New course structure for MSc programme in Department of Physics (2020-21 academic session onwards)

Semester I			Semester II		
Course No.	**Course Name**	**Credits**	**Course No.**	**Course Name**	**Credits**
PH401	Math Phy-I	2-1-0-6	PH402	Math Phy-II	2-1-0-6
PH403	Classical Mechanics	3-1-0-8	PH404	Statistical Mechanics	3-1-0-8
PH405	Quantum Mechanics-I	3-1-0-8	PH406	Quantum Mechanics-II	3-1-0-8
PH407	Computer programming & numerical methods	3-0-2-8	PH408	Measurement techniques	2-0-2-6
PH409	Electronics	3-1-0-8	PH410	Electrodynamics-I	3-1-0-8
PH411	Electronics Lab	0-0-6-6	PH412	General Physics Lab-I	0-0-6-6
	Credits	14-4-8-44		Credits	13-4-8-42
Semester III			**Semester IV**		
PH501	Electrodynamics-II	3-1-0-8	PH516	Advanced Physics Lab	0-0-6-6
PH503	Atomic & Molecular Physics	3-1-0-8	PH518	Project-II	0-0-12-12
PH505	Solid State Physics	3-1-0-8	PH5xx	Elective-II	3-0-0-6
PH507	Nuclear & particle Physics	3-0-0-6	PH5xx	Elective-III	3-0-0-6
PH509	Project-I	0-0-4-4	PH5xx	Elective-IV	3-0-0-6
PH5xx	Elective-I	3-0-0-6			
PH511	General Physics Lab-II	0-0-6-6			
	Credits	15-3-10-46		Credits	9-0-18-36

Total Credits: 168

New course structure for MSc programme in Department of Physics (2020-21 academic session onwards)

Syllabus

Semester I

PH401: Mathematical Physics I (2-1-0-6)

Linear Algebra: Linear Vector Space:dual space and vectors, Cauchy-Schwarz inequality, definition of real and complex vector spaces, Metric space, linear operator, subspace; Span and linear independence: row reduction and method; Basis and Dimension: use of simplified span and independence test (RREF) method; Linear Transformation: image, kernel, rank, change of basis, transition matrix, isomorphism, similarity transformation, orthonormality, Gram-Schmidt procedure, eigenvalues and eigenvectors, Hilbert space]. Tensors: inner and outer products, contraction, symmetric and antisymmetric tensors, metric tensor, covariant and contravariant derivatives.

Ordinary and Partial Differential equations: power series solution, Frobenius method, Sturm-Liouville theory and boundary value problems, Green's functions; method of separation of variables for different wave equations in Cartesian and curvilinear coordinates involving special functions like Legendre, Hermite, Laguerre and Bessel functions and method involving Green's function and its applications.

Text Books:

1. S. Andrilli & D.Hecker, Elementary Linear Algebra, Academic Press (2006).
2. A.W.Joshi, Matrices and Tensors in Physics, 3rd Edition, New Age Int. (2005)
3. G.B.Arfken, H.J.Weber and F.E. Harris, Mathematical Methods for Physicists, Seventh Edition, Academic Press(2012).

References:

1. M.L.Boas, Mathematical Methods in Physical Sciences, John Wiley & Sons (2005)
2. S. Lang, Introduction to Linear Algebra, Second Edition, Springer (2012)
3. E.A. Coddington, Introduction to Ordinary Differential Equations, Prentice Hall of India (1989)
4. I. Sneddon, Elements of Partial Differential Equations, McGraw Hill
5. T. Lawson, Linear Algebra, John Wiley & Sons (1996)
6. P. Dennery & A. Krzywicki, Mathematics for Physicists, Dover Publications (1996)
7. Mathematical Methods for Physics, J. Mathews and R. L. Walker, Pearson Addison-Wesley; 2 edition (1 January 1971).
8. Linear Algebra Done Right, Sheldon Axler, Springer; 3rd edition (2015).

PH 403: Classical Mechanics (3-1-0-8)

D'Alembert's principle and Lagrange equation: Generalized coordinates, principle of virtual work, D'Alembert's principle, Lagrangian formulation and simple applications.

Variational principle and Lagrange equation: Hamilton's principle, Lagrange equation from Hamilton's principle, Extension to non-Holonomic systems, Lagrange multipliers, symmetry and con-servation laws .

Hamiltonian formulation: Legendre transformations, Hamilton's equations, symmetries and conser-vation laws in Hamiltonian picture, Hamilton's principle, canonical transformations, Poisson brackets, HamiltonJacobi theory, action-angle variables.

