Course Structure and Syllabus for

B.Sc.(Hon.) and M.Sc.(Physics)

under Flexible Choice Based Credit Scheme (FCBCS)

2025-27

https://uomphysics.net

General Information about FCBCS

- The Master's Degree program is of 4 semesters-two years duration. A candidate can avail a maximum of 8 semesters, i.e., 4 years (in one stretch) to complete Master's Degree (including blank semesters, if any). Whenever a candidate opts for blank semester(s), he/she has to study the prevailing courses offered by the department as per the prevailing scheme.
- A candidate has to earn a minimum of 76 credits, for successful completion of the Master's Degree. The credits to be earned should be as per the distribution shown below.

Course Type		Credits
Hard Core	:	A minimum of 24
Soft Core	:	A minimum of 20
Open Elective	:	4

- A candidate can register for a maximum of 24 credits per semester.
- Only such candidates who register for a minimum of 18 credits per semester in the first two semesters and complete successfully 76 credits in 4 successive semesters shall be considered for declaration of ranks, medals and are eligible to apply for student fellowship, scholarship, free ships and hostel facilities.
- A candidate admitted to Master's program can exercise an option to exit with Bachelor Honors degree / PG diploma after earning 40 credits successfully.
- The evaluation of the candidate shall be based on continuous assessment. The period of formative assessment is split into 3 components-C1, C2, and C3. At the end of each semester, there will be a summative assessment C4 conducted for 40%.
- Minor/ Major Project will be evaluated for 20%, and the final viva voce and report evaluation will be for 40% as C4.
- A candidate should have a minimum of 75% attendance by the end of 16th week in each course, else he/she is considered to have Dropped the course.
- In case a candidate secures less than 40% in C1, C2 and C3 put together in a course, the candidate is said to have DROPPED that course, and such a candidate is not allowed to appear for C4 in that course.

- The student can approach the teaching faculty for any clarification in the marks scored in C1, C2, or C3. Once satisfied, he/she will sign a register containing those scores. A student can appeal for revaluation of C4 scores within 10 days of the announcement of results. The Department Council will take the necessary action. If the student is still not satisfied, he/she can appeal to the Registrar (Evaluation).
- In case a candidate secures less than 40% in C4, he/she may choose DROP/MAKE- UP option. If he/she chooses the MAKE-UP option, it has to be completed during 19–21 week of the same semester. If the candidate fails to secure 40% even in the MAKE-UP evaluation, he/she is considered to have Dropped the course. The candidate has to exercise his/her option to DROP immediately within a week from the date of notification of results.
- A candidate has to re-register for the Dropped course when the course is offered again by the department, if it is a hard-core course. The candidate may choose the same or an alternate core/elective in case the dropped course is soft core / elective course. A candidate who is said to have Dropped project work may re-register for the same subsequently within the stipulated period. The details of any DROPPPED course will not appear in the grade card.
- Upon successful completion of Bachelors Honors / Master's Degree a final grade card consisting of grades of all courses successfully completed by the candidate will be issued by the Registrar (Evaluation).
- The classification of results is by the final Qualitative Index awarded to the student which is based CGPA as shown below:

CGPA	Qualitative Index
$5 \le \text{CGPA} < 6$	Second class
$6 \le \text{CGPA} < 8$	First class
$8 \le \text{CGPA} < 10$	Distinction
Overall percentage $= 10 \times \text{CGPA}$	

- In case there are any issues not addressed in these regulations, the decision of the Vice-Chancellor on the advice of the Board of Studies will be final.

To know the complete regulations presently in force at the university, please visit the university website

http://uni-mysore.ac.in

Semester 1

Paper		Credits (L+T+P)
Hard Core Papers		
PHY101	Classical Mechanics	3 + 0 + 0 = 3
PHY102	Mathematical Methods of Physics 1	3 + 0 + 0 = 3
PHY103	Mathematical Methods of Physics 2	3 + 0 + 0 = 3
PHY104	Classical Electrodynamics, and Optics	3 + 0 + 0 = 3
PHY105	Computer Lab CL-A	0 + 0 + 2 = 2
Soft Core Papers		
PHY106	Optics Lab*	0 + 0 + 4 = 4
PHY107	Electronics Lab*	0 + 0 + 4 = 4

* A student can opt either for PHY106 or PHY107.

L: Lecture; T: Tutorial; P: Practical

Credits earned: Hard core: 14; Soft core: 4

Semester 2

	Paper	Credits (L+T+P)
Hard Core Papers		
PHY201	Continuum Mechanics and Relativity	3 + 0 + 0 = 3
PHY202	Thermal Physics	3 + 0 + 0 = 3
PHY203	Quantum Mechanics 1	3 + 0 + 0 = 3
PHY204	Spectroscopy and Fourier Optics	3 + 0 + 0 = 3
PHY205	Computer Lab CL-B	0 + 0 + 2 = 2
Soft Core Papers		
PHY206	Optics Lab*	0 + 0 + 4 = 4
PHY207	Electronics Lab**	0 + 0 + 4 = 4

* For students who have completed PHY107.
** For students who have completed PHY106.

L: Lecture; T: Tutorial; P: Practical

Credits earned: Hard core: 14; Soft core: 4

Semester 3

Paper		Credits (L+T+P)
Hard Core Papers		
PHY301	Nuclear and Particle Physics	3 + 0 + 0 = 3
PHY302	Condensed Matter Physics	3 + 0 + 0 = 3
PHY311	Nuclear Physics Lab‡	0 + 0 + 4 = 4
PHY312	Condensed Matter Physics Lab‡	0 + 0 + 4 = 4
Soft Core Papers		
(Students are permitted to register for any one of the following groups)		
PHY303	Nuclear Physics 1	3 + 0 + 0 = 3
PHY313	Nuclear Physics Lab 1*	0 + 0 + 2 = 2
PHY304	Solid State Physics 1	3 + 0 + 0 = 3
PHY314	Solid State Physics Lab 1**	0 + 0 + 2 = 2
PHY305	Theoretical Physics 1	3 + 0 + 0 = 3
PHY315	Theoretical Physics Lab 1†	0 + 0 + 2 = 2
Soft Core Papers		
(Students are permitted to register for any one of the following groups)		
PHY306	Accelerator Physics	3 + 0 + 0 = 3
PHY307	Astrophysics	3 + 0 + 0 = 3
PHY308	Atmospheric Physics	3 + 0 + 0 = 3
PHY309	Numerical Techniques & Computational Physics	3 + 0 + 0 = 3
PHY316	Methods of Material Characterization	1 + 0 + 2 = 3
PHY322	Minor Project	4
Open Elective Papers		
PHY320	Energy Science	3 + 1 + 0 = 4
PHY321	Nonlinear Optics	3 + 0 + 0 = 3

‡ A student can opt either for PHY311 or PHY312.

