Physics

Semester 1 (AUG)

UP 101: Introductory Physics I - Mechanics, oscillations and waves (2:1)

Kinematics, laws of motion. Circular motion, Work. Kinetic and potential energy. Line integrals. Conservative forces. Friction, terminal velocity in air. Systems of particles. Conservation of linear momentum. Scattering in one and two dimensions. Angular momentum. Moment of inertia. Rotation about one axis. Precession of gyroscope. Central force. Reduction of two-body problem to one-body problem and effective one-body potential. Planetary motion and Kepler's laws. Simple pendulum, damped and forced, resonance. Coupled oscillators, normal modes. Small oscillations. Transverse waves on a string. Linear superposition, interference, beats. Fourier series. Sound waves in air. Doppler effect.

Instructors: V Venkataraman, Prasad V Bhotla, K Ramesh

Suggested books:

1. Kittel C, Knight W D, Ruderman M A, Helmholz A C and Moyer B J, Mechanics, Berkeley Physics Course: Volume 1, 2nd Edition (2011)
2. Kleppner D and Kolenkow R J, An Introduction To Mechanics (Special Indian Edition) (2007)

Semester 2 (JAN)

UP 102: Introductory Physics II – Electricity, Magnetism and Optics (2:1)

Introduction, Review of vector algebra, Vector calculus: gradient, divergence, curl, Gauss's theorem and Stokes' theorem, Laplacian etc. Coulomb's law, electric field, Electrostatic potential, Uniqueness theorem, Conductors, capacitance, Method of images, Bound charges and dipole moment density, Energy stored in electric fields. Magnetostatics: Electric currents, Biot-savart law, Ampere's law, magnetic fields of straight wires, circular loops and infinite solenoids, Vector potential, Magnetic dipole moment and bound currents. Lorentz force and Faraday's law, Inductance, Energy stored in a magnetic field. Linear dielectric and magnetic materials, Charge conservation, displacement current, Maxwell's equations and gauge invariance, Classical wave equation and plane monochromatic waves, Energy of EM waves and Poynting's theorem.

Instructors: Tarun Deep Saini, Sai Gorthi, D V S Muthu

Suggested books:

1. Purcell E.M., Electricity and Magnetism, Berkeley Physics Course - Volume 2, 2nd edn (Tata McGraw Hill, 2011)
2. Griffiths D.J., Introduction to Electrodynamics, 3rd edn (Prentice-Hall of India, 2003)

Semester 3 (AUG)

UP 201: Introductory Physics III - Thermal and Modern Physics (2:1)

Temperature, The First Law of Thermodynamics, Kinetic Theory of Gases and Maxwell -Boltzmann Statistics, Heat Engines, Entropy and the Second Law of Thermodynamics, Relativity, Introduction to Quantum Physics, Basics of Quantum Mechanics, Atomic , Molecular and Solid state Physics, Nuclear Physics, Particle Physics and Cosmology

Instructors: H R Krishnamurthy, P S Anil Kumar, K P Ramesh

Suggested books:

1. Serway and Jewitt, Physics for Scientists and Engineers (7th Edition)
2. Young and Friedman, University Physics (12th Edition)
3. Halliday, Resnick and Walker, Fundamentals of Physics, Extended (8th Edition)
4. Harris Benson , University Physics, Revised Edition
5. Kenneth Krane, Modern Physics, Second Edition

Semester 4 (JAN)

UP 202: Intermediate Mechanics, Oscillations and Waves (2:1) (Core course for Physics major)

Special theory of relativity. Lorentz transformations. Energy-momentum relation. Lorentz four-vectors. Motion in non-inertial frames. Fictitious forces. Coriolis force. Focault pendulum. Basic scattering theory. Vibrations of particles on a circle and a line. Orthonormal basis. Wave equation. Fourier transform. Phase space. Hamiltonian equations, fixed points and stability. Nonlinear equations. Chaos. Logistics map and period doubling. Fluid mechanics. Euler equation. Bernoulli's equation. Waves in fluids. Gravity waves. Viscosity. Navier-Stokes equation. Basic ideas about turbulence. Elasticity. Strain and stress tensors. Elastic modulii. Bending of rods. Waves in solids.

