastic collisions using suspended spherical balls of different materials.
9. To measure the force between two current carrying conductors.
10. Determine the Mechanical/ Electrical equivalent of heat by Joule's calorimeter.

Semester III

PD-211 Quantum Physics (Non-major) **(L2-T0-P1-CH4-CR3)**

Black body radiation, Kirchhoff's radiation law, Rayleigh-Jeans law, Wien's law, Stefan's law, EM waves, photoelectric effect, wave particle duality, particle properties of waves,

Atomic physics: Rutherford model, Bohr model, hydrogen atom (quantum numbers and spectral series; qualitative), X-ray, Moseley's law,

Limitations of classical physics: Interpretation of spectral lines, the photo-electric effect, Franck-Hertz experiment and the existence of energy levels, Experimental evidence for wave-particle duality; X-ray diffraction and Bragg law, Compton scattering, Electron and neutron diffraction, deBroglie hypothesis, Qualitative discussion of the problem of the stability of the nuclear atom,
Basics of Lasers, Basics particle physics: elementary forces and particles.

Schrodinger equation: The concept of the wave function as a probability amplitude and its probabilistic interpretation. Plane wave solutions of the one-dimensional time-dependent Schrodinger equation for a particle in free space and elementary derivation of the phase and group velocities (quantitative discussion of wave packets is not required).

Uncertainty relation: The position-momentum uncertainty relation and simple consequences, Solutions of the one-dimensional Schrodinger's equation for an infinite square well potential; qualitative treatment of the finite well (derivation not required), Linear harmonic oscillator

Textbooks:

1. Beiser, A., *Concepts of Modern Physics* (McGraw-Hill, 2002)
2. Krane, K. S., *Modern Physics* (Wiley)

Reference Books:

1. Beiser, A., *Perspectives of Modern Physics* (McGraw-Hill Inc., USA)
2. Thornton, S. T. and Rex, A., *Modern Physics for Scientists and Engineers* (Cengage Learning; 4 edition)
3. Gautreau, R., *Schaum's Outline of Modern Physics*, 2nd edition, (McGraw-Hill)
4. Young, H.D. and Freedman, R.A., *University Physics,* 12th edition, (Pearson, 2009)

PD-203 Classical Mechanics (L2-T1-P0-CH3-CR3)

Mechanics of a particle: Conservation theorems for a particle, motion of a particle under damping forces, motion of a particle under central force, motion of a body in a resisting medium, Kepler's laws of planetary motion, moving co-ordinate systems, Galilean transformation, Coriolis force, Foucault's pendulum,

Mechanics of a System of Particles: Centre of mass and its motion, conservation theorems for a system of particles, collision problems, constraints, generalised co-ordinates, configuration space, principle of virtual work, D'Alembert's principle,

Lagrangian Formulation: Lagrange's equation, the rules of forming Lagrange's equation, Lagrange's equations for non-conservative forces, spherical and cylindrical co-ordinates, Hamilton's principle and Lagrange's equation, application of Lagrange's equation, motion of charged particle in an electromagnetic field, superiority of Lagrange's approach over Newtonian approach,

Hamiltonian Formulation: Phase space, Hamiltonian function and Hamiltonian equation, Application of Hamiltonian equation, Harmonic oscillator, compound pendulum, cyclic co-ordinates, Liouville's theorem, Routh's procedure

Textbooks:

1. Upadhyaya, J. C., *Classical Mechanics*, (Himalayan Publishing House)
2. Gupta, S. L., Kumar, V. and Sarma, H. V., *Classical Mechanics*, (Pragati Prakashan)

Reference Books:

1. Goldstein, H., *Classical Mechanics*, (Narosa, 2001)
2. Rana N. C., and Joag, P. S., *Classical Mechanics,* (Tata McGraw-Hill, 1991)
3. Takwale, R. G. and Puranik, P. S., *Introduction to Classical Mechanics,* (Tata McGraw-Hill, 1978)
4. Panat, P. V., *Classical Mechanics*, (Narosa Publishing House)

PD-217 Mathematical Physics-I (L2-T0-P1-CH4-CR3)

Scalar and vector fields, differentiations, divergence and curl; integrations, Greens, Gauss's and Stokes theorems and their applications, transformations of coordinate systems and vector components, metric coefficients, curvilinear coordinates; expressions for grad., div., and curl; Helmholtz equation in three-dimensions and separable variables in various coordinate systems; matrices and determinants,

Beta, gamma and error functions; relationship between the beta and gamma functions; reduction of some classes of integrals to gamma functions; Sterling's formula; derivation of values of gamma functions,

Fourier series: Evaluation of coefficients, graphical representations, even and odd functions, properties of Fourier series, Fourier integrals,