* Compulsory for students who have opted for PHY303.

** Compulsory for students who have opted for PHY304.

† Compulsory for students who have opted for PHY305.

Credits earned: Hard core: 10; Soft core: 8 or 9

Semester 4

Paper		Credits (L+T+P)
Hard Core Papers		
PHY407	Quantum Mechanics 2	3 + 0 + 0 = 3
PHY411	Condensed Matter Physics Lab[a]	0 + 0 + 4 = 4
PHY412	Nuclear Physics Lab[b]	0 + 0 + 4 = 4
Soft Core Papers		
(Students are permitted to register for any one of the following groups)		
PHY401	Nuclear Physics 2*	3 + 0 + 0 = 3
PHY402	Nuclear Physics 3*	3 + 0 + 0 = 3
PHY421	Nuclear Physics Lab 2*	0 + 0 + 2 = 2
PHY403	Solid State Physics 2**	3 + 0 + 0 = 3
PHY404	Solid State Physics 3**	3 + 0 + 0 = 3
PHY423	Solid State Physics Lab 2**	0 + 0 + 2 = 2
PHY405	Theoretical Physics 2†	3 + 0 + 0 = 3
PHY406	Theoretical Physics 3†	3 + 0 + 0 = 3
PHY425	Theoretical Physics Lab 2†	0 + 0 + 2 = 2
Soft Core Papers		
(Students are permitted to register for any one of the following groups)		
PHY416	Nuclear Spectroscopy Methods	3 + 0 + 0 = 3
PHY417	Modern Optics	3 + 0 + 0 = 3
PHY418	Electronics	3 + 0 + 0 = 3
PHY419	Biophysics	3 + 0 + 0 = 3
PHY431	Minor Project	4
Open Elective Papers		
PHY415	Radiation Physics and Dosimetry	3 + 1 + 0 = 4

[a] For students who have completed PHY311.
[b] For students who have completed PHY312.
* Compulsory for students who have completed PHY303.
** Compulsory for students who have completed PHY304.
† Compulsory for students who have completed PHY305.

Credits earned: Hard core: 7; Soft core: 8 or 11 or 12

PHY101: Classical Mechanics

Mechanics of a system of particles: Mechanics of a single particle and its conservation laws, system of particles, external and internal forces, centre of mass, conservation of linear momentum and conservation of angular momenta in the absence of (net) external forces and torques. The energy equation and the total potential energy of a system of particles using scalar potentials, conservation of total energy.

The Lagrangian method: Constraints and their classifications with examples. Generalized coordinates, configuration space, virtual displacement and principle of virtual work, D'Alembert's principle and Lagrangian equations of second kind. Newtons equations of motion from Lagrange' s equations. Examples: (i) single particle in cartesian, polar, spherical and cylindrical polar coordinate systems, (ii) Atwood's machine and (iii) a bead sliding on a rotating wire in a force-free space, (iv) simple pendulum, (v) simple harmonic oscillator, (vi) compound pendulum, (vii) Lagrange's equation for LC circuit. Variational Principle, derivation of Lagrange equation from Hamilton principle.

Motion of a particle in a central force field: Binet equation for central orbit (Lagrangean method).

[16 hours]

Hamilton's equations: Generalized momenta, Legendre transformations, Legendre transformation between the Lagrangian and the Hamiltonian, derivation of Hamilton's equations of motions. Hamiltonian and Hamilton's equations of motions of different physical systems: (i) 1D and 3D simple harmonic oscillator, (ii) simple pendulum, (iii) compound pendulum, (iv) motion of a particle in a central force field, (v) charged particle moving in an electromagnetic field, (vi) free particle in cartesian, spherical polar and cylindrical polar coordinate systems, (vii) Brachistochrone problem.

Cyclic coordinates with examples, Jacobi integrals, physical significance of the Hamiltonian function in a conservative system, modified Hamilton's principle, derivation of Hamilton's equations from a variational principle.

Canonical transformations: Definition of canonical transformations, examples of canonical transformations, four types of generating functions, harmonic oscillator as an example to canonical transformation, infinitesimal contact transformation.

Poisson brackets and Lagrange brackets, Jacobi identity and other properties of Poisson brackets, relation between Lagrange and Poisson brackets, Poisson bracket for the two constants of motion, angular momentum and Poisson bracket, equation of motion in the Poisson bracket notation, Hamilton-Jacobi equation, solution of harmonic oscillator problem by the Hamilton-Jacobi method.

[16 hours]

Mechanics of rigid bodies: Degrees of freedom of a free rigid body, angular momentum and kinetic energy of rigid body. Moment of inertia tensor, principal moments of inertia, products of inertia, the inertia tensor. Euler equations of motion for a rigid body. Torque free motion of a rigid body. Precession of earth's axis of rotation, Euler angles, angular velocity of a rigid body. Force-free motion of a symmetrical top. Motion of a heavy symmetrical top.

Small oscillations of mechanical system: Introduction, types of equilibria, one dimensional oscillator, two coupled oscillator, solution of differential equations, quadratic forms of kinetic and potential energies of a system in equilibrium, general theory of small oscillations, secular equation and eigenvalue equation, small oscillations in normal coordinates and normal modes, examples of double pendulum, vibrations of a linear triatomic molecule.

[16 hours]

References

- Goldstein H., Poole C. and Safko J., Classical mechanics, 3rd Edn., Pearson Education, New Delhi. 2002.
- Upadhyaya J. C., Classical mechanics, Himalaya Publishing House, Mumbai. 2006.
- Kagali B. A. and Shivalingaswamy T., Classical mechanics, Himalaya Publishing House, New Delhi, 2018.
- Rana N. C. and Joag P. S., Classical mechanics, Tata McGraw-Hill Publishing Company Limited, 1999.
- Srinivasa Rao K. N., Classical mechanics, Universities Press, Hyderabad. 2003.
- Takwale R. G. and Puranik S., Introduction to classical mechanics, Tata McGraw, New Delhi,1991.
- Landau L. D. and Lifshitz E. M., Classical mechanics, 4th Edn., Pergamon Press, 1985.

PHY102: Mathematical Methods of Physics 1

Tensor analysis: Curvilinear coordinates, tensors and transformation theory: Tensors of rank r as a r-linear form in base vectors. Transformation rules for base vectors and tensor components. Invariance of tensors under transformation of coordinates. Sum, difference and outer products of tensors, contraction. Curvilinear coordinates in the Euclidean 3-space. Covariant and contravariant basis vectors. Covariant and contravariant components of the metric tensor. Raising and lowering of indices. Differentials of base vector fields. Christoffel symbols. Covariant differentiation. The contracted Christoffel symbol. Grad, divergence, curl and Laplacian in arbitrary curvilinear coordinates.