Instructors: Biplob Bhattacharjee, K P Ramesh, R Ganesan

Suggested books:

1. Kleppner D and Kolenkow R J, An Introduction To Mechanics (Special Indian Edition) (2007)
2. Rana, N.C., and Jog, P.S., Classical Mechanics Tata McGraw-Hill, New Delhi, 1991.
3. L. D. Landau and E. M. Lifshitz, Fluid Mechanics and Theory of Elasticity (Vols. 6 and 7 of Course of Theoretical Physics)

UP 203: Intermediate Electromagnetism and the Quantum Physics of Radiation (2:1) (core Course for Physics major)

Electromagnetic waves: Wave equation from Maxwell's equations, polarization, energy and momentum in EM waves, propagation in linear media, reflection and refraction, Snell's law and Fresnel's equations, Brewster angle and total internal reflection. EM waves in conductors, skin depth, simple theories for disperion of EM waves. Wave guides and coaxial cables, optical fibres Geometrical optics: Fermat's principle, Snell's law, reflection and refraction at spherical surfaces, convex and concave mirrors and lenses, real and virtual images Physical optics: Coherence, Young's two slit experiment, multiple slits, diffraction grating, wavelength resolution and fringe visibility, Newton's rings, Michelson and Fabry-Perot interferometer, difraction from rectangular and circular apertures, Airy disc and resolving power of microscopes. Quantum optics: Photons, spontaneous and stimulated emission, Einstein A and B coefficients and relation to the Planck distribution, rate equations for absorption and emission, two level and three level systems,

population inversion and light amplification, optical resonators and the basic working principle of a laser, examples of lasers: Ruby, He-Ne, semiconductor etc.

Instructors: Prerna Sharma, K S R Koteswara Rao and K Ramesh

Suggested books:

1. Griffiths D.J., Introduction to Electrodynamics, 3rd edn (Prentice-Hall of India, 2003)
2. Hecht E. & Ganesan A.R., Optics, 4th edn (Pearson, 2008)
3. Ghatak A. and Thyagarajan K., Optical Electronics (Cambridge University Press, 1991)

UP 204: Intermediate Thermal Physics and the Physics of Materials (2:1) (core course for Physics major and minor)

Review of kinetic theory and thermodynamics, Free energies, Phases and phase transitions, Van der Walls gas and the liquid gas transition, Thermodynamics of magnetic systems, Ensembles and rules of Statistical Mechanics, The Ideal Maxwell-Boltzmann Gas, The Ideal Fermi Gas, The Ideal Bose Gas, Crystal Structure, Lattice Vibrations, Band theory of electrons in crystalline solids, Thermal properties of crystalline solids.

Instructors: Chandan Dasgupta, V Venkataraman, Prasad V Bhotla

Suggested books:

1. Callen, H.B., Thermodynamics and Introduction to Thermostatistics (2^{nd} edition), Wiley Student Edition
2. Reif, F., Statistical Physics. Berkeley Physics Course Volume 5, Tata McGraw Hill.
3. Kittel,C., Introduction to Solid State Physics, 5^{th}/6^{th}/7^{th} edition, Wiley International

Semester 5 (AUG)

PH 201: Classical Mechanics (3:0) (core course for Physics major)

Newton's laws, generalized co-ordinates. Lagrange's principle of least action and equations. Conservation laws and symmetry. Integrable problems, elastic collisions and scattering. Small oscillations including systems with many degrees of freedom, rigid body motion. Hamilton's equations. Poisson brackets. Hamilton Jacobi theory. Canonical perturbation theory, chaos, elements of special relativity. Lorentz transformations, relativistic mechanics.