Elements of probability: Mathematical probability, compound probability, total probability, sample space, random variables, expectation value, averages, mean, standard deviation, binomial distribution, normal distribution; variance, covariance and correlation; theory of errors, central limit,

Random Process: Random variables to random process, statistical averages, stationary processes

Textbooks:

1. Harper, C., *Introduction to Mathematical Physics, (*Prentice Hall, 2009)
2. Arfken, G. B., and Weber, H. J., *Mathematical Methods for Physicists*, (Elsevier Ltd, Oxford, 2005)
3. Spiegel, M. R., *Vector Analysis*, Schaum's outline series, (Tata McGraw-Hill 1979)

Reference Books:

1. Marganeau, H. and Murphy, C. M., *The Mathematics of Physics and Chemistry,* (Young Press, 2009)

PD-207 Physics Laboratory-I (L0-T0-P4-CH8-CR4)

1. To observe the rotation of the plane of polarization of monochromatic light by a given solution and to determine the specific rotation of sugar solution using a Polarimeter.
2. Determine the wavelength (λ) of the given monochromatic light by using Lloyd's mirror.
3. To measure thermo e.m.f. of a thermocouple as a function of temperature and find inversion temperature.
4. To measure the radius of curvature of a given concave mirror and to measure the refractive index of a liquid by this method.
5. To measure the inductance of a given inductor using Anderson bridge.
6. To measure the capacitance of a capacitor by de-Sauty method and to find permittivity of air.
7. To study Op-Amp. characteristics:
   a. To get data for different input bias current,
   b. To measure and null the output offset voltage.

8. Determine the efficiency of the given solar cell for different intensity and different frequency of light sources.
9. Measure the elasticity of the given sample by Newton's ring method.

Semester IV

PD-216 Thermodynamics & Optics (non-major) **(L2-T1-P0-CH3-CR3)**

Brownian motion (Einstein-Langevin theory), Equation of state of a gas, Andrew's experiment, Van der Waal's equation of state, critical constants and law of corresponding states,

Thermal conductivity, Zeroth and first law of thermodynamics, specific heats of gases, isothermal and adiabatic processes,

Second law of thermodynamics, Heat engine, Kelvin-Planck statement of second law, Clausius' statement of second law, Entropy, entropy changes in reversal and irreversible processes, entropy of an ideal gas, relation between entropy and probability, enthalpy, Gibbs-Helmholtz function, Maxwell's thermodynamic relations and their applications,

Geometrical optics: Fermat's principle and its application in establishing laws of reflection and refraction at the plane and the spherical boundaries, refraction of paraxial rays at spherical surface, thin lens, sign convention, combination of thin lenses, conjugate foci,

Physical optics: Interference, superposition of waves, Fresnel's bi-prism, Michelson interferometer, diffraction at a single slit and a double-slit, Polarisation: Double refraction, optic axis and $CaCO_3$ crystal, plane, circular and elliptically polarised light

Textbooks:

1. Saha, M. N. and Srivastava, B. N., *A Treatise on Heat*, 5th edition, (The Indian Press, 1965)
2. Chakravarty, P. K., *Advanced Textbook on Heat,* (New Central Book agency (P) Ltd)
3. Mathur, B.K., and Pandya, T.P., *Principles* of Optics, (Tata McGraw Hill International, 1981)
4. Chakraborty, P.K., *Geometrical and Physical Optics,* 3rd Edition, (New Central Book agency (P) Ltd, 2005)

Reference Books:

1. Hecht, E., *Optics,* 4th Edition, (Addison-Wesley Pub. Co., 2001)
2. Lipson, S., Lipson, H., and Tannhauser, D., *Optical Physics,* 3rd Edition, (Cambridge University press, 1995)
3. Ghatak, A. K., *Optics,* 3rd Edition, (Tata McGraw-Hill International, 2005)
4. Zemansky, M. W. and Dittman, R. H., *Heat and Thermodynamics,* 7th edition, (Tata McGraw-Hill International, 2007)
5. Sears, F. W. and Salinger, G. L., *Thermodynamics, Kinetic Theory and Statistical Thermodynamics,* (Addison-Wesley Pub. Co., 1975)

PD-205 Electromagnetism (L2-T1-P0-CH3-CR3)

Electrostatics in vacuum: Coulomb's law, Electric field due to a system of charges, Field lines, flux and Gauss's law, Gauss's law in differential form, the electric dipole and its electric field and potential, the couple and force on, and the energy of, a dipole in an external electric field, Gauss's law in integral form, field and potential due to surface and volume distributions of charge, force on a conductor, the capacitance of parallel plate, cylindrical and spherical capacitors, electrostatics in the presence of dielectric media, Modification to Gauss's law, polarisation, the electric displacement, relative permittivity, capacitance and energy in the presence of dielectric media,