[16 hours]

Special functions: Differential equations, Hermite and Laguerre functions: Partial differential equations, separation of variables - Helmholtz equation in cartesian, cylindrical and spherical polar coordinates. Differential equations: Regular and irregular singular points of a second order ordinary differential equations. Series solutions - Frobinius method. Examples of Harmonic oscillator and Bessel's equation. Linear dependence and independence of solutions - Wronskian. Hermite functions: Solution to the Hermite equation, Generating functions, Recurrence relations, Rodrigues representation, Orthogonality. Laguerre functions: Differential equation and its solution - Laguerre polynomials, generating function, recurrence relations, Rodrigues representation, orthogonality. Associated Laguerre functions: Definition, generating function, recurrence relations and orthogonality.

[16 hours]

Linear vector space: Definition. Linear dependence and independence of vectors. Dimension. Basis. Change of basis. Subspace. Isomorphism of vector spaces. Linear operators. Matrix representative of a linear operator in a given basis. Effect of change of basis. Invariant subspace. Eigenvalues and eigenvectors. Characteristic equation. The Schur canonical form. Diagonalization of a normal matrix. Schur's theorem.

Complex Analysis: Analytic functions, Cauchy-Riemann equations. Taylor and Laurent series. Singularities: Poles, essential singularities. Residue theorem and evaluation of definite integrals using contour integration**.**

[16 hours]

References

- Arfken G. B. and Weber H. J., Mathematical methods for physicists, 4th Edn., Academic Press, New York (Prism Books, Bangalore, India), 1995.
- Harris E. G., Introduction to modern theoretical physics, Vol. 1, John Wiley, New York, 1975.
- Srinivasa Rao K. N., The rotation and Lorentz groups and their representations for physicists, Wiley Eastern, New Delhi, 2003.
- Shankar R., Principles of quantum mechanics, 2nd Edn., Plenum Press, New York, 1984.

PHY103: Mathematical Methods of Physics 2

Linear representations of groups: Groups of regular matrices; the general linear groups GL(n, C) and GL(n, R). The special linear groups SL(n, C) and SL(n, R). The unitary groups U(n) and SU(n). The orthogonal groups O(n, C), O(n, R), SO(n, C) and SO(n, R).

Rotation group: Rotation matrix in terms of axis and angle. Eigen values of a rotation matrix. Euler resolution of a rotation. Definition of a representation. Equivalence. Reducible and irreducible representations. Schur's lemma. Construction of the $D^{1/2}$ and D^{1} representation of SO(3) by exponentiation.

Mention of the D^j irreps SO(3).

[16 hours]

Special functions: Bessel functions: Bessel differential equation, Bessel functions of the first kind, generating function, recurrence relations, orthogonality.

Legendre functions: Legendre differential equation, Legendre functions, generating function, recurrence relation, Rodrigues formula, orthogonality, associated Legendre functions, spherical harmonics.

Laplace Transforms: Definition, standard transforms, properties. Inverse Laplace transform; convolution theorem. Application to ordinary differential equations and initial value problems.

[16 hours]

Fourier transforms and integral equations: Integral transforms, development of the Fourier integral. Fourier transforms - inversion theorem. Fourier transform of derivatives. Convolution theorem.

Integral equations: Types of linear integral equations - definitions. Transformation of a differential equation into an integral equation. Abel's equation, Neumann series, separable kernels.

Probability theory and distributions: Basic concepts of probability and random variables. Discrete distributions; Binomial and Poisson distributions. Continuous distributions: Normal (Gaussian) distribution. Central limit theorem and its significance in physics experiments.

[16 hours]

References

- Srinivasa Rao K. N., The rotation and Lorentz groups and their representations for physicists, Wiley Eastern, New Delhi, 1988.
- Arfken G. B. and Weber H. J., Mathematical methods for physicists, 5th. Edn., Academic Press, New York, 2001.Page no.621–630, 675–694, 741–770.
- Guptha B. D., Mathematical physics, 4th Edn, 2011. Page no. 8.48–8.83, 8.16- 8.48

PHY104: Classical Electrodynamics, Plasma Physics and Optics

Electrostatics: Coulomb's law, Gauss's law and its applications, Electric potential, Poisson's and Laplace's equation. Boundary conditions and uniqueness theorems, method of images.

Magnetostatics: Biot-Savart Law, divergence and curl of B, Ampere's law and its applications. Magnetic vector potential, multipole expansion of the vector potential.

Electric multipole moments: The electric dipole and multipole moments of a system of charges. Multipole expansion of the scalar potential of an arbitrary charge distribution.

Potential formulation: Maxwell equations in terms of electromagnetic potential. Gauge transformations. The Lorentz, Coulomb and radiation gauges.

Fields of moving charges and radiation: The retarded potentials. The Lienard-Wiechert potentials. Fields due to an arbitrarily moving point charge.

Radiating systems: Radiation from an oscillating dipole. Power radiated by a point charges - Larmor formula. Lienard's generalization of Larmor formula. Radiation reaction-Abraham-Lorentz formula.

[16 hours]

Relativistic electrodynamics: Lorentz transformation of coordinates. 4-divergence, 4-Laplacian operator, 4-velocity, 4-momentum. Covariant formulation of electrodynamics: invariance of charge, 4-current density, 4-vector potential, continuity equation, Lorentz force equation, Lorentz gauge condition and wave equation in terms of 4-vector potential. Electromagnetic field tensor-Maxwell field equations in tensor form-transformation of fields-field due to a point charge in uniform motion-Lagrangian formulation of motion of a charged particle in an electromagnetic field.

Plasma physics: Quasineutrality of a plasma. Plasma as a conducting fluid, magnetohydrodynamics, magnetic confinement, Pinch effect, instabilities.

[16 hours]

Electromagnetic waves: Monochromatic plane waves-velocity, phase and polarization. Propagation of plane electromagnetic waves in (a) conducting media and (b) ionized gases. Reflection and refraction of electromagnetic waves-Fresnel formulae for parallel and perpendicular components. Brewster law. Normal and anomalous dispersion-Clausius-Mossotti relation. Wave guides, TE waves in a rectangular wave guide.

Interference: General theory of interference of two monochromatic waves. Two-beam and multiple-beam interference with a plane-parallel plate. Fabry-Perot interferometer-etalon construction, resolving power and its application.