Central force problem: Two body problem in central force, Equations of motion, effective potential energy, nature of orbits, Virial theorem, Kepler's problem, condition for closure of orbits, scattering in a central force field, centre of mass and laboratory frame.

Rotating frame: Angular velocity, Lagrange equation of motion, inertial forces.

Rigid body motion: kinetic energy, momentum of inertia tensor; angular momentum, Euler angles, heavy symmetrical top, Euler equations, stability conditions.

Small Oscillations: Eigenvalue problem, frequencies of free vibrations and normal modes, forced vibrations, dissipation.

Text Books:

1. H. Goldstein, C. P. Poole and J. Safko, Classical Mechanics, 3 rd Edition, Pearson (2012).

References:

1. N. C. Rana and P. S. Joag, Classical Mechanics, Tata Mcgraw Hill (2001).
2. L. Landau and E. Lifshitz, Mechanics, Oxford (1981).
3. S. N. Biswas, Classical Mechanics, Books and Allied (P) Ltd.,Kolkata (2004) .
4. F. Scheck, Mechanics, Springer (1994).

PH405: Quantum Mechanics-I (3-1-0-8)

Introduction: concept of wave function, probability and probability current density, conservation of probability, equation of continuity, uncertainty principle.

One dimensional problems: Brief review of infinite and finite potential wells, bound states, potential barrier and tunneling, scattering off step potential. 1-d Harmonic Oscillator): Hermite polynomials, minimal uncertainty product, operator algebra of harmonic oscillator.

Formalism: Function spaces, inner product space, operators, expectation values of physical variables, bases, Dirac notation, eigenvalues and eigenvectors, commutation relations, Hilbert space, measurement of physical observables, compatible and incompatible observables, postulates of Quantum Mechanics.

Angular momentum algebra: Commutation relations, raising and lowering operators, coordinate representation of L^2 and L_z and their eigenfunctions, L-S coupling, Total angular momentum, addition of angular momenta, Clebsch-Gordon Coefficients, spin angular momentum, Pauli matrices, interaction of spin with magnetic field.

Three dimensional problems: Free particle in a spherical cavity, three dimensional harmonic oscillator, degeneracy, solution of Schrodinger's equation for central potentials, Hydrogen atom problem.

Symmetries and their generators: translational invariance and linear momentum, Discrete symmetries (parity and time reversal), rotational Symmetry and angular momentum.

Text Books:

1. R. Shankar, Principles of Quantum Mechanics, Springer (India) (2008).
2. J. J. Sakurai, Modern Quantum Mechanics, Pearson Education (2002).

References:

1. K. Gottfried and T-M Yan, Quantum Mechanics: Fundamentals,2nd Ed., Springer (2003).
2. D. J. Griffiths, Introduction to Quantum Mechanics, Pearson Education (2005).
3. P. W. Mathews and K. Venkatesan, A Textbook of Quantum Mechanics, Tata McGraw Hill(1995).
4. F. Schwabl, Quantum Mechanics, Narosa (1998).
5. L. Schiff, Quantum Mechanics, Mcgraw-Hill (1968).
6. E. Merzbacher, Quantum Mechanics, John Wiley (Asia) (1999).
7. B. H. Bransden and C. J. Joachain, Quantum Mechanics, Pearson Education 2nd Ed. (2004).

PH 407 Computer programming and Numerical methods (3-0-2-8)

Computer programming:

Introduction: Basic introductions of structure of the program; Constants, Variables and expressions; general features of input/output and formatting; Standard libraries; Control structures: Loops and logical statements; Arrays, strings, functions and Pointers.

Numerical Methods:

Error analysis; Finding roots of a function: Bisection, Newton-Raphson, Secant method; Linear equations: Gauss and Gauss-Jordan elimination, Partial-Pivoting, LU decomposition, Gauss-Seidel, Jacobi; Eigenvalue Problem: power methods, Similarity transformation and their applications; Curve Fitting: Linear and Non-linear fitting of curves; Interpolation: Newton's divided difference and Lagrange's algorithms, Cubic Spline; Numerical Differentiation: First and Second order derivatives, Truncation errors and Order of the schemes; Integration:

Trapezoidal and Simpson's rules, Romberg correction, Gauss quadrature. Order of the schemes; Ordinary differential equation: Initial value problem, Euler, Mid-point, Heun's and Runge-Kutta methods; Partial differential equations: Boundary value problems, Application to physics problems.

