B. Sc. (HONS.) PHYSICS
DISTRIBUTION OF DIFFERENT COURSES AND CREDITS IN VARIOUS SEMESTERS
Offered By:
Department of Physics
Faculty of Science
Banaras Hindu University
### Semester-wise Distribution of Courses and Credits

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<tr>
<th>Semester</th>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
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BPT-101: MECHANICS AND RELATIVITY

Mechanics:
Inertial and non-inertial frames of reference, Effect of centrifugal and Coriolis forces due to earth’s rotation, Center of mass (C.M), Lab and C.M frame of reference, motion of CM of system of particles subject to external forces, elastic, and inelastic collisions in one and two dimensions, Scattering angle in the laboratory frame of reference, Conservation of linear and angular momenta.

Relativity:
Postulates of special theory of relativity, Derivation of Lorentz transformation and physical significance of Lorentz invariance, Length contraction and time dilation, Concept of simultaneity, Relativistic velocity transformation relations, mass energy relation, Concept of zero rest mass of photon, Relativistic relation between energy and momentum.

Mechanical Properties of Matter:
Modulus of rigidity, Poisson’s ratio, relation connecting different elastic- constants, twisting couple of a cylinder(solid and hallow), Statical method (Barton’s method), Dynamical method (Maxwell’s needle) for determining the modulus of rigidity, Bending moment, Cantilever (neglecting mass), Young modulus by bending of beam, Viscosity, Poiseulle's equation of liquid flow through a narrow tube, Damped harmonic oscillations, Compound pendulum, Ballistic galvanometer.

Reference Books:
BPT-201: THERMAL PHYSICS

Kinetic Theory:

Thermodynamics:
Reversible and irreversible processes, Examples of thermal, mechanical and chemical irreversibility, Carnot’s cycle and Carnot’s theorem. Second law of thermodynamics, Thermodynamic scale of temperature.

Concept of entropy, Entropy change in reversible and irreversible processes. Entropy and disorder, Principle of increase of entropy, Entropy and unavailable energy, Entropy of ideal gases, Entropy as a thermodynamic variable, S-T diagram.

Thermodynamic functions, Internal energy, Enthalpy, Helmholtz function and Gibb’s free energy, Maxwell’s thermodynamical equations and their applications, TdS equations, Energy and heat capacity equations Clapeyron equations.


Criterion of equilibrium of a system, Isolated system, System in contact with constant temperature reservoir. System in contact with constant temperature and pressure reservoir, Phase transition, Coexistence of phases, Triple point.


Radiation:
The blackbody spectrum, Wien’s displacement law, Rayleigh-Jean’s law, Planck’s quantum theory of radiation.

Reference Books:
**List of Experiments**

**Group I**

1. Determination of Stefan’s constant.
2. PN junction diode and Zener diode characteristics.
3. Determination of Young’s modulus, modulus of rigidity and Poisson’s ratio of material of a wire using Searle’s method.
4. Determination of absolute capacity of a condenser.
5. Determination of Young’s modulus of material of a metallic bar by bending of beam method.
7. Determination of acceleration due to gravity using compound pendulum.
8. Determination of focal length of combination of lenses and nodal distance using nodal slide assembly.

**Group II**

1. Determination of internal resistance of micro ammeter and conversion of micro ammeter into voltmeter, milliammeter and Ohmmeter.
2. Determination of modulus of rigidity using Bortron’s apparatus.
3. Construction of two-input ‘OR’ and ‘AND’ gates using diode logic and preparation of their truth tables.
5. To study variation of magnetic field along the axis of Helmholtz Galvanometer and to determine reduction factor.
6. Determination of resistance per unit length and an unknown resistance using C. F. Bridge.
7. Determination of dispersive power of material of a prism.
8. Determination of temperature coefficient of resistance of material of a given coil.

* In Semester-I, half of the students will do the experiments of Group-I and the other half will do the experiments of Group-II. In Semester II, the students will exchange their groups. Addition and deletion in the list of experiments may be made from time to time by the department.
SEMESTER -II

ANCILLARY PHYSICS COURSE - I: FOR NON-PHYSICS STUDENTS

Credits: 2

Mechanics and General Properties of Matter:
Elasticity: Strain and stress, elastic limit, Hooke’s law; Moduli (Young’s, Bulk, Rigidity) and Poisson’s ratio,
Surface tension: Surface tension and surface energy, angle of contact, capillary action,
Flow of liquids and gases: Streamline and turbulent flow, Equation of continuity, Bernoulli’s theorem and its application to biological system, Torricelli’s theorem; Coefficient of viscosity, Stoke’s law.