Diffraction: Integral theorem of Helmholtz and Kirchoff. Fresnel-Kirchoff diffraction formula-conditions for Fraunhofer and Fresnel diffraction. Fraunhofer diffraction due to a circular aperture.

[16 hours]

References

- Griffiths D. J., Introduction to electrodynamics, 5th Edn., Prentice-Hall of India, New Delhi, 2006.
- Jackson J. D., Classical electrodynamics, 3rd Edn., Wiley-Eastern Ltd, India, 1999.
- Born M. and Wolf E., Principles of optics, 6th Edn., Pergamon Press, Oxford, 1980.
- Matveev A . N., Optics, Mir Publishers, Moscow, 1988.
- Laud B. B., Electromagnetics, Wiley Eastern Limited, India, 2000.

PHY105: Computer Lab CL-A

- Linux operating system basics (4 sessions):
  Login procedure; creating, deleting directories; copy, delete, renaming files; absolute and relative paths; Permissions—setting, changing; Using text editor.
- Scientific text processing with LaTeX.
  Typeset text using text effects, special symbols, lists, table, mathematics and including figures in documents.
- Using the plotting program GNUPLOT (2 sessions) :
  Plotting commands; To plot data from an experiment and applying least-squares fit to the data points. Including a plot in a LaTeX file.
- Using the mathematics package OCTAVE (2 sessions) To compute functions, matrices, eigenvalues, inverse, roots.

*Total work load :*1 day(s) per week × 4 hours × 16 weeks 64 hours

PHY106: Optics Lab

Any ten of the following experiments:

- Verification of the Brewster law of polarization.
- Verification of Fresnel laws of reflection from a plane dielectric surface.
- Determination of the inversion temperature of the copper-iron thermocouple.
- Birefringence of mica by using the Babinet compensator.
- Birefringence of mica by using the quarter-wave plate.
- Experiments with the Michelson interferometer.
- Determination of the refractive index of air by Jamin interferometer.
- Determination of the size of lycopodium spores by the method of diffraction

haloes.
- Determination of wavelength by using the Fabry-Perot etalon.
- Dispersion of the birefringence of quartz.
- The Franck-Hertz experiment.
- Experiments with the laser.
- Determination of the Stokes vector of a partially polarized light beam
- Determination of the modes of vibration of a fixed-free bar.

*Total work load :*2 day(s) per week × 4 hours × 16 weeks 128 hours

PHY107: Electronics Lab

Any ten of the following experiments:

- Regulated power supply.
- Active Low pass and High pass filter.
- Input and output impedance of a voltage follower.
- Op amp integrator and differentiator.
- Op amp as an inverting and non-inverting amplifier.
- Op amp as a summing and difference amplifier.
- JK flip flop and RS flip flop.
- Half adder, full adder half subtractor and full subtractor.
- Boolean algebra and logic gates.
- Op amp as an astable multivibrator.
- Experiments with Exp-Eyes Junior.
- Experiments with Arduino Uno.

*Total work load :*2 day(s) per week × 4 hours × 16 weeks 128 hours

PHY201: Continuum Mechanics and Relativity

Continuum mechanics of solid media: Small deformations of an elastic solid; the strain tensor. The physical meaning of the strain tensor components. The stress tensor and the symmetry of the stress tensor. Equations of equilibrium. The generalized Hooke law for a homogeneous elastic medium; the elastic modulus tensor. Navier equations of motion for a homogeneous isotropic medium. Elastic waves in an isotropic homogeneous elastic medium. Importance of ratio of the velocity of longitudinal and transverse waves.

Fluid mechanics: Stress tensor of an ideal fluid. Euler equation of motion for an ideal fluid. Equation of continuity. Bernoulli's theorem. Flow of a viscous fluid - Navier-Stokes equation and its solution for the case of a flow through a cylindrical pipe. The Poiseuille formula.

[16 hours]

Minkowski space time: Real coordinates in Minkowski space time. Definition of 4-tensors. The Minkowski scalar product and the Minkowski metric $\eta_{ij} = \mathrm{diag}(1, -1, -1, -1)$. Orthogonality of 4-vectors. Raising and lowering of 4-tensor indices. Time like, null and space like vectors and world-lines. The light-cone at an event.

Relativistic mechanics of a material particle: The proper-time interval $d\tau$ along the world-line of a material particle. The instantaneous (inertial) rest-frame of a material particle and the components of 4-velocity, 4-acceleration and the 4-momentum vector in this frame. Statement of second law of Newton in this frame. Determination of the fourth component F_4 of the 4-force along the world-line of the particle. Motion of a particle under the conservative 3-force field and the energy integral. The rest energy and the relativistic kinetic energy of a particle.

Relativistic kinematics: Relativistic kinematics of scattering and reactions. Elastic, inelastic reactions, decay of a particle $A \to B + C, A + B \to C, P + \bar{P} \to P + \bar{P} + P + \bar{P}$

[16 hours]

Einstein's equations: The principle of equivalence and general covariance, inertial mass, gravitational mass, Eotvos experiment, gravitation as space-time curvature, gravitational field equations of Einstein and its Newtonian limits.

The Schwarzschild metric: Heuristic derivation of the Schwarzschild line element. Motion of particles and light rays in the Schwarzschild field. Explanation of the (a) perihelion advance of planet Mercury, (b) gravitational red shift and (c) gravitational bending of light. A brief discussion of the Schwarzschild singularity and the Schwarzschild black hole.

[16 hours]

References

- Landau L. D. and Lifshitz E. M., Fluid mechanics, Pergamon Press, 1987.
- Landau L. D. and Lifshitz E. M., Theory of elasticity, Pergamon Press, 1987.
- Synge J. L., Relativity: The special theory, North-Holland, 1972.
- Landau L. D. and Lifshitz E. M., The classical theory of fields, 4th Edn., (Sections 1 to 6, 16 to 18, 23 to 25, 26 to 35), Pergamon Press, Oxford, 1985.
- Wald R. M., General relativity, The University of Chicago Press, Chicago, 1984.
- Schutz B. F., A first course in general relativity, Cambridge University Press, Cambridge, 1985.
- Bergman P., Introduction to theory of relativity, Prentice-Hall of India, 1969.
- Rindler R., Relativity: Special, general and cosmological, Oxford University Press, 2006.

- Griffiths D. J., Introduction to elementary particles, John Wiley and Sons, Inc., New York, 1987.

PHY202: Thermal Physics

Thermodynamics: Preliminaries, thermodynamic potential functions and Maxwell's relations, specific heats from thermodynamic relations, the third law of thermodynamics. Applications of thermodynamics: Thermodynamic description of phase transitions. Classification of phase transitions; First-order phase transitions, phase equilibrium condition. Clausius-Clapeyron equation and its applications; phase diagrams. Second-order phase transitions. Surface effects in condensation. Vander Waals' equation of state. Irreversible thermodynamics - Onsager's reciprocal relation, thermoelectric phenomenon, Peltier effect, Seebeck effect, Thompson effect, systems far from equilibrium.