Magnetic effects in the absence of magnetic media: the B-field, steady currents: the B-field set up by a current, the Biot-Savart law, the force on a current carrying conductor and on moving charges in a B-field, the magnetic dipole and its B-field, the force and couple on, and the energy of, a dipole in an external B-field, energy stored in a B-field, Gauss's law in integral form, simple cases of the motion of charged particles in electric and magnetic fields

Textbooks:

1. Griffith, D. J., *Introduction to Electrodynamics*, 3rd edition, (Prentice-Hall of India, 1999)
2. Purcell, E. M., *Electricity and Magnetism*, Berkely Physics Course, Vol. 2 (McGraw-Hill, 1965)
3. Matveev, A.N., *Electricity and Magnetism*, (Mir Publishers, 1986)

PD-214 Electronics (L2-T1-P0-CH3-CR3)

Network Theorems: Kirchhoff's laws, nodal analysis, mesh analysis, source transformations, linearity and superposition, Thevenin's and Norton's theorems, maximum power transfer theorem, Star-Delta and Delta-Star conversion,
Introduction to three-phase circuits, Two-port n/w, Z-parameter, Y-parameter, transmission (ABCD) parameter, hybrid (H) Parameter, interconnection of two-port n/ws, T and π representation, Wheatstone bridge and its applications to Wein bridge and Anderson bridge,

Semiconductors: p and n type semiconductors, energy level diagram, mobility and conductivity, transport phenomenon due to donor and acceptor impurities, Fermi level, Hall effect, conductivity measurement,

Diodes: barrier formation in p-n Junction diode (simple idea), current flow mechanism in forward and reverse biased diode (recombination, drift and saturation of drift velocity), derivation of equations for barrier potential, barrier width and current for Step Junction, p-n junction and its characteristics, static and dynamic resistance, diode equivalent circuit, ideal diode, load line analysis of diodes and Q-point,

Two-terminal devices and their applications: (1) rectifier diode, half-wave rectifiers, centre-tapped and Bridge full-wave rectifiers, calculation of ripple factor and rectification, efficiency, qualitative idea of C, L and π –filters; (2) wave shaping circuits; (3) Zener diode and voltage regulation; (4) photo-diode; (5) varactor diode,

Bipolar junction transistors, n-p-n and p-n-p transistors, characteristics of CB, CE and CC configurations, current gains α, β and γ and relations between them, load line analysis of transistors, DC load line and Q-point, physical mechanism of current flow; active, cutoff, and saturation regions, transistor in active region and equivalent circuit,

Amplifiers: transistor biasing and stabilization circuits, fixed bias and voltage divider bias, transistor as 2-port Network, h-parameter equivalent circuit, analysis of a single-stage CE amplifier using hybrid model, input and output impedance; current, resistance, voltage and power gains; class A, B, and C amplifiers; coupled amplifiers: RC-coupled amplifier and its frequency response of voltage gain, feedback in amplifiers, effects of positive and negative feedback on input impedance, output impedance and gain; stability, distortion and noise.

Sinusoidal oscillators: Barkhauson's criterion for self-sustained oscillations, RC phase shift oscillator, determination of frequency, Hartley oscillator, Colpitts oscillator,
Non-sinusoidal oscillators: astable and monostable multivibrators,

Junction field effect transistors (JFETs): principle of operation and characteristics, biasing, small signal models, small signal analysis, advantages of JFET

Textbooks:

1. Robbins, A. H. and Miller, W. C., *Circuit Analysis*, (Delmar Cengage Learning, 2003)
2. Hayt, W. H. and Kemmerly, J. E., *Engineering Circuit Analysis*, (McGraw-Hill, New York, 1993)
3. Malvino A. P., *Electronic Principles*, (Glencoe, 1993)

Reference Books:

1. Toro, V. Del, *Electrical Engineering Fundamentals*, (Prentice Hall, 1994)
2. Smith, R. J. and Dorf, R. C., *Circuits, Devices and Systems*, (John Wiley & Sons, 1992)
3. Morris, J., *Analog Electronics*, (Arnold Publishers, 1991)
4. Mottershead, A., *Electronic Circuits and Devices*, (Prentice Hall, 1997)
5. Streetman, B. G. & Banerjee, S., *Solid State Electronic Devices*, (Pearson Prentice Hall, 2006)
6. Bhargava, N. N., Kulshreshtha D. C. and Gupta S. C., *Basic Electronics and Linear Circuits*, (Tata McGraw-Hill, 2006)

7. Boylestad, R. and Nashelsky, L., *Electronic Devices and Circuit Theory*, 8th edition, (Pearson Education, India, 2004)