Text Books:

1. Kelley and I. Pohl, A Book on C Programming in C, Pearson Education (2005).
2. K. R. Venugopal and S. R. Prasad, Mastering C Programs, Tata McGraw-Hill 2010.
3. V. Rajaraman, Computer Programming in Fortran 90 and 95, Prentice-Hall India (2006).
4. K. E. Atkinson, *Numerical Analysis*, John Wiley (Asia) (2004).

PH409: Electronics (3-1-0-8)

Analog electronics:
Review of BJT circuits covering p-n junction, wave shaping circuits using a diode, BJT biasing, CE amplifier, feedback - amplifier and oscillator.

FET: JFET biasing and amplifier, MOSFET - enhancement and depletion, amplifier.

Differential amplifiers: BJT/MOSFET differential amplifiers, difference and common mode gains, CMRR.

Operational amplifier: Difference amplifiers, ideal OP-AMP, IC741, OP AMP parameters and corrections, arithmetic circuits, comparator, multiplier, divider, differentiator, integrator, active filters, oscillators.

555 Timer: internal circuitry, astable, monostable and bistable operations, voltage regulators (IC 78xx, 79xx), A/D and D/A conversion.

Digital electronics: Review of number systems, logic gates, Boolean algebra, logic Families, Binary Arithmetic Circuits (adder, subtractor, half adder, full adder), Data processing circuits (multiplexers/demultiplexers, encoder/decoder, parity generator/checker, comparator), Sequential Circuits (Flip-flops, Registers, Counters), Memories - ROM and RAM.

INTEL 8085 microprocessor: Architecture, Instruction set, Programming, Peripheral interfacing, and Serial communication, evolution of architecture and instruction set of 16-, 32- and 64-bit INTEL processors

Text Books:

1. A. S. Sedra and K. C. Smith, Electronics Circuits, (6th Edn), Oxford University Press (2009)

2. R. L. Boylestad and L. Nashelsky, Electronic Devices and Circuit Theory (10th Edn), Prentice Hall (2008)
3. D. P. Leach, A. P. Malvino and G. Saha, Digital Principles and Applications (6th Edn), Tata McGraw Hill (2007)
4. R. Gaekwad, Op-Amps and Linear Integrated Circuits, Prentice Hall of India (1995).
5. R. S. Gaonkar, Microprocessor Architecture: Programming and Applications with the 8085, Penram India (1999).

References:

1. J. Millman (late), C C Halkias. And C Parikh, Integrated electronics Analog and Digital Circuits and system, Tata McGraw Hill Education Pvt Ltd. Second edition, 2012.
2. M. J. Roberts and G. Sharma, *Fundamentals of Signals and Systems,* 2nd edition. McGraw-Hill Education, 2017.

PH411 Electronics Lab (0-0-6-6)

Typical experiments based on:

Voltage rectifiers and regulation circuits, Regulated dual voltage power supply, Single stage and dual stage amplifier circuits; feedback amplifier; OP-AMP: frequency response, arithmetic operation, differentiator and integrator circuits, active filters; oscillators circuits; experimental circuits with NE555; circuits involving LED, Photo transistors and photodiode; Universality of NOR/NAND gates; Verification of De Morgan's theorem; half-adder, full adder; multiplexers and de-multiplexers; comparators; JK flip-flop, registers and counters; assembly language programming exercises with INTEL 8085 microprocessor kit; Simple interfacing experiments with microprocessor.

References:

1. P. B. Zbar and A. P. Malvino, Basic Electronics: a text-lab manual, Tata McGraw Hill (1983).
2. D. P. Leach, Experiments in Digital Principles, McGraw Hill (1986).
3. R. S. Gaonkar, Microprocessor Architecture: Programming and Applications with the 8085, Penram India (1999).
4. Laboratory manual with details about the experiments.

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Semester II:

PH402: Mathematical Physics II (2-1-0-6)

Complex Analysis: Functions, derivatives, Cauchy-Riemann conditions, analytic and harmonic functions, contour integrals, Cauchy-Goursat Theorem Cauchy integral formula; Series: convergence, Taylor series, Laurent series, singularities, residue theorem, applications of residue theorem, branch cut and its application involving complex integrals, conformal mapping and application.

Integral transformations: Laplace transformations and applications to differential equations.

Group Theory: properties of groups, Homomorphism and isomorphism, subgroups, infinite groups, cosets, conjugacy classes, and invariant subgroups; Symmetry and group representation by matrix [unitary representation and conservation laws]; Lie groups and algebras [generators, SO(2), SO(3) and SU(2)]; introduction to discrete groups (Abelian only).