[16 hours]

Classical statistical mechanics: Phase space, division of phase space into cells, ensembles, ergodic hypotheses, average values in phase space, density distribution in phase space. Liouville theorem, statistical equilibrium, postulate of equal a priori probability, Stirling's formula, concept of probability, microstates and macrostates, general expression for probability, the most probable distribution, Maxwell-Boltzmann distribution, microcanonical ensemble, canonical ensemble, grand canonical ensemble, partition function of system of particles, translational partition function (monoatomic). Gibb's paradox, Sackur-Tetrode equations. Boltzmann theorem of equipartition of energy, vibrational partition function of diatomic molecules (Einstein relations), rotational partition function (diatomic), electronic and nuclear partition function.

[16 hours]

Quantum statistical mechanics: The postulates of quantum statistical mechanics. Symmetry of wave functions. The Liouville theorem in quantum statistical mechanics; condition for statistical equilibrium; Ensembles in quantum mechanics; The quantum distribution functions (Bose-Einstein and Fermi-Dirac); the Boltzmann limit of Boson and Fermion gases; the derivation of the corresponding distribution functions.

Applications of quantum statistics: Equation of state of an ideal Fermi gas (derivation not expected), application of Fermi-Dirac statistics to the theory of free electrons in metals. Fermi energy relation for electron gas and Fermi temperature. Application of Bose Einstein statistics to the photon gas, derivation of Planck's law, comments on the rest mass of photons, Thermodynamics of Black body radiation. Bose-Einstein condensation. Weak and strong degeneracy of perfect gases.

[16 hours]

References

- Agarwal B. K. and Eisner M., Statistical mechanics, New Age International Publishers, 2000.
- Sathya Prakash, Statistical mechanics. Kedar Nath Ram Nath Publishers,

2017.
- Roy S. K., Thermal physics and statistical mechanics, New Age International Pub., 2000.
- Huang K., Statistical mechanics, Wiley-Eastern, 1975.
- Laud B. B., Fundamentals of statistical mechanics, New Age International Pub., India, 2000, p6–39, p77–105.
- Gopal E. S. R., Statistical mechanics and properties of matter, Ellis Horwood Ltd., UK, 1976, p34–77.
- Schroeder D. V., An introduction to thermal physics, Pearson Education New Delhi, 2008.
- Salinas S. R. A., Introduction to statistical physics, Springer, 2004.

PHY203: Quantum Mechanics 1

Introduction: Failures of classical mechanics, basic postulates of quantum mechanics and explanation, mathematical basics of quantum mechanics. The wave function, the Schrodinger equation, the statistical interpretation, probability, discrete and continuous variables, normalisation, momentum, expectation values, Ehrenfest's theorem, the Heisenberg uncertainty principle.

The time-independent Schrodinger equation: Stationary states, The infinite square well, The harmonic oscillator, algebraic and analytic methods, the free particle, The delta-function potential, the finite square well [Griffiths, Chap. 2].

[16 hours]

Formalism: Hilbert space and its properties, observables, Hermitian operators, determinate states, eigen values and eigenfunctions of a Hermitian operator. The generalized statistical interpretation, the generalized uncertainty principle, Dirac notations.

Quantum mechanics in three dimensions: Schrödinger Equation in three-dimension, separation of Schrodinger equation in spherical polar coordinates, the spherical well, the hydrogen atom, eigen values and eigen functions, angular momentum, eigen values and eigen functions of angular momentum operators, spin, spin half system, addition of angular momentum, C-G coefficients.

Identical particles: Two particle systems, distinguishable and indistinguishable states.

[16 hours]

The time-independent perturbation theory: Nondegenerate perturbation theory, first and second order perturbation, degenerate perturbation theory, the fine structure of hydrogen, the Zeeman effect. The Variation principle: Theory, the ground state of helium, the hydrogen molecule ion. The WKB approximation: The classical region, tunneling [Griffiths, p261–273, 278–282, 289–292, 305–320, 327–337].

[16 hours]

References

- Griffiths D. J., Introduction to quantum mechanics, 2nd Edition, Pearson, India, 2005.
- Shankar R., Principles of quantum mechanics, 2nd Edn., Plenum Press, New York, 1984.
- Nouredine Z., Quantum mechanics: Concepts and applications, 2nd edn, Wiley and sons, Ltd. 2009

PHY204: Spectroscopy and Fourier Optics

Atomic spectroscopy: Spectroscopic terms and their notations. Spin-orbit interaction and fine structure in alkali spectra, quantum mechanical relativity correction; Lamb shift. Zeeman effect, normal and anomalous Zeeman effect - magnetic interaction energy, selection rules, splitting levels in hydrogen atom., Paschen-Back effect. Stark effect, weak field and strong field effects. Hyperfine structure of spectral lines: Nuclear spin and hyperfine splitting, intensity ratio and determination of nuclear spin. Breadth of spectral lines, natural breadth, Doppler effect and external effect.

[16 hours]

Nuclear magnetic resonance: Quantum mechanical expression for the resonance condition. Chemical shift: spin-spin interaction. Example of ethyl alcohol. Fourier transform technique in NMR. FTNMR spectrometer and experimental procedure. Magnetic resonance imaging (MRI) technique.

Microwave spectroscopy: The classification of molecules. The rotational spectra of rigid diatomic rotator and spectra of non-rigid diatomic rotator. Note on microwave oven.

Infrared spectroscopy: Born-Oppenheimer approximation, vibrational energy of diatomic molecule. Anharmonic oscillator. The diatomic vibrating rotator, example of the CO molecule. The vibrations of polyatomic molecules; skeletal and group frequencies. Experimental technique in FTIR.

Raman spectroscopy: Quantum theory of Raman effect. Pure rotational Raman spectra. Vibrational Raman spectra. Instrumentation technique in Raman spectroscopy. Structure determination from Raman and IR spectroscopy. Laser-Raman effects.

[16 hours]

Fourier optics: Spatial frequency filtering process- qualitative discussion with examples. Effect of a thin lens on an incident field distribution-Lens as a Fourier transforming element. Phase contrast microscopy method and its applications.

Propagation of light in an anisotropic medium: Structure of a plane electromagnetic wave in an anisotropic medium. Dielectric tensor. Fresnel's formulae for the light propagation in crystals. Ellipsoid of wave normals and ray normals. The normal and ray surface. Optical classification of crystals. Light propagation in uniaxial and biaxial crystals. Refraction in crystals. Elements of non-linear optics: Harmonic generation, second harmonic generation, optical mixing, optical rectification and phase matching; third harmonic generation, self-focusing of light, parametric generation of light.