PD-208 Physics Laboratory-III (L0-T0-P4-CH8-CR4)

1. To determine the resistivity of the given semiconductor sample by Four Probe method.
2. To determine the susceptibility of the given sample by Quince tube method
3. To determine the Planck constant using different wavelength of light using Planck constant kit.
4. To study interference and diffraction with a laser beam at a single slit, double slit, three slits and four slits, and measure the slit separations.
5. To measure the spot size of a beam from a He-Ne laser and a diode laser and to calculate the M parameter.
6. To study the p-n junction characteristics and obtain output voltage at different frequencies.
7. To study connector losses in optical fibers:
    a. loss due to diameter mis-match,
    b. loss due to lateral off-set,
    c. loss due to angular misalignment
8. To measure the refractive index of a sample with a Michelson interferometer.
9. Determination of the focal length and hence the power of a convex lens by displacement method on an optical bench.
10. To find out the velocity of ultrasonic waves in a medium using ultrasonic interferometer.

Semester V

PD-303 Physical and Geometrical Optics (L2-T1-P0-CH3-CR3)

Basic Geometric Optics: law of reflection; reflection from planar and curved surfaces; Snell's law; refraction at the planar and curved surfaces; thin lens; prisms

Matrix methods: matrix optics concepts and basic matrices; cascading matrices: thin lens, thick lens, principal planes and imaging; study of a compound lens

Aberrations: monochromatic and chromatic aberrations; Seidel aberrations: spherical aberration, coma, astigmatism, field curvature and distortion; chromatic aberrations; examples

Polarization: light as a transverse wave, linear and circular polarizations; methods of producing and analyzing polarized light; linear polarizers and wave plates; Fresnel reflection and transmission coefficients; total internal reflection; Jones vectors and matrices for the ploarizer and wave plate; Stokes vectors and Muller matrices

Interference: division of wavefront and amplitude; intensity distribution in an interference pattern; visibility of fringes; Young's double-slit interferometer; Michelson interferometer; Rayleigh interferometer; multiple beam interference: Fabry-Perot etalon and interferometer; resolving power

Diffraction: Fresnel-Huygens theory of diffraction; Fresnel and Fraunhofer regions of diffraction; diffraction at a straight edge; Fraunhofer diffraction at the slit, circular and rectangular apertures; resolving power of a telescope; diffraction at multiple slits, grating, resolving power of a grating

Holography: recording and reconstruction of a wave; characteristics of the diffracted waves from the hologram; diffraction efficiency; types of the holograms; zone plate analogy of the hologram

Fourier Optics: simple concepts

Textbooks:

1. Subrahmanyam, N., Lal, B. and Avadhanulu, M. N., *A Textbook of Optics*, (S. Chand & Co. Ltd., 2012)
2. Mathur, B. K. and Pandya, T. P., *Principles of Optics*, (Tata McGraw-Hill International, 1981)

3. Chakraborty, P. K., *Geometrical and Physical Optics*, 3rd edition, (New Central Book Agency (P) Ltd., 2005)

Reference Books:
1. Hecht, E., *Optics*, 4th Edition, (Addison-Wesley Pub. Co., 2001)
2. Born, M. and Wolf, E., *Principles of Optics*, 7th edition, (Pergamon Press Ltd, 2000)
3. Jenkins, F. A. and White, H. E., *Fundamentals of Optics*, 4th edition, (Tata McGraw-Hill International, 1981)
4. Sirohi, R. S., *Wave Optics and Applications*, (Orient Longman, 1993)

PD-202 Introductory Quantum Mechanics (L2-T1-P0-CH4-CR3)

Origin of quantum theory, inadequacy of classical ideas, Planck's quantum hypothesis, photoelectric effect, Compton scattering,

Wave-particle duality, de Broglie's hypothesis, experimental evidence for de Broglie's hypothesis, Davisson-Germer experiment, Thompson experiment,

Simple consequences of uncertainty relation, wave function and its probabilistic interpretation, wave packet and uncertainty relation,

Schrodinger equation, solution of one-dimensional Schrodinger equation for an infinite square well potential, reflection and transmission at potential steps, qualitative treatment of barrier penetration for simple rectangular barriers,

The quantum harmonic oscillator

Textbooks:
1. Schiff, L. I., *Quantum Mechanics,* 3rd edition, (McGraw-Hill, New Delhi, 1968)
2. Ghatak, A. and Lokanathan, S., *Quantum Mechanics*, 5th edition, (Macmillan, 2004)