Instructor: Banibrata Mukhopadhyay

Suggested books:

1. Goldstein, H., Classical Mechanics, Second Edn, Narosa, New Delhi, 1989.
2. Landau, L.D., and Lifshitz, E.M., Mechanics, Pergamon, UK, 1976.
3. Rana, N.C., and Jog, P.S., Classical Mechanics Tata McGraw-Hill, New Delhi, 1991.

PH 203: Quantum Mechanics I (3:0) (core course for Physics major)

Historical foundations. Wave function for a single particle. Hamiltonian. Schrodinger equation. Probability current. Wave packets. One-dimensional problems: step, barrier and delta-function potentials. Tunnelling, scattering and bound states. Harmonic oscillator, operator approach. Matrix formulation of quantum mechanics. Hermitian and unitary operators. Orthonormal basis.

Momentum representation. Uncertainty relations. Postulates of quantum mechanics. Heisenberg representation. Ehrenfest's theorem. Three-dimensional problems. Rotations, angular momentum operators, commutation relations. Spherical harmonics. Hydrogen atom, its spectrum and wave functions. Symmetries and degeneracies. Spin angular momentum. Spin-1/2 and two-level systems. Addition of angular momentum. Spin-orbit and hyperfine interactions. Time-independent perturbation theory. Stark and Zeeman effects. Variational methods, ground state of helium atom.

Instructor: Diptiman Sen

Suggested books:

1. Cohen-Tannoudji, C., Diu, B., and Laloe, F., Quantum Mechanics Vol.1, John Wiley, 1977.
2. Landau, L.D., and Lifshitz E.M., Quantum Mechanics, Pergamon, NY, 1974.
3. R. Shankar, Principles of Quantum Mechanics, Springer, 2010
4. F. Schwabl, Quantum Mechanics, Springer, 1995

PH 205: Mathematical Methods of Physics (3:0) (core course for Physics major)

Linear vector spaces, linear operators and matrices, systems of linear equations. Eigen values and eigen vectors, classical orthogonal polynomials. Linear ordinary differential equations, exact and series methods of solution, special functions. Linear partial differential equations of physics, separation of variables method of solution. Complex variable theory; analytic functions. Taylor and Laurent expansions, classification of singularities, analytic continuation, contour integration, dispersion relations. Fourier and Laplace transforms.

Instructor: Subroto Mukerjee

Suggested books:

1. Mathews, J., and Walker, R.L., Mathematical Methods of Physics, Benjamin, Menlo Park, California, 1973.
2. Dennery, P., and Krzywicki, A., Mathematics for Physicists, Harper and Row, NY, 1967.
3. Wyld, H.W., Mathematical Methods for Physics, Benjamin, Reading, Massachusetts, 1976.

PH 211: General Physics Laboratory (0:3)

Diffraction of light by high frequency sound waves, Michelson interferometer, Hall effect, band gap of semiconductors, diode as a temperature sensor, thermal conductivity of a gas using Pirani gauge, normal modes of vibration in a box, Newton’s laws of cooling, dielectric constant measurements of tri-glycerine selenate, random walk in porous medium.

Instructors: Vasant Natarajan, Aveek Bid, D V S Muthu, G R Jayanth, Anindya Das

Semester 6 (JAN)

PH 202: Statistical Mechanics (3:0) (core course for Physics major)

Basic principles of statistical mechanics and its application to simple systems. Probability theory, fundamental postulate, phase space, Liouville’s theorem, ergodicity, micro-canonical ensemble, connection with thermodynamics, canonical ensemble, classical ideal gas, harmonic oscillators, paramagnetism, Ising model, physical applications to polymers, biophysics. Grand canonical

ensemble, thermodynamic potentials, Maxwell relations, Legendre transformation. Introduction to quantum statistical mechanics, Fermi, Bose and Boltzmann distribution, Bose condensation, photons and phonons, Fermi gas, classical gases with internal degrees of freedom, fluctuation, dissipation and linear response, Monte Carlo and molecular dynamics methods.