[16 hours]

References

- Tralli N. and Pomilla P. R., Atomic theory, McGraw-Hill, New York, 1999.
- Bransden and Joachain, Physics of atoms and molecules, (2nd Edition) Pearson Education, 2004.
- Aruldhas G., Molecular structure and spectroscopy, 2nd Edition, PHI Learning Pvt. Ltd., 2007
- Banwell C. N. and McCash E. M., Fundamentals of molecular spectroscopy, 4th Edn., Tata McGraw-Hill, New Delhi, 1995.
- Hecht E., Optics, Addison-Wesley, 2002.
- Lipson S. G., Lipson H. and Tannhauser D. S., Optical physics, Cambridge University Press, USA, 1995.

PHY205: Computer Lab CL-B

List of Python programs:

- Check whether given number is odd or even.
- Find the largest and smallest number in the input set.
- Compute the Fibonacci sequence.
- Check whether the input number is prime or not.
- Compute the roots of a quadratic equation.
- Generate Pascal's triangle.
- Sum of two matrices.
- Product of two matrices.
- Linear, exponential and power least-squares fitting to data in a file.
- To find the trajectory of a projectile shot with an initial velocity at an angle. Also, find the maximum height travelled and distance travelled. Write the trajectory data to a file specified and plot using Gnuplot.

*Total work load :*1 day(s) per week × 4 hours × 16 weeks 64 hours

PHY206: Optics Lab

For those who have completed PHY107

Any ten of the following experiments:

- Verification of the Brewster law of polarization.
- Verification of Fresnel laws of reflection from a plane dielectric surface.
- Determination of the inversion temperature of the copper-iron thermocouple.
- Birefringence of mica by using the Babinet compensator.
- Birefringence of mica by using the quarter-wave plate.
- Experiments with the Michelson interferometer.
- Determination of the refractive index of air by Jamin interferometer.
- Determination of the size of lycopodium spores by the method of diffraction haloes.
- Determination of wavelength by using the Fabry-Perot etalon.
- Dispersion of the birefringence of quartz.
- The Franck-Hertz experiment.
- Experiments with the laser.
- Determination of the Stokes vector of a partially polarized light beam.
- Determination of the modes of vibration of a fixed-free bar.

*Total work load :*2 day(s) per week × 4 hours × 16 weeks 128 hours

PHY207: Electronics Lab

For those who have completed PHY106

Any ten of the following experiments:

- Regulated power supply.
- Active Low pass and High pass filter.
- Input and output impedance of a voltage follower.
- Op amp integrator and differentiator.
- Op amp as an inverting and non-inverting amplifier.
- Op amp as a summing and difference amplifier.
- JK flip flop and RS flip flop.
- Half adder, full adder half subtractor and full subtractor.
- Boolean algebra and logic gates.
- Op amp as an astable multivibrator.
- Experiments with Exp-Eyes Junior.
- Experiments with Arduino Uno.

Total work load : 2 day(s) per week × 4 hours × 16 weeks 128 hours

PHY211: Modern Physics

Paper to be offered to Non-Physics Postgraduate students

Nuclear physics: A brief overview of nuclear physics. Nuclear reactions, a brief description of nuclear models. Interactions of X-rays and γ-rays with matter, slowing down and absorption of neutrons. Fundamental particles, classification of fundamental particles, fundamental forces, conservation laws in particle physics, a brief outline of the quark model.

Nuclear power: Nuclear fission, fission chain reaction, self-sustaining reaction, uncontrolled reaction, nuclear bomb. Nuclear reactors, different types of reactors and reactors in India. Nuclear waste management. Nuclear fusion, fusion reactions in the atmosphere. Radiation effects - dosage calculation. Nuclear energy - applications and disadvantages.

[16 hours]

Condensed matter physics: Amorphous and crystalline state of matter. Crystal systems. Liquid crystals. X-ray diffraction - Bragg equation. Structure of NaCl. FTIR - experiment analysis. NMR - experiment and analysis. Electrical conductivity of metals and semiconductor. Magnetic materials - para, ferro, ferri- and anti-magnetism. Dielectrics - para, ferro, pyro and piezo properties. Symmetry in physics.

[16 hours]

Quantum physics: Qualitative discussion. Molecules, atoms, nucleus, nucleons, quarks and gluons. Particle physics (qualitative). Stern-Gerlach experiment and consequences. Uncertainty relation. Hydrogen atom. Positron annihilation. Laser trapping and cooling. Ion traps. Electromagnetic, strong, weak and gravitational forces. Big Bang theory, String theory. Large Hadron Collider experiment, consequences. Higgs Boson.

[16 hours]

Tutorial [32 hours]

References

- Ghoshal S. N., Atomic and nuclear physics, Vol.2., S. Chand and Company, Delhi, 1994.
- Evans R. D., Atomic nucleus, Tata McGraw Hill, New Delhi, 1976.
- Penrose R., Road to reality, Vintage Books, 2007.
- Ladd M. F. C. and Palmer R. A., Structure determination by X-ray crystallography, Plenum Press, USA, 2003.
- De Gennes P. G. and Prost J., The physics of liquid crystals, 2nd Edn., Clarendon Press, Oxford, 1998.

- Myer R., Kennard E. H. and Lauritsern T., Introduction to modern physics, 5th Edn., McGraw-Hill, New York, 1955.
- Halliday D., Resnick R. and Merryl J., Fundamentals of physics, Extended 3rd Edn., John Wiley, New York, 1988.

PHY301: Nuclear and Particle Physics

Properties of the nucleus: Nuclear radius-determination by mirror nuclei, mesic X-rays and electron scattering methods. Nuclear moments - spin, magnetic dipole moment. Relation between spin and magnetic moments on the basis of single particle model. Determination of nuclear magnetic moment by molecular beam experiment.

Nuclear models: Liquid drop model - semi-empirical formula and its application to (i) stability of isobars and (ii) fission process. Nuclear shell model -Evidence of shell structure, single-particle shell model, its validity and limitations.

Nuclear reactions: Q-values. Threshold energy. Reactions induced by proton, deutron and particles. Photodisintegration. Compound nuclei and direct reactions.

Radiation quantities and units: Radiation exposure, absorbed dose and effective dose. Dose limits.

[16 hours]

Nuclear decay modes: Beta decay: Beta ray spectrum, Pauli neutrino hypothesis, mass of the neutrino from beta ray spectral shape, Fermi theory of beta decay, Kurie plot, ft- values and forbidden transitions. Methods of excitation of nuclei. Nuclear isomerism. Mossbauer effect (qualitative only). Auger effect.