Reference Books:
1. Merzbacher, E., *Quantum Mechanics*, 2nd edition, (John Wiley, New York, 2005)
2. Richtmyer, F. K., Kennard E. H. and Lauritsen, T., *Introduction to Modern Physics,* 5th edition, (McGraw-Hill, 1976)
3. Waghmare, Y. R., *Fundamentals of Quantum Mechanics,* 1st edition, (Wheeler publishing, 1996)
4. Mathews, P. M. and Venkatesan, K., *A Textbook of Quantum Mechanics*, 2nd edition, (Tata McGraw-Hill, 1976)

PD-399 Physics Laboratory-V (L0-T0-P4-CH8-CR4)

1. To find out the magneto-resistance of the semiconductor sample as a function of magnetic field and to plot the graph between magnetic field vs. potential developed using magneto-resistance set-up.
2. To plot the gain – bandwidth relation for a negative feed back amplifier using IC 741.
3. To find out the Curie temperature of the given ferromagnetic material ($BaTiO_3$) using Curie temperature kit.
4. To study Malus' law of polarization.
5. To measure optical nonlinearity using z-scan method.
6. To find out the value of Boltzmann constant using Boltzmann Constant kit.
7. To find out the Rydberg constant by observing the Balmer series of Hydrogen using spectrophotometer.
8. To study diffraction at a circular aperture and find the resolving power of a given lens used as an objective of a telescope.
9. a. Develop a clipping and a clamping circuit and determine the output voltage with different DC bias voltage applied.
   b. Design and develop a full wave and a half wave rectifier circuits and find out the ripple factor of the circuits.

10. To study the temperature dependence of Hall coefficient of a semiconductor sample using Hall effect set-up.

Semester VI

PD-307 Basic Material Science (L2-T1-P0-CH3-CR3)

Fundamentals of crystallography: Bravais lattice, unit cell, crystal systems, Miller indices of crystal planes and directions, point groups.

Typical crystal structures: Simple (sc) cubic, body centered (bcc) cubic and face centered (fcc), cubic and structures, Hexagonal closed packed (hcp), Diamond and Zinc blende (ZnS) closed packed structures, packing factors, NaCl, CsCl and cubic perovskite and wurtzite structures.
Structure of solids: linear and planar density, ligancy, packing efficiency, closed pack planes and directions, voids.

Crystal imperfections*:* point imperfections (vacancies and interstitials), Frenkel and Schottky defects, dislocations, grain boundary, grain growth and surface energy calculation.

Crystal binding: Primary and secondary bondings, bond length and bond energy, van der Waals bonding, inert gas crystals, ionic, covalent and metallic bondings, Madelung constant, Madelung energy.

Phase and phase transformation: Melting point of crystalline and amorphous solids, degrees of freedom, phase rule, binary alloys, nucleation and phase transformation.

Elastic properties, Young, bulk and rigidity moduli, yield stress, Poisson's ratio, compressibility, creep and fatigue, plasticity.

Diffusion*:* Fick's first and second laws, thermal diffusion.

Textbooks:

1. Callister, W. D., *Materials Science and Engineering*, 5th edition (John Wiley, 2000)
2. Raghavan, V., *Materials Science and Engineering,* 4th edition (Prentice Hall India, 1991)
3. Kittel, C., *Introduction to Solid State physics,* 7th edition, (Wiley Eastern Ltd.,1996)
4. Burns, G., *Solid State Physics*, (Academic press, 1995)
5. Dekker, A. J., *Solid State Physics*, (Macmillan India Ltd., 2003)
6. Ashcroft, N. W. and Mermin, N. D., Solid State Physics, (Saunders, 1976)

Reference Books:

1. Smith, W. F., *Principles and Materials Science and Engineering*, 2nd edition (Tata McGraw-Hill Inc., 1990)
2. Patterson, J. D. and Bernard, B., *Introduction to the Theory of Solid State Physics*, 2nd edition, (Springer, 2007)
3. Ghatak, A. K. and Kothari, L.S., *Introduction to Lattice Dynamics*, (Addison-Wesley, 1972)
4. Hall, H. E. and Hook J. R., *Solid State Physics*, 2nd edition, (Wiley, 1991)
5. Azaroff, L. V., *Introduction to Solids*, (Tata McGraw-Hill, 1977)
6. Mathur, D. S., Properties of Matter, (S. Chand & Co., 2010)

PD-325 Thermodynamics and Statistical Physics (L2-T1-P0-CH3-CR3)

Macroscopic description of the state, extensive and intensive variables, temperature, thermodynamic variables (pressure, temperature, etc.), thermal equilibrium, equation of state,

Thermal conductivity, zeroth law of thermodynamics**,** temperature scales; work, heat and internal energy, the Gibbs-Duhem relation,
Thermodynamic processes: reversible, irreversible, quasi-static, adiabatic, isothermal,