Text Books:

1. J. Brown and R.V.Churchill, Complex Variables and Applications, McGraw-Hill, 8th Edition (2008)
2. A.W.Joshi, Elements of Group Theory, New Age Int. (2008)

References:

1. M.L.Boas, Mathematical Methods in Physical Sciences, John Wiley & Sons (2005)
2. G.B.Arfken, H.J.Weber and F.E. Harris, Mathematical Methods for Physicists, Seventh Edition, Academic Press (2012)
3. M. Hamermesh, Group Theory and Its Applications to Physical Problems, Dover (1989)
4. D.B. Lichtenberg, Unitary symmetry and elementary particles, second edition, Academic Press (1978).

PH404: Statistical Mechanics (3-1-0-8)

Thermodynamic Potentials: Thermodynamic potentials for fluid and magnetic systems, internal energy and entropy, Legendre transformation, enthalpy, Helmholtz free energy, Gibbs free energy and grand potential. Thermodynamic parameters and response functions.

Theory of Probability: Frequency and probability, Probability of compound event, independent event, probability distribution functions: Binomial, Poisson and Normal, average, variance; Shanon information entropy and H-function, Statistical concept of uncertainty, Relation of probability and Boltzmann entropy with H-function.

Statistical description of physical systems: Microstates and Macrostates, Specification of microscopic states of system of classical systems, Phase space, free particle in one dimension, one dimensional harmonic oscillator, classical ideal gas, etc. Different ensembles for thermodynamic systems. Specification of microscopic states of quantum systems, Localized spin-1/2 particles in absence and presence of external magnetic field, one dimensional harmonic oscillator, free particle in one-dimensional box. Distinguishable and indistinguishable particles, classical and quantum statistics.

Microcanonical Ensemble (E,N,V): Phase space density, Time average, ensemble average and ergodic hypothesis, Liouville's theorem, equal a priori probability. Boltzmann hypothesis, Statistical definition of entropy, Entropy as an ensemble average quantity, Classical ideal gas, Gibbs' paradox, Classical harmonic oscillator. Quantum systems in microcanonical ensemble, Pure and mixed states, density matrix, time evolution of density matrix, entropy in terms of density matrix, Ideal paramagnet, two state stystems, negative absolute temperature, Quantum harmonic oscillator, Free particles in a box.

Canonical Ensemble (N,V,T): Probability distribution of phase points, Partition function, statistical averages, thermodynamics in canonical ensemble, entropy and Helmholtz free energy, thermodynamic parameters and response functions, classical ideal gas and classical harmonic oscillator. The "equipartition" and the "virial" theorem. Quantum canonical ensemble, density operator, partition function, quantum ensemble average, electron in a magnetic field, entropy and free energy, density matrix for free particles, harmonic oscillators. Fluctuation in energy, Correspondence with the microcanonical ensemble.

Gibbs' Ensemble (N,P,T): Probability distribution of phase points, Partition function, statistical averages, thermodynamics in pressure ensemble, entropy and Gibbs' free energy, thermodynamic parameters and response functions, stretched polymers, classical ideal gas, statistics of paramagnetism. Fluctuation in volume and enthalpy.

Grand Canonical Ensemble (μ,V,T): Probability distributions, partition function, Statistical average, entropy and grand potential, thermodynamics in grand canonical system, classical ideal gas Density and energy fluctuations in the grand canonical ensemble, correspondence with other ensembles. Grand canonical density operator, partition function, entropy in terms of density operator and grand potential, quantum harmonic oscillator, Solid vapour equilibrium.

Quantum ideal gas of indistinguishable particles: Symmetric, anti-symmetric wave functions, Fermions and Bosons, Quantum gas in microcanonical ensemble, Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac distributions, Quantum gas in canonical ensemble, partition function, gases of molecules with internal motion, grand canonical distribution of quantum gas, occupation number distributions, thermodynamics, Calculation of continuum limit.

Ideal Bose gas: Thermodynamics of Bose gas, mean energy, heat capacity, Bose–Einstein condensation in ultra cold atomic gases, Blackbody radiation, Lattice vibrations and Debye model.

Ideal Fermi gas: Thermodynamics of Fermi gas, Fermi energy, Mean energy and equation of state at T=0, Heat capacity, the degenerate Fermi gas, Pauli paramagnetism.

Introduction to phase transition: General properties, Phase transitions in Van der Waals Fluid, Critical exponents.