Interaction of nuclear radiation with matter and detectors: Energy loss due to ionization for proton-like charged particles. Bethe-Bloch formula. Range-energy relations. Ionization and radiation loss of fast electrons (Bremsstrahlung). Interaction of gamma and X-rays with matter. Brief description of NaI (Tl) gamma ray spectrometer. Boron trifluoride counter.

Nuclear reactors: Condition for controlled chain reactions, slowing down of neutrons, four factor formula, logarithmic decrement in energy, Homogeneous spherical reactor, critical size. Effect of reflectors. Breeder reactor.

[16 hours]

Nuclear forces: General features of nuclear forces with experimental evidences - spin dependence, charge independence, charge symmetry, exchange character, short-range repulsive nature, tensor nature, velocity dependence, saturation.

Meson theory of nuclear forces: Yukawa's theory, pseudoscalar meson field theory, nuclear potentials. Properties of pi mesons: charge, isospin, mass, spin and parity, decay modes, meson resonances.

Elementary particles: Classification of elementary particles based on spin and statistics, classification of fundamental forces.

Conservation laws: Basic conservation laws (energy, momentum, angular momentum, electric charge), conservation of charge, parity, isospin, strangeness, time reversal, CP and CPT, CP violation in Kaon decay. Associated particle production and Tau-theta puzzle; Gellmann-Nishijima scheme and strange particles.

Symmetric classification of elementary particles: Different quantum numbers and symmetries in particle physics, SU (3) symmetry and the eight-fold way for mesons and baryons (Gell-Mann and Neeman model), quark model. Elementary ideas of gluons, Higgs boson and the standard model.

[16 hours]

References

- Kenneth S. K., Introductory nuclear physics, Wiley, 1988.
- John L., Nuclear physics: Principles and applications, Wiley, 2001.
- Blatt J. M. and Weisskopf V. F., Theoretical nuclear physics, Springer, 1991.
- Bernard L. C., Concepts of nuclear physics, Tata McGraw-Hill, 2004.
- Tayal D. C., Nuclear physics, Himalaya Publishing House, Revised Edition.
- Ghoshal S. N., Nuclear physics, S. Chand and Company, Delhi, 2025.
- Wong S. S. M., Introductory nuclear physics, Prentice Hall of India, Delhi, 1998.
- Khanna M. P., Introduction to particle physics, Prentice Hall of India, Delhi, 2008.
- Kapoor S. S. and Ramamoorthy V., Nuclear radiation detectors, Wiley Eastern, Bangalore, 2007.
- Glenn F. K., Radiation detection and measurement, Wiley, 4th Edition, 2010.
- John R. L., and Anthony J. B., Introduction to nuclear engineering, Pearson Education, 3rd Edition, 2001.
- Donald H. P., Introduction to high energy physics, Cambridge University Press, 4th Edition, 2000.
- Francis H. and Alan D. M., Quarks and leptons: An introductory course in modern particle physics, Wiley, 1984.
- Griffiths D. J., Introduction to elementary particles, Wiley-VCH, 2nd Edition, 2008.
- Williams W. S. C., Nuclear and particle physics, Oxford University Press, 2nd Edition, 1991.
- Jean L. B., James R. and Michel S., Fundamentals of nuclear physics, Springer, 2005.

PHY302: Condensed Matter Physics

Crystalline state: Reference axes, equation of a plane, Miller indices, axial ratios, zones. Symmetry operations. Two- and three-dimensional point groups. Lattices; two dimensional lattices, choice of unit cell. Three-dimensional lattices; crystal systems and Bravais lattices. Screw and glide operations. Space groups; analysis of the space group symbol. Diffraction of X-rays by crystals: Laue equations. Reciprocal lattice. Bragg equation. Equivalence of Laue and Bragg equations. Atomic scattering factor (qualitative). Quasicrystals and buckyballs (qualitative).

Electron and neutron diffraction: Basic principles. Differences between them and X-ray diffraction. Applications (qualitative) [Vainshtein, p336–338, 350–352, 355-357].

Crystal growth: Czochralski, Kyropoulus, Stockbarger-Bridgman and zone refining techniques [Rose et al., p146–154].

[16 hours]

Liquid crystals: Types: Nematic, smectic (A-H) and cholesteric phases. Orientational order and its determination in the case of nematic liquid crystals.

Crystal lattice dynamics: Vibration of an infinite one-dimensional monoatomic lattice, first Brillouin zone. Group velocity. Finite lattice and boundary conditions. Vibrations of a linear diatomic lattice - optical and acoustical branches; relation. Dynamic of identical atoms in three dimensions. Experimental measurements of dispersion relation [Wahab, p288–305].

Magnetic properties of solids: Diamagnetism and its origin. Expression for diamagnetic susceptibility. Paramagnetism: Classical and quantum theory of paramagnetism. Brillouin function. Ferromagnetism. Curie-Weiss law. Spontaneous magnetization and its variation with temperature. Ferromagnetic domains. Antiferromagnetism. Two sub-lattice model. Susceptibility below and above Neel's temperature. Ferrimagnetism: structure of ferrites, the saturation magnetization and elements of Neels theory. [Dekker, p446–490].

[16 hours]

Superconductivity: Experimental facts. Type I and type II superconductors. Phenomena logical theory. London equations. Meissner effect. High frequency behavior. Thermodynamics of superconductors. Entropy and specific heat in the superconducting state. Qualitative ideas of the theory of superconductivity [Kittel, p333–364].

Semiconductors: Intrinsic semiconductors. Crystal structure and bonding. Expressions for carrier concentrations. Fermi energy, electrical conductivity and energy gap in the case of intrinsic semiconductors. Extrinsic semiconductors; impurity states and ionization energy of donors. Carrier concentrations and their temperature variation. Qualitative explanation of the variation of Fermi energy with temperature and impurity concentration in the case of impurity semiconductors [Mckelvey, p256–277].

Semiconductor devices: Brief discussion of the characteristics and applications of phototransistors, JFET, SCR and UJT.