First law of thermodynamics**,** specific heat capacity, enthalpy, kinetic theory of gases and Maxwell-Boltzmann statistics; calculation of pressure, kinetic interpretation of temperature, mean free path, Maxwell's distribution, equi-partition of

energy; heat engines,

The second law of thermodynamics, Carnot cycle and Kelvin temperature scale, Clausius' theorem, entropy and its physical interpretation, entropy change for simple processes,

Free energies: Helmholtz free energy, Gibbs free energy, Legendre transformations, conditions of equilibrium, Maxwell's relations, phases and phase transitions, equilibrium between two-phases, general equilibrium conditions, the Clausius-Clapeyron equation, phase transformation of substances, Van der Walls gas and the liquid gas transition, thermodynamics of magnetic systems, The third law of thermodynamics,

Microscopic versus macroscopic points of view, kinetic theory of gases, concept of ensembles, micro-canonical, canonical, grand-canonical ensembles, partition function, postulates of classical statistical mechanics, derivation of thermodynamics from statistical mechanics principles, equation of state for ideal and real gases, Gibbs paradox

Textbooks:

1. Callen, H. B., *Thermodynamics and Introduction to Thermostatistics,* 2nd edition, (Wiley Student Edition)
2. Reif, F., *Fundamentals of Statistical and Thermal Physics,* (Tata McGraw-Hill, 1985)
3. Zemansky, M. W. and Dittman, R. H., *Heat and Thermodynamics,* 7th edition, (Tata McGraw-Hill International, 2007)

PD-311 Waves and Acoustics (L2-T1-P0-CH3-CR3)

Vibrations: Potential energy vs. displacement relation, concept of equilibrium, development of simple harmonic oscillation (SHO) and other anharmonic terms from force equations, damped oscillation, critical damping, Q-factor of an oscillator, forced vibration, resonance, low and high frequency responses, eigen frequency and normal modes, energy transfers between modes, coupled pendulum, Lissajous figures, anharmonic oscillator, Fourier series and Fourier coefficients, Fourier analysis in some simple cases,

Waves: Progressive wave in one-dimension and in three-dimensions, wave equation, plane wave and spherical wave, intensity, dispersion, group velocity, phase velocity, speed of transverse waves in a uniform string, eigen frequencies and eigen modes for plucked and struck strings, speed of longitudinal waves in a field, energy density and intensity of waves, Superposition of waves: Superposition principle, interference in space and energy distribution, beats, combinational tones, production, detection and applications of ultrasonic waves, Doppler effect, shock waves,

Acoustics: Vibrations in bounded system, normal modes of a bounded system, harmonics, quality of sound, noise and music, intensity and loudness, bel and phon, principle of sonar system, acoustic transducers and their characteristics, recording and reproduction of sound, measurement of velocity, frequency and intensity, acoustics of halls, reverberation and Sabines formula

Textbooks:

1. Chattopadhyay, D., *Vibration, Waves and Acoustics*, (New Central Book Agency, 2010)
2. Main, I. G., *Vibrations and Waves in Physics,* 2nd edition (Cambridge University Press, 1984)

Reference Books:

1. Randall, R. H., *An Introduction to Acoustics*, Sect. 7-21, 7-22, (Addison-Wesley, 1951)
2. Wood, A. B., *A Textbook of Sound*, 3rd Edition, (Bell & Sons, 1955)
3. Crawford, F. S., *Waves*, *Berkeley Physics Course*, Vol. 3, (Tata McGraw-Hill, 1968)
4. Pain, H. I., *The Physics of Vibrations and Waves,* 6th edition (John Wiley & Sons Ltd., 2005)

PD-498 Physics Laboratory-VIII (L0-T0-P4-CH8-CR4)

1. Electron spin resonance spectrometer:
    a. To find out the Lande' g – factor of 2,2-Diphenyl-1-picrylhydrazyl sample using ESR spectrometer.

b. To observe the E.S.R. signal of given sample (DPPH) and to measure its full width at half maximum (FWHM).

2. GM counter:
    a. Determine the resolving time of the GM counting system.
    b. Study and determine the statistical distribution low that governs nuclear decay.
    c. Determine the characteristics of a GM tube to study the variations of count rate with applied voltage and thereby determine the plateau, the operating voltage and the slope of the plateau.
    d. Determine the dead time of the GM tube using a single source.
3. To determine the coercivity, saturation magnetization and retentivity of different given samples using hysteresis loop tracer set-up.
4. To measure the impedance of a coaxial cable and a rectangular waveguide using microwave bench.
5. Determine the dielectric constant of the ferroelectric ceramic sample using the given experimental set-up.
6. Determine the electrical charge of an electron by Millikan oil drop experiment and determine the value of e/m.
7. To study response of a non-linear crystal as a function of intensity of Nd:YAG laser (532nm)
8. a. To plot intensity of Luminescence vs. Temperature glow curve using thermo-luminescence set-up.
   b. To draw the glow curve and find out the activation energy (E) of different Alkali Halide Crystals using thermo-luminescence set-up (Demonstration only)
9. To study, take a measurement and prepare a report on
    a. PL/UV-VIS Spectrophotometer
    b. Scanning Electron Microscope (SEM)
    c. X-Ray Difractometer (XRD)