Radiation Effects on Biological Systems:
Electromagnetic spectrum, Ionizing radiations and their effect on biological systems, Effects of radiation relevant to Biology: Photosynthesis, Green House Effect, DNA Damage and Depletion of Ozone.

Reference Books:
1. University Physics: Sears and Zemansky.
Interference:


Diffraction:

Fresnel’s diffraction, Zone plate, diffraction due to straight edge. Fraunhoffer diffraction due to single and double slits, plane transmission grating Resolving power of grating, telescope and Microscope.

Polarization:

Polarized light and its mathematical representation, Production of polarized light by reflection, refraction and scattering. Polarization by double refraction and Huygen’s theory, Nicol prism, Retardation plates, Production and analysis of circularly and elliptically polarized light. Optical activity and Fresnel’s theory, Biquartz polarimeter.

Basic concepts of Laser

Reference Books:

5. Optics: P. K. Srivastav.
Properties of Materials

Dielectric constant, Polar and Non Polar dielectrics, Dielectrics and Gauss’s Law, Dielectric Polarization, Electric Polarization vector $P$, Electric displacement vector $D$. Relation between three electric vectors, Dielectric susceptibility and permittivity, Polarizability and mechanism of Polarization, Lorentz local field, Classius Mossotti equation, Debye equation, Ferroelectric and paraelectric dielectrics.


Network Analysis:


Physics of Semiconductors:


$p$-$n$ junction diode, depletion width and potential barrier, junction capacitance, $I$-$V$ characteristics. Rectifiers, ripple factor, filter circuits, rectification efficiency and percentage regulation. Clipping and clamping circuits, Zener diode and voltage regulation.

Bipolar Junction Transistors:

Transistor circuits, Input and Output characteristics in CB and CE configurations, Early effect, $\alpha$ and $\beta$ parameters; DC load line, operating point, biasing and bias-stabilization circuits; Transistor as an amplifier (CE Mode) and frequency response.

Cathode Ray Oscilloscope (CRO)

Cathode ray tube, deflection sensitivity, time-base and wave form display.

Modern Physics


Reference Books:

1. Electronic devices : T.L. Floyd
2. Modern Physics : A.P. Arya
4. Concepts of Modern Physics : A. Beiser
**BPL-301 & BPL-401: LIST OF EXPERIMENTS**

**Credits: 2**

**Group-I**

1. Determination of wavelength of sodium yellow line by Fresnal’s Biprism.
2. Determination of specific rotation of cane sugar by polarimeter.
3. Determination of wavelength of mercury lines by diffraction grating.
4. Determination of minimum resolution power of a telescope to distinguish two close objects at a large distance.
5. Determination of self inductance of a coil by Anderson’s bridge.
6. To draw characteristic curves of a triode valve.

**Group-II**

1. Determination of wavelength of sodium yellow line by Newton’s rings.
2. To determine the Planck’s constants by Wein’s radiation formula using an LDR.
3. To determine diameter/thickness of a thin wire by diffraction method.
4. Measurement of energy band gap of Si using a p-n junction diode.
5. Determination of mutual inductance of a pair of coils.
6. Phase shift between the current and the applied voltage in (a) C.R., (b) L.R. (c) L.C.R. circuits using a CRO and an oscillator.
7. To draw the input and output characteristics of a p-n-p transistor.

* In Semester-III, half of the students will do the experiments of Group-I and the other half will do the experiments of Group-II. In Semester IV, the students will exchange their groups. Addition and deletion in the list of experiments may be made from time to time by the department.
SEMESTER -IV

Ancillary Physics Course - II: FOR NON-PHYSICS STUDENTS

Credits: 2

Thermal Physics:
Thermodynamics: Laws of thermodynamics and interpretation, Relevance to biological systems, Entropy and disorder, free-energy and chemical potential. Elementary ideas of Brownian motion, equipartition energy, Phenomenon of Diffusion, Mean free path and drift speed.

Optics:
Light: Fermat’s principle of least time, reflection and refraction.