[16 hours]

References

- Buerger M. J., Elementary crystallography, Academic Press, UK, 1956.
- Ladd M. F. C. and Palmer R. A., Structure determination by X-ray crystallography (Fifth Edition), Springer, 2013.
- Sherwood D. and Cooper J., Crystals, X-rays and proteins, Oxford University Press, 2015.
- Rose R. M., Shepard L. A. and Wulff J., The structure and properties of materials Vol. 4, Electronic properties, Wiley Eastern, 1965.
- Vainshtein B. K., Modern crystallography, Vol. I, Springer-Verlag, Germany, 1981.
- Gray G. W. and Goodby J. W. G., Smectic liquid crystals: Textures and structures, Leonard Hill, USA, 1984.
- Dekker A. J., Solid state physics, Prentice Hall, 1985.
- Kittel C., Introduction to solid state physics, 8th Edn., John Wiley, New York, 2005.
- Mckelvey J. P., Solid state and semiconductor physics, 2nd Edn., Harper and Row, USA, 1966.
- Streetman B. G., Solid state electronic devices, 2nd Edn., Prentice-Hall of India, New Delhi, 1983.
- Wahab M. A., Solid state physics (Second edition), Narosa Publishing House, New Delhi, 1999.
- Pillai S. O., Solid state physics (Seventh edition), New Age International Publications, 2002.

PHY303: Nuclear Physics 1

Nuclear detectors: Scintillation processes in inorganic crystals (NaI(Tl)). Semiconductor detectors - Diffused junction, surface barrier and lithium drifted detectors Relation between applied voltage and depletion layer thickness in junction detectors, hyper pure germanium detectors, Cerenkov detectors.

Nuclear pulse techniques: Preamplifier circuits. Charge sensitive and voltage sensitive preamplifiers. Linear pulse amplifiers. Linearity, stability, pulse shaping, pulse stretching. operational amplifiers. Analog to digital converters. Scalars, Schmidt trigger as a pulse discriminator, Single channel analyzer-Integral and differential discriminators. Multichannel analyzers, memory devices and online data processing.

[16 hours]

Shell model: Evidences for the shell structure of the nucleus, single-particle potential; Motion of a nucleon in a mean potential - infinite square potential, harmonic oscillator potential well, spin-orbit correction and magic numbers; Energy levels in spectroscopic notation; Extreme single particle model, ground state properties of nuclei based on shell model: - spin, parity, magnetic moment and electric quadrupole moment. Nordheim's rules with examples. Applications and limitations of shell Model.

Collective model: Evidences for the collective model, collective vibrations and collective rotations, paring energy, nuclear rotational motion. Rotational energy spectrum and nuclear wave functions for even-even nuclei. Rotational energy spectrum and nuclear wave functions for odd- A nuclei and their energy eigen values solutions; nuclear moments.

Nilsson model: Nuclear deformations, evidences for the Nilsson model, Nilsson potential (modified Hamiltonian of an anisotropic oscillator), Nilsson diagrams for different Z and N with examples, applications and limitations of Nilsson Model.

Many body self-consistent models: Self-consistency potentials, Hartree-Fock model.

[16 hours]

Timing spectroscopy: Rossi, Garwin's and Bothe coincidence and anti-coincidence circuits. Delay circuits. Time to amplitude conversion- Start-stop and overlap converters.

Gamma ray spectroscopy: Life time measurements. Delay coincidence techniques, gamma-gamma, beta-gamma angular correlation studies. Angular distribution of gamma rays from oriented nuclei. Polarization of gamma rays.

[16 hours]

References

- Mermier P. and Sheldon E., Physics of the nuclei and particles, Vol. 1 and 2, Academic Press, New York, 1970.
- Segre E., Nuclei and particles, Benjamin Inc, New York, 1977.
- Arya A. P., Fundamentals of nuclear physics, Allyn and Bacon, USA, 1968.
- Blatt J. M. and Weisskopf V. F., Theoretical nuclear physics, Wiley and Sons, New York, 1991.
- Siegbahn K., The alpha, beta and gamma ray spectroscopy: Vol. 1 and 2, North Holland, Amsterdam, 1965.
- Price J. W., Nuclear radiation detectors, McGraw Hill, New York, 1965.
- Kapoor S. S. and Ramamoorthy V., Nuclear radiation detectors, Wiley Eastern, Bangalore, 1993.
- Kowalski E., Nuclear electronics, Springer Verlag, Berlin,1970.
- Leo W. R., Techniques for nuclear and particle physics experiments, Springer Ver- lag, 1992.
- Roy R. R. and Nigam B. P., Nuclear physics, New Age International, New

Delhi, 1986.
- Hans H. S., Nuclear physics - Experimental and theoretical, New Age International Publishers, 2001.

PHY304: Solid State Physics 1

Dielectric properties of solids: Macroscopic description of static dielectric constant, the static electronic and ionic polarizabilities of molecules, orientation polarization, the static dielectric constant of gases, Local electric field at an atom. Lorentz field, field of dipoles inside cavity. The static dielectric constant of solids, Clausius- Mossotti relation, the complex dielectric constant and dielectric losses. Polarization catastrophe. Dielectric losses and Debye relaxation time. Classical theory of electronic polarization and optical absorption.

Ferroelectricity: Basic properties of ferroelectric materials. Classification and properties of ferroelectrics. Dipole theory of ferroelectricity, objections against the dipole theory, ionic displacements and behavior of barium titanate above the curie temperature, theory of spontaneous polarization of barium titanate. Thermodynamics of ferroelectric transitions. Landau theory of phase transitions, Dielectric constant near the curie point. Ferroelectric domains. A brief discussion of antiferroelectricity.

[16 hours]

Magnetic properties: Definition of magnetization and susceptibility. Hund's rule. Calculation of L, S and J for 3d and 4f shells. Setting up of Hamiltonian for an atom in an external magnetic field. Based on this, explanation of diamagnetism, Van-Vleck paramagnetism and quantum theory of paramagnetism using the above Hamiltonian, in solids (see Ashcroft and Mermin). Interpretation of the Weiss field in terms of exchange integral (Page 473-474, A. J. Dekker). Calculation of the singlet-triplet splitting, spin Hamiltonian and Heisenberg model (as given in Ashcroft N. W. and Mermin N. D.).

Zero-temperature properties: Ground state of the Heisenberg ferromagnet. First excitation of one-dimensional ferromagnetism at zero-temperature: spin waves in one-dimensional ferromagnetism and anti-ferromagnetism. Low-temperature behavior of ferromagnets: Bloch's $T^{3/2}$ law (as given in Ashcroft N. W. and Mermin N. D. and C. Kittel).

Magnetic relaxation and resonance: Phenomenological description, relaxation mechanisms, derivation of Casimir-Dupre relation. Nuclear magnetic moments, condition for resonance absorption, setting up of Bloch's equations. (as given 498-511 of A. J. Dekker).

[16 hours]

Band theory of solids: Statement and proof of Bloch theorem. Explanation of periodic potentials in solids. Reciprocal lattice, periodic boundary conditions, density of states. Construction of Brillouin zones for a square lattice. Nearly