PD-315 Mathematical Physics-II (L2-T1-P0-CH3-CR3)

Ordinary differential equations, second-order homogeneous and inhomogeneous equations, Wronskian, general solutions; adjoint of a differential equation, ordinary and singular points, series solution; Legendre, Hermite, Laguerre and the associated polynomials, their differential equations, generating functions; Bessel functions, spherical Bessel equations, integral representation of special functions,

Generating functions; Recurrence relations; Rodrigue's formulae and orthogonality of the special functions; Sturm Liouville problem, elements of hyper-geometric functions, Gauss hyper-geometric and confluent hyper-geometric equations, Dirac delta function, Green function,

Partial differential equations in physical problems: Laplace's equation, Poisson's equation, Heat flow equations, Wave equations, Helmholtz equations; solutions of these equations; eigenvalue problems, boundary value problems, method of separation of variables,

Integral transforms: Laplace transform, Hankel transform, Mellin transform, Fourier transform,

Properties of Laplace and Fourier transforms, application of Laplace and Fourier transforms

Textbooks:

1. Harper, C., *Introduction to Mathematical Physics, (*Prentice Hall, 2009)
2. Arfken, G. B., and Weber, H. J., *Mathematical Methods for Physicists*, (Elsevier Ltd, Oxford, 2005)
3. Spiegel, M. R., *Vector Analysis*, Schaum's outline series, (Tata McGraw-Hill 1979)

Reference Books:

1. Morganeau, H. and Purphy, C. M., *The Mathematics of Physics and Chemistry,* (Young Press, 2009)

PD-204 Atomic and Nuclear Physics (L2-T1-P0-CH3-CR3)

Atomic Physics: The Bohr model of the hydrogen-like atom, brief account of the Sommerfeld model, electron spin; Stern-Gerlach experiment, space and spin quantization, the vector model of the atom, spin-orbit interaction, fine structure of spectral lines, LS and jj coupling, the Zeeman effect, Paschen-Back effect, Stark effect, scattering of light: Rayleigh scattering formula, colour of the sky, polarisation of the scattered light,

Nuclear Physics: General properties of nuclei, concept of nuclear size, spin, parity, magnetic dipole moment and electric quadropole moment of nuclei, nuclear forces and stability of nuclei, concept of packing fraction and binding energy, binding energy curve and its significance,

Natural radioactivity and radioactive decay: Type of radioactive decays, theory of radioactive disintegration, radioactive constants, mean-life of a radio element, radioactive equilibrium, half-life of a radio element, determination of decay constant and half-life,

Nuclear reactions: Types of nuclear reactions, conserved quantities of nuclear reaction, energies of nuclear reaction, Q-value, exoergic & endoergic reactions, nuclear fusion and fission reactions,

Detectors: Principles of detection of charge particles, construction and working principle of gas-filled detectors, ionization chamber, its construction and working principle, interaction of γ-particle with matter, construction and working principles of a scintillating detector

Textbooks:

1. Krane, K. S., *Introductory Nuclear Physics*, (John Wiley, New York, 1987)
2. White, W. H., *Introduction to Atomic Spectra*, (McGraw-Hill, 1934)

Reference Books:

1. Green, A. E. S., *Nuclear Physics*, (McGraw-Hill Book Company, Inc., New York, 1955)
2. Srivastava, B.N., *Basic Nuclear Physics and Cosmic Rays,* (Pragati Prakashan, Meerut, 2011)

PD-400 Physics Laboratory-VII (L0-T0-P5-CH10-CR5)

1. To design and fabricate a phase shift oscillator for the given frequency and to study the output using Op-Amp. 741/ 324 / 325.
2. Determination of thermal conductivity of a substance by Lee's method.
3. Scintillation counter:
    a. Find out the resolution and the FWHM of the given Scintillation counter
    b. Find out the gamma ray energy of the given radioactive sources
4. Determination of the Young's modulus of a beam by four-point bending.
5. To determine the velocity of sound in (a) dry air, and (b) rods by Kundt's tube method
6. Calculate the difference in wavelength between atomic transition lines and Zeeman lines using Zeeman effect set-up. (SES instruments Pvt. Ltd).
7. To study Talbot imaging and to obtain Talbot distances with moiré interferometry and to measure the focal length of a lens.
8. Determination of the boiling point of a liquid by platinum resistance thermometer and metre-bridge.
9. To measure the diameter of a thin wire using (a) interference, and (b) diffraction and compare the results.
10. To measure the dielectric constant and loss using microwave bench.