Texts Books:

1. R. K. Pathria, Statistical Mechanics, Butterworth-Heinemann (1996).

References:

1. W. Greiner, L Neise, and H. Stocker, Thermodynamics and Statistical Mechanics, Springer (1994).
2. A. R. A. Salinas, Introduction to Statistical Physics, Springer, New York (2001).
3. K. Huang, Statistical Mechanics, John Wiley Asia (2000).
4. R. Kubo, Statistical Mechanics, Elsevier, Amsterdam (1965).

PH406: Quantum Mechanics II (3-1-0-8)

Time Independent Perturbation Theory: Non-degenerate case(quadratic Stark effect)and degenerate case [linear Stark effect, fine structure and Zeeman effect, Van der Walls interaction).

Time dependent perturbation theory: Interaction picture [examples like two state problems including resonance]; Dyson series, applications using constant [Fermi's Golden rule], harmonic perturbation [principle of detailed balance] and electric dipole approximation, concept of decay width.

Variational method and WKB approximation.

Scattering Theory: Lippmann-Schwinger equation and concept of differential cross section; Born approximation (including higher order and validity of it); Optical Theorem; Method of partial waves [unitarity and phase shift, hard sphere scattering], low energy scattering and bound states [Ramsauer-Townsend effect], Resonance scattering.

Relativistic Quantum Mechanics: free particle Klein Gordon equation, Dirac equation and its solutions; introduction of gamma matrices and their algebra, concept of spinors, covariance of Dirac equation and bilinear covariants.

Text Books:

1. 1.J. J. Sakurai, Modern Quantum Mechanics, Pearson Education (2002).
2. B. H. Bransden & C. J. Joachain, Quantum Mechanics, Pearson Edu., 2^{nd} Ed. (2004).

References:

1. R. L. Liboff, Introductory Quantum Mechanics, Pearson Education, 4th Ed. (2003).
2. F. Schwabl, Quantum Mechanics, Narosa (1998).
3. L. I. Schiff, Quantum Mechanics, Mcgraw-Hill(1968).
4. R. Shankar, Principles of Quantum Mechanics, Springer; 2nd edition (1994).

PH408: Measurements Techniques (2-0-2-6)

Sensors: Resistive, capacitative, inductive, electromagnetic, thermoelectric, elastic, piezoelectric, piezoresistive, photosensitive and electrochemical sensors; interfacing sensors and data acquisition using serial and parallel ports.

Low Pressure generation and measurement: Rotary, sorption, oil diffusion, turbo molecular, getter and cryo pumps; Mcleod, thermoelectric (thermocouple, thermister and pirani), penning, hot cathode and Bayard Alpert gauges; leak detection; effective pump speed.

Low Temperature generation and measurement: Gas liquifiers; Cryo-fluid baths; liquid He cryostat design; closed cycle He refrigerator; low temperature measurement.

Principles of Analytical Instruments: X-ray diffractometer; Spectrophotometers (UV-Vis-NIR & FTIR), fluorescence and Raman spectrometer, DSC & DTGA, lock-in amplifier & PID controller, spectrum analyzer, Resonance Spectroscopy (ESR & NMR), Electron microscope, atomic force microscope.

Laboratory Component: Physical parameters measurement using different sensors, low pressure generation and measurement. Data analysis: X-ray and electron diffraction patterns, Transmission data of thin films for determination of thickness and optical constants, Raman and PL data (deconvolution etc), DTA and DTGA curve.

Scientific Seminar on related topics.

Text Books:

1. A.D. Helfrick and W. D. Cooper, Modern Electronic Instrumentation and Measurement Techniques, Prentice-Hall of India, 1996.
2. J. P. Bentley, Principles of Measurement Systems, Longman, 2000.
3. V V Rao, T K Ghosh and K L Chopra, Vacuum Science and Technology, Allied Publishers, 2001.

References:

1. G. K. White, Experimental Techniques in Low Temperature Physics, Clarendon, 1993.
2. Roth, Vacuum Technology, Elsevier, 1990.
3. D. A. Skoog, F. J. Holler and T. A. Nieman, Principles of Instrumental Analysis, Saunders Coll. Publ., 1998

4. A Ghatak and K.Thyagarajan, Optical Electronics, C.U.P. (1991).
5. G.C.M. Meijer, Smart Sensor Systems, John Wiley & Sons Ltd, UK (2008).
6. M. Alley, The Craft of Scientific Presentations: Critical Steps to Succeed and Critical Errors to Avoid, Springer-Verlag New York (2003).