Geometrical optics: Focal length of a spherical surface, Concave and convex mirror and lenses, magnification, compound lenses, telescope and microscope, Resolving power

(i) Interference: Young’s double-slit experiment its application (ii) Diffraction: Fraunhoffer and Fresnel diffraction; Grating and its resolving power (iii) Refractive index, dispersion and absorption (iv) Polarization and Polarisers, Birefringence Optical activity and its relevance to biological systems.

Reference Books:

1. University Physics: Sears and Zemansky.
Curvilinear Coordinates:
Orthogonal curvilinear coordinates; differential operators, concept of a metric, spherical and cylindrical coordinates and their unit vectors.

Tensor Analysis:
Introduction to tensors, Cartesian, covariant and contravariant tensors; contractions and direct products, Examples: pseudo, dual, isotropic, symmetric and anti-symmetric tensors.

Matrices:
Hermitian, orthogonal and unitary matrices, inverse of a matrix, similarity transformations, Eigenvalue problems and diagonalization of matrices (Examples: non-degenerate and degenerate cases).

Differential Equations:
Second order homogeneous differential equations and their series solution (example: Bessel equation), linear independence of two solutions (Wronskian), Integral and power series methods for second solution.

Special Functions:
Bessel, Legendre (spherical harmonics), Hermite and Laguerre: generating functions and recurrence relations, orthonormality conditions, Dirac delta function.

Fourier Analysis:
Fourier theorem, Fourier analysis of square wave, saw-tooth wave, plucked strings, half wave/full wave rectifier wave forms

Reference Books:
BPT-502: CLASSICAL MECHANICS

System of particles, Constraints, Generalized coordinates, D'Alemberts principle and Lagrange's equation, Velocity dependent potential of electro-magnetic field.


Legendre transformations and Hamilton's equations of motion, Hamiltonian for a charge particle in Electro-magnetic field, Cyclic coordinates and conservation laws, Poisson Brackets, Jacobi Identity, Canonical transformation.

Hamilton-Jacobi theory, Action-Angle variables, related problems.

Two body central force problem, reduction to the equivalent one body problem, Differential equation for the orbit and integrable power law potentials, Condition for stable circular orbit, Kepler problems.

Reference Books:
Limits of Classical Physics:
Black body radiation (without derivation), Photoelectric effect, Compton effect.

Wave Packets and Uncertainty Relation:
de Broglie hypothesis, Wave-particle duality, Davisson-Germer experiment, Wave packets, Group velocity and phase velocity, Uncertainty principle, Complimentarity.

Wave Mechanics:
Schrödinger equation, Physical interpretation of wave function, Probability current density and conservation of probability, Free particle wave function, Schroedinger equation in the presence of a potential, Linear operators, Hermitian operators, Observables, Eigenvalues and Eigenfunctions, Expectation values, Ehrenfest's theorem, Stationary states, Superposition principle, Commutation relations, Commuting observables and compatibility.

Application of Schrödinger Wave Equation:
Particle in one dimensional Box, Square well, Rectangular potential barrier and tunnelling, Linear harmonic oscillator, Spherically symmetric potential, Angular momentum operators and their eigen functions, Concept of spin, Hydrogen atom.

Reference Books:
1. Quantum Physics: S. Gasiorowicz.
4. Quantum Mechanics: V. Devanathan.
5. Quantum Mechanics: C. S. Chaddha.
BPT-504: ELECTRONIC DEVICES AND CIRCUITS                Credits: 3

Electronic Devices:

Analog Circuits:
Hybrid parameter model of transistor, analysis of transistor amplifier (with and without RS and RL) using h-parameters, simplified hybrid model, brief idea about hybrid model. Single stage amplifier in CE, CB and CC modes. RC coupled CE amplifier and its frequency response, tuned voltage amplifier. Power amplifier classification, distortion and efficiency, push pull amplifier, Feedback in amplifiers, positive and negative feedback, effect of negative feedback on the characteristics of different types of amplifiers, voltage and current series feedback circuits. Barkhausen criterion of oscillations, tuned collector oscillator, Hartley / Colpitt oscillator, phase shift oscillator and multiuvibrators.
Need and types of modulation, amplitude modulation, analysis of A.M. wave, modulator and demodulator circuits.

Digital Circuits:
Boolean algebra, logic gates, NAND and NOR gates as universal gates. Simplification of Boolean expressions using K- maps. Half and full adders and subtractors.