Semester VIII

PD-317 Basic Computation Technique (L2-T1-P0-CH3-CR3)

Introduction to computers

Programming using FORTRAN; programming using C and C^{++}

Simple programming examples from calculus; solution of simple algebraic equations, solution of simple differential equations

Examples of least squares curve fitting, matrix eigenvalue problems

Textbooks:

1. *Gottfried, B. S.,* Schaum's outline of theory and problems of programming with C, (McGraw-Hill Professional, 1996)
2. Kanetkar, Y., *Let us C,* (BPB Publications, 2012)
3. Mayo, W. E. and Cwiakala, M., *Schaum's Outline of Programming With Fortran 77*, Schaum's Outline series, (McGraw-Hill, 1995)
4. Scheid, F., *Schaum's outline of theory and problems of numerical analysis*, 2nd edition, Schaum's outline series, (McGraw-Hill, 1989)

Reference Books:

1. Mathews, J. H., *Numerical Methods for Mathematics, Science and Engineering*, (Prentice Hall, 1997)
2. Narsingh Deo, *System Simulation with Digital Computers*, (Prentice Hall, 1979)

PD-308 Laser Physics (L2-T1-P0-CH3-CR3)

Planck's Law; Absorption, spontaneous emission and stimulated emission; Einstein's A & B coefficients; two-level atomic systems; light amplification; threshold condition;

Line broadening mechanism; pumping methods and laser rate equations; variation of laser power around threshold; optimum output coupling;

Modes of a rectangular cavity and open planar resonator; the quality factor (Q-factor); the ultimate bandwidth of laser; mode selection; Q-switching; mode locking; modes of a confocal resonator; general spherical resonator;

Properties of laser beam; propagation of Gaussian beam and ABCD matrix;

Some laser systems like He-Ne laser; ruby laser; neodymium-based lasers; CO_2 laser; dye laser; fiber laser, semiconductor laser; DFB lasers; DH lasers,

Generation of ultra fast optical pulses; pulse compression; femto-second laser and its characteristics

Some applications of lasers like laser cooling, laser tweezers, material processing

Textbooks:

1. Ghatak, A. K. and Thyagarajan, K., *Optical Electronics*, (Cambridge University Press, 2009)
2. Svelto, O., *Principles of Lasers*, 3rd edition, (Springer, 2007)
3. Milonni, P. W. and Eberly, J. H., *Laser Physics*, (John Wiley & Sons, 2010)

Reference Books:

1. Yariv, A., *Quantum Electronics*, 3rd edition, (Wiley Eastern Ltd.)
2. Davis, J. H., *Introduction to Low Dimension Physics*, (Cambridge University Press, 1997)
3. Siegman, A. E., *Lasers*, (University Science Books, 1986)

PD-314 Measurement Physics (L2-T1-P0-CH3-CR3)

Data interpretation and analysis; precision and accuracy, error analysis, propagation of errors, least squares fitting, linear and nonlinear curve fitting, chi-square test;
Measurement of energy and time using electronic signals from the detectors and associated instrumentation, signal processing; multi-channel analyzer; Time of flight technique; coincidence measurements, true-to-chance ratio,

Transducers (temperature, pressure/vacuum, magnetic field, vibration, optical), measurement and control, ionization chamber, proportional counter, GM counters, spark chambers, cloud chamber, semiconductor detectors for charged particles and γ-ray detectors, scintillation counters, photodiodes and charge coupled device (CCD) and CMoS cameras for detection of electromagnetic radiation,

Production of low temperature below 1K, adiabatic demagnetisation and magnetic refrigerator, special properties of liquid helium, temperature below 10^{-6}K, nuclear demagnetisation, measurement of low temperatures,

Op-amp based, instrumentation amp, feedback, filtering and noise reduction, shielding and grounding; Fourier transforms; lock-in detector, box-car integrator, modulation techniques

Textbooks:

1. Sayer, M. and Mansingh, A., *Measurement, Instrumentation and Experiment Design in Physics and Engineering*, (Prentice-Hall India, 2000)
2. Nakra, B. C. and Chaudhry, K. K., *Instrumentation Measurement and Analysis* (Tata McGraw-Hill, 1985)

Reference Books:

1. Knoll, G. F., *Radiation, Detection and Measurement*, 3rd edition, (John Wiley & Sons, 2000)
2. Jones, B. E., *Instrumentation measurement and feedback* (Tata McGraw-Hill, 1978)

PD-300 Project (L0-T0-P4-CH8-CR4)

PD-450 Seminar (L0-T0-P2-CH4-CR2)