PH410 Electrodynamics I (3-1-0-8)

Electrostatics: Poisson and Laplace equations, Dirichlet and Neumann boundary conditions; Boundary value problems: Method of images, Laplace equation in Cartesian, spherical and cylindrical coordinate systems, applications;

Green function formalism: Green function for the sphere, expansion of Green function in spherical coordinates; Multipole expansion; Boundary value problems for dielectrics;

Magnetostatics: vector potential, magnetic induction for a circular current carrying loop, magnetic materials, boundary value problems, Magnetic shielding, magnetic field in conductors;

Electrodynamics: Maxwell's equations, Gauge transformations, Poynting's theorem, Energy and momentum conservation;

Electromagnetic waves: wave equation, propagation of electromagnetic waves in non-conducting medium, reflection and refraction at dielectric interface, total internal reflection, polarization of waves, Goos-Hänchen shift, Brewster's angle, complex refractive index.

Text Books:
1. J. D. Jackson, Classical Electrodynamics, John Wiley (Asia) (1999).

References:
1. H J W Muller Kirsten, Electrodynamics, World Scientific (2011).
2. J. R. Reitz and F. J. Milford, Foundation of Electromagnetic Theory, Narosa (1986).
3. W. Greiner, Classical Electrodynamics, Springer (2006).
4. L. D. Landau and E. M. Lifshitz, Electrodynamics of Continuous Media, Butterworth-Heimemann (1995)

PH412: General Physics I (0-0-6-6)

A typical set of following experiments in general physics, condensed matter physics and optics would be performed. General physics: Frank-Hertz experiment, Radioactive decays; Condensed matter physics: electrical resistivity and bandgap of semiconductors, Hall coefficient and carrier concentration using Hall effect in semiconductors, magneto-resistance, magnetic susceptibility of paramagnetic liquid; Optics: Diffraction by double slit, grating and circular aperture, Newton Rings and wire thickness using air wedge method, Fresnel Bi-prism.

References:

1. R. A. Dunlop, Experimental Physics, Oxford University Press (1988).
2. A. C. Melissinos, Experiments in Modern Physics, Academic Press (1996).
3. E. Hecht, Optics, Addison-Wesley; 4 edition (2001)
4. A. Lipson, S G Lipson, H Lipson, Optical Physics, Cambridge University (2010).
5. Laboratory manual with details about the experiments.

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Semester III:

PH 501 Electrodynamics II (3-1-0-8)

Electromagnetic waves in conducting medium: reflection and transmission, frequency dependence of permittivity, permeability and conductivity, electrons in conductors and plasma;

Wave Guides: waves between parallel conductors, TE and TM waves, rectangular and cylindrical wave guides, resonant cavities; Radiating Systems and Multipole fields: retarded potential, field and radiation of a localized oscillating source, electric dipole fields and radiation, quadrupole fields, multipole expansion, energy and angular momentum, multipole radiations;

Scattering: scattering at long wavelengths, perturbation theory, Rayleigh scattering;

Radiation by Moving Charges: Lienard Wiechert potential, radiation by nonrelativistic and relativistic charges, angular distribution of radiations, distribution of frequency and energy, Thomson's scattering, bremsstrahlung in Coulomb collisions;

Relativistic Electrodynamics: covariant formalism of Maxwell's equations, transformation laws and their physical significance, relativistic generalization of Larmor's formula, relativistic formulation of radiation by single moving charge.

Text Books:

1. J. D. Jackson, Classical Electrodynamics, John Wiley (Asia) (1999).

References:

1. H J W Muller Kirsten, Electrodynamics, World Scientific (2011).
2. E. C. Jordan and K. G. Balmain, Electromagnetic Waves and Radiating Systems, Prentice Hall (1995).
3. J. Schwinger et aI., Classical Electrodynamics, Perseus Books (1998).
4. G. S. Smith, Classical Electromagnetic Radiation, Cambridge (1997).
5. R.P. Feynmaan, The Feynmann lectures on Physics: Vol. II, Milennial Edition, Pearson (2012)
6. D.J.Griffiths, Introduction to Electrodynamics, 4^{th} Edition, Pearson (2015).

PH 503: Atomic and Molecular Physics (3-1-0-8)

One electron atoms: Free particle Dirac Equation, Dirac Equation with electromagnetic coupling: Darwin term, spin-orbit, relativistic corrections, Zeeman and Pashchen Back effects; Lamb shift, Magnetic hyperfine interactions.