Reference Books:
1. Electronics Fundamental and Application: Chattopadhyay and Rakshit.
3. A Text Book of Electronics: Kakani and Bhandari.
5. Integrated Electronics: Millman and Halkias.
Vector Calculus:

Concept of gradient, divergence and curl operators; Gauss divergence theorem, Stokes theorem and related problems.

Boundary Value Problems

Laplace & Poisson’s equation, boundary condition, solution through method of images.

Electromagnetism:

Laws of Electromagnetism (Gauss law of electricity, Gauss law of magnetism, Faraday’s law of electromagnetic induction, Ampere’s circuital law); Concept of different charge and current densities (free charges, bound charges); Displacement current and generalized Ampere’s law; Equation of continuity, Maxwell’s equations in differential form; Electric and magnetic polarization vectors and their mutual relationship; Vector and scalar potentials, Poynting theorem and energy conservation (qualitative idea of momentum conservation).

EM wave propagation:

EM wave equation and their solutions; Polarization of EM wave; Propagation of plane EM waves in different media: free space, dielectrics and conductors; Laws of reflection, transmission at normal and oblique incidence in linear media and conducting media (Fresnel’s equations), total internal reflection and Brewster angle, Problems.

Guided E.M. Wave Propagation:

Propagation of e.m. wave through transmission line, reflection coefficient, standing wave, characteristic impedance, propagation constant. Rectangular waveguides. Expressions for field components, TE, TM & TEM modes. Propagation properties, cutoff frequency, group & phase velocity, Problems.

Reference Books:

1. Introduction to Electrodynamics (3rd Edition): David J. Griffiths.
2. EM Waves and Fields: P. Lorrain and O. Corson.
BPT-601: STATISTICAL MECHANICS  
Credits: 3

Random Walk Problem:
Probability distribution, calculation of mean and dispersion (as a measure of fluctuation), and simple numerical problems.

Basics of Statistical Mechanics:
State of a system (Microscopic and Macroscopic); Phase space, density of states and Liouville’s theorem; Postulates of statistical mechanics; Relation between statistical and thermodynamic parameters.

Classical Statistical Mechanics:
Ensemble theory (Micro-canonical, Canonical and Grand-canonical), applications to classical ideal gas and simple numerical problems; Gibbs paradox; Statistical equivalence of three ensembles.

Quantum Statistical Mechanics:
Introduction to Bose-Einstein and Fermi-Dirac statistics; Maxwell-Boltzmann statistics as a classical limit; Comparison of the three statistics; Qualitative features of degenerate Fermi and Bose gases.

Reference Books:
1. Fundamentals of Statistical and Thermal Physics: Frederick Reif.
BPT-602: SOLID STATE PHYSICS

Structure and Symmetry:

Elements of external symmetry of crystals, space lattice, Bravais lattices, Miller indices for direction and planes, Common crystal structures: NaCl, CsCl, ZnS and Diamond, Close packed structures, elementary idea of quasicrystals and amorphous materials.

Diffraction of x-rays, Laue equations and Braggs law, reciprocal lattice, Brillouin Zones and Ewald construction, atomic scattering and structure factors.

Elementary idea of bonding in solids, Lennard Jones potential.

Lattice Vibrations:

Vibrational modes of continuous medium, Density of states, Einstein’s and Debye's theory of specific heat, Vibrations of one dimensional monoatomic and diatomic chain, Phonons.

Electronic Properties:

Theory of free electron gas, Fermi surface, Electrons in periodic potential, Kronig-Penny model, Bloch theorem, energy bands, metals, insulators and semiconductors, Motion of electron in electric and magnetic fields, Hall Effect.

Magnetic Properties:


Reference Books:

Properties of Nuclei and Models:

Introduction to the nucleus, Fermi gas model, Binding energy, Bethe-Weizsaecker mass formula and its application to explain most stable isobars and nuclear fission, Inferences of nuclear size from elastic electron-nucleus experiments (no derivation).

Nuclear Force and Two-nucleon System:

Properties of nucleon-nucleon interaction, General forms of N-N potential, Description of low energy neutron-proton scattering to show the spin dependence of nuclear force, Ground state properties of deuteron, Simple consideration of deuteron using central potential (square well).