Instructor: Arnab Rai Choudhuri

Suggested books:

1. Pathria, R.K., Statistical Mechanics, Butterworth Heinemann, Second Edn, 1996.
2. Reif, F., Fundamentals of Statistical and Thermal Physics, McGraw Hill, 1965.
3. Landau, L.D., and Lifshitz E.M., Statistical Physics, Pergamon, 1980.

PH 204: Quantum Mechanics II (3:0) (core course for Physics major)

Time dependent perturbation theory. Fermi golden rule. Transitions caused by a periodic external field. Dipole transitions and selection rules. Decay of an unstable state. Born cross section for weak potential scattering. Adiabatic and sudden approximations. WKB method for bound states and tunneling. Scattering theory: partial wave analysis, low energy scattering, scattering length, Born approximation, optical theorem, Levinson's theorem, resonances, elements of formal scattering theory. Minimal coupling between radiation and matter, diamagnetism and paramagnetism of atoms, Landau levels and Aharonov- Bohm effect. Addition of angular momenta, Clebsch Gordon series, Wigner Eckart theorem, Lande's g factor. Many particle systems: identity of particles, Pauli principle, exchange interaction, bosons and fermions. Second quantization, multielectron atoms, Hund's rules. Binding of diatomic molecules. Introduction to Klein Gordon and Dirac equations, and their non-relativistic reduction, g factor of the electron.

Instructor: B Ananthanarayan

Suggested books:

1. Landau, L.D., and Lifshitz E.M., Quantum Mechanics, Pergamon, NY, 1974.
2. Cohen-Tannoudji, C., Diu, B., and Laloe, F., Quantum Mechanics (2 Vols.), John Wiley, 1977.

Optional Courses for Physics Major

Course no.	GP	Title	Faculty
PH 206	3:0	Electromagnetic Theory	Anindya Das
PH 207	1:2	Analog Digital and Microprocessor Electronics	K Rajan and M N Ramanuja
PH 208	3:0	Condensed Matter Physics-I	Manish Jain
PH 209	2:1	Analog and Digital Electronics Lab	K Rajan and M N Ramanuja
PH 212	0:3	Experiments in Condensed Matter Physics	Raghu Menon, Suja Elizabeth, D V S Muthu and Ramesh Mallik
PH 213	0:4	Advanced Experiments in Condensed Matter Physics	Arindam Ghosh, R Ganesan, K R Gunasekhar and Ambarish Ghosh

PH 217	3:0	Fundamentals of Astrophysics	Biman Nath and Tarun Saini
PH 231	0:1	Workshop practice	Vasant Natarajan
PH 320	3:0	Condensed Matter Physics II	Rahul pandit
PH 322	3:0	Molecular Simulation	Prabal K Maiti
PH 325	3:0	Advanced Statistical Physics	Vijay B Shenoy
PH 330	0:3	Advanced Independent Project	Faculty
PH 340	4:0	Quantum Statistical Field Theory	
PH 347	2:0	Bioinformatics	S Ramakumar and K Sekar
PH 350	3:0	Physics of Soft Condensed Matter	Jadeep K Basu
PH 351	3:0	Crystal Growth, Thin Films and Characterization	Suja Elizabeth and P. S. Anil Kumar
PH 352	3:0	Semiconductor Physics and Technology	K S R Koteswara Rao
PH 359	3:0	Physics at the Nanoscale	A K Sood and Arindam Ghosh
PH 362	3:0	Matter at Low Temperatures	Ambarish Ghosh
HE 215	3:0	Nuclear and Particle Physics	Sudhir Vempati
HE391	3:0	Quantum Mechanics III	Sachindeo Vaidya
HE395	3:0	Quantum Field Theory I	Chetan Krishnan
HE397	3:0	The standard model of Particle Physics	Rohini Godbole
HE316	3:0	Advanced Mathematical Methods of Physics	Apoorva Patel
HE396	3:0	Quantum Field Theory II	Aninda Sinha
HE398	3:0	General Relativity	Justin R David
AA363	2:0	Fluid mechanics and plasma physics	Prateek Sharma