Two electron atoms: Symmetry of wave functions, electron spins, Pauli exclusion principle, Approximate methods, Energy levels, the spectrum of Helium atom. Observation of Zeeman splitting using Fabry Perot interferometer.

Many electron atoms: Central field approximation, Hartee Fock method, configuration interaction; Electronic configurations and coupling of angular momenta: coupling schemes, vector-model, electronic configurations and atomic states.

Interactions between atoms and radiation: transition probabilities, Stimulated and spontaneous emission, absorption, selection rules: Einstein coefficients, magnetic quantum number, parity, spin; spectra of alkali atoms, multiplet structure.

Molecular structure: molecular potential; Born-Oppenheimer approximation, diatomic molecules, electronic angular momenta; approximate methods: linear combination of atomic orbitals (LCAO) approach; states for hydrogen molecular ion; shapes and term symbols for simple molecules.

Molecular spectra: rotational, vibrational, electronic, Raman and Infra-red spectra of diatomic molecules; electronic and nuclear spins, Frank-Condon principle and selection rules.

Spectroscopic techniques: Raman spectroscopy of Carbon-tetrachloride, IR spectroscopy, optical cooling and trapping of atoms.

Text Books:

1. B.H. Bransden and C.J. Joachain, Physics of atoms and molecules, 2nd Ed. Pearson (2008).
2. C.N.Banwell and E.M.McCash, Fundamentals of Molecular Spectroscopy, 4th Ed., Tata McGraw (2004).
3. H.E.White, Introduction to Atomic spectra, Tata McGraw Hill (1934).

References:

1. M. Weissbluth, Atoms and molecules, Academic Press (1978).
2. W. S. Struve, Fundamentals of Molecular spectroscopy, John Wiley (1999)
3. W. Demtroder, Atoms, Molecules and Photons, 2nd Ed., Springer (2010).
4. C.J.Foot, Atomic Physics, Oxford University Press (2005).
5. G.K.Woodgate, Elementary Atomic Structure, Clarendon Press (1989).

PH505: Solid State Physics (3-1-0-8)

Crystal structures: Point group and space group, Bravais lattice, reciprocal lattice, Brillouin zone, Miller indices, Bragg and Laue diffractions, structure factor.

Lattice vibration and thermal properties: Lattice vibrations in harmonic approximation, dispersion relations in monatomic and diatomic chains, optical and acoustic modes, concept of Brillouin zone, phonons, crystal momentum, dispersion relations in three dimensional systems, Einstein and Debye theory of specific heat, Anharmonic effects, thermal expansion.

Electronic properties: Sommerfeld model of free electrons, Electrons in a periodic potential, Nearly free electron model, Bloch's theorem, Kronig-Penny model, Tight binding model, band theory, effective mass, concept of hole, classification of metal, insulator and semiconductor, Fermi surface of metals, de Haas-Van Alphen effect, Shubnikov de Haas Oscillations, semiconductors: intrinsic and extrinsic semiconductors, mobility and electrical conductivity, Hall effect, statistics of semiconductors.

Dielectric properties: General properties of dielectrics: Polarization and Fundamental equation of dielectrics (Clausius-Mosotti equation). Polarization mechanisms in dielectrics: induced, orientational, electronic, ionic, interfacial and lattice polarizations; combined mechanisms. Relaxation (Debye & non-Debye) mechanisms in dielectrics. Dielectric breakdown. Ferro, pyro, piezo-electricity: phenomenology, theory and applications.

Magnetic properties: Classical and quantum models of diamagnetism, quantum theory of Paramagnetism, Lande g factor, Hund's rule, crystal field effect, Curie law, concepts of Ferro, Ferri and antiferromagnetism, Neel temperature, Heisenberg model and exchange interaction, spin waves and magnon dispersions, Ferromagnetic domains.

Superconductivity: Introduction to superconductivity, London equations, Temperature dependence of the critical field and the critical current, Coherence length and the penetration depth, Type-I and type-II superconductors, A description of the normal state, elements of the BCS theory, energy gap and Tc.

Text Books:

1. Introduction to Solid State Physics, C. Kittel, 8th ed; John Wiley & Sons (2005).
2. Solid State Physics, N. W. Ashcroft and N. D. Mermin Cengage Learning India Pvt. Ltd. (2003).

References:

1. Philip Hofmann, Solid State Physics: An Introduction 2nd Edition (2015),
2. J.D. Patterson and B.C. Bailey; Solid State Physics, Springer (2007).
3. M.S. Rogalski and S.B. Palmer; Solid State Physics, Gordon and Breach Science Publishers (2001).