Nuclear Stability:

Nucleon emission, separation energy, Alpha decay and its energy spectrum, Q-value, Gamow’s theory of alpha decay (no derivation), Beta decay and its energy spectrum (for example, $^{137}$Cs), Need for neutrinos, Q-value for beta decay, Gamma decay, Selection rules for gamma transitions (no derivation).

Accelerators and Detectors:


Elementary Particles:

Classification of particles and their interactions, Quantum numbers, Quarks as the building blocks of hadrons, colour degree of freedom.

Reference Books:

1. Introductory Nuclear Physics: S. S. M. Wong.
5. Introduction to Nuclear Physics: H. A. Enge.
Atomic Physics:


One valence electron atom:


Lasers and Non-Linear Optics:


Reference Books:

2. Introduction to Atomic Spectra: H.E. White.
Theory of Relativity:

Gravitational red-shift, Doppler effect in relativity, Four dimensional space and concept of fourvector, Transformation properties of four-momentum and four-force, Vector and scalar potentials and Gauge transformation, Four-potential and four-current, Transformation relations for E and B, Invariance of Maxwell’s equations.

Astrophysics and Cosmology:


Atoms, Nuclei and Solids:

Rutherford scattering (detailed derivation), Compton scattering and comparison with Raman scattering, Mössbauer effect, Solid state detectors, Mass spectrometer (illustrated by Bainbridge and Aston spectrometer), Charge particles in magnetic field, Landau levels.

Reference Books:

2. Introduction to Special Relativity : Robert Resnick.
Background Physics for Nano and Exotic Materials:

Electron Band Structure and Its Modification due to change in dimensionality. Phonon absorption in Nanomaterials.

Nano Materials:


Exotic Materials:


Quasicrystals:

Basic definition of quasicrystal, Fibonacci Sequence, Penose Tiling and its Relevance to Structure of Quasicrystals.

Reference Books:

2. Introduction to Nanotechnology: C.P. Poole and F.J. Owens.
LIST OF EXPERIMENTS*

Group – I

BPL-501  Credits: 3

1. To determine the ionic magnetic moment of Ni-ion in NiSO₄ solution (Magnetic susceptibility)
2. To determine the wavelength and speed of ultrasonic wave by method of Acoustic grating.
3. To draw the dispersion curve for the constant deviation prism spectrograph using the spectral lines of iron as standard and to determine the wave length of Copper lines.
4. To determine the Cauchy’s constant for the material of a given prism using the spectrometer.
5. (a) To determine the angle of a given wedge using given laser beam.
   (b) To determine the refractive index of water using hollow prism.
6. To study the Hall Effect and to calculate the different parameter like Hall Coefficient, carrier density & mobility.

BPL-502  Credits: 3

1. Experiment on logic gates- Verification of laws of Boolean algebra.
2. Transient response of LCR circuit and determination of quality factor.
3. Experiment of negative feedback amplifier.
4. Power supply and filter characteristics.
5. Design of Zener regulated power supply.
6. Characteristics of SCR and its application as phase control rectifier

Group –II

BPL-601  Credits: 3

1. To determine Planck’s constant ‘h’ using a photoelectric cell and a direct reading potentiometer.
2. (a) To draw the operating characteristic of Geiger Muller counter.
   (b) To determine the dead time of the counter by the two source Method.
3. To draw the Hysteresis loop of the given specimen and to determine the Energy loss per unit volume per cycle of magnetization with Universal B-H curve Tracer.
4. To determine the wavelength of yellow line of sodium and the wavelength Difference between the two components of this line using Michelson Interferometer.
5. To draw the dispersion curve for the grating spectrograph using the Spectral lines of iron as standard and to determine the wavelength of the Bands of ALO and to compare them with the standard value given in the Chart.
6. To calibrate the given constant deviation spectrometer (CDS) with the help of mercury lines and to calculate the Rydberg constant and series limit of Balmer series using hydrogen lamp.
7. To calculate the Numerical aperture and the bending loss using the fiber optics kit.

BPL-602  Credits: 3

1. Positive feedback- Hartley and phase shift oscillator.
2. Amplitude modulation and demodulation characteristics.
3. Characteristics of FET and MOSFET and their application as amplifier.
4. Wave shaping circuits.
5. Characteristics of UJT and its application as relaxation oscillator.

* In Semester-V, half of the students will do the experiments of Group-I and the next half will do the experiments of Group-II. In Semester- VI the students will exchange their groups. Addition and deletion in the list of experiments may be made from time to time by the department.