PH507: Nuclear and Particle Physics (3-0-0-6)

Nuclear properties: radius, size, shape: scattering experiments, form factors; mass, spin, isospin, moments, abundance of nuclei, binding energy, semi-empirical mass formula, excited states. Nuclear forces: Nature of nuclear forces, deuteron, n-n and p-p interaction; Yukawa hypothesis. Nuclear Models: Liquid drop model; Fermi gas model; Shell model and its predictions: spin-parity, moments, magic numbers. Nuclear decay and radioactivity: Radioactive decay, Energetics of decay; Alpha decay, tunneling probability; Beta decay, decay rate and beta spectrum, parity violation; Gamma decay, selection rules, counting statistic and Geiger-Muller counter; Radioactive dating. Nuclear reactions: Conservation laws, energetics of reactions, nuclear scattering, Rutherford scattering; Nuclear fission and nuclear fusion, nuclear reactors.

Particle accelerators and detectors: electrostatic accelerators, cyclotron, synchrotron; linear accelerators, fixed target and colliding beam accelerators, circular colliders. Fundamental forces and particles: Fundamental forces and elementary particles, symmetries: discrete, continuous and conservation laws; Properties of quarks and leptons; Properties of mesons and baryons; Quark model, concept of colour charge. Gauge symmetry: Gauge symmetry in electrodynamics, conservation laws from gauge symmetries; Particle interactions and introduction to Feynman diagrams.

Text Books:

1. K. S. Krane, Introductory Nuclear Physics, John Wiley (1988).

References:

1. R.R. Roy & B. P. Nigam, Nuclear Physics: Theory and Experiment, New Age (1967).
2. A. Das and T. Ferbel, Introduction to nuclear and particle physics, John Wiley (1994).
3. K. Heyde, Basic Ideas and Concepts in Nuclear Physics: An Introductory Approach, Third Edition (Series in Fundamental & Applied Nuclear Physics), CRC Press (2004).
4. M. A. Preston and R. K. Bhaduri, Structure of the nucleus, Addison-Wesley (1975).
5. I. S. Hughes, Elementary Particles, Cambridge (1991).
6. F. Halzen and A. D. Martin, Quarks and Leptons, John Wiley (1984).
7. D. Perkins, Introduction to High Energy Pysics, Cambridge University Press; 4th edition (2000).

PH511: General Physics Lab II (0-0-6-6)

The following experiments in general physics, condensed matter physics and optics would be performed. General Physics: LCR Circuit Forced damped oscillator, emission spectra of gases. Condensed Matter Physics: P-N junction properties with biasing and temperature variations, electron spin resonance spectrum, magnetic hysteresis loop, ferroelectric transition, dielectric constant of liquids. Optics: Polarization and Brewster angle, numerical aperture of optical fibre, solar cells, Michelson interferometer, absorption spectroscopy in liquids, Fabry-Perot interferometer.

References:

1. R. A. Dunlop, Experimental Physics, Oxford University Press (1988).

2. A. C. Melissinos, Experiments in Modern Physics, Academic Press (1996).
3. E. Hecht, Optics, Addison-Wesley; 4th Edition (2001).
4. J Varma, Nuclear Physics Experiments, New Age Publishers (2001).
5. Laboratory Manual with details about the experiments.

New course structure for MSc programme in Department of Physics
(2020-21 academic session onwards)

Semester IV:

PH 516 Advanced Physics Lab (0-0-6-6)

Atomic spectra by constant deviation spectrometer; polarization, Fraunhoffer and Bragg diffraction using microwave,; Holography: construction of the hologram and reconstruction of the object beam; Zeeman effect; X ray diffraction; Radioactive decay: counting statistics; optical fiber: mode field diameter and numerical aperture, bend loss measurement; superconducting, ferroelectric and ferromagnetic transition, characterisation of quantum dot structures.

References:

1. E. Hecht, Optics, Addison-Wesley; 4th edition (2001).
2. R. A. Dunlop, Experimental Physics: Modern methods, Oxford University Press, USA 1st edition (1988).

A. Ghatak, K. Thyagarajan, Introduction to fiber Optics, Cambridge University Press, 1st edition (1999).

3. A.C. Melissinos, J. Napolitano, Experiments with modern physics, Academic press, 2nd edition (2003).
4. J. Varma, Nuclear Physics Experiments, New Age Publishers (2001).
5. Laboratory manual with details about the experiments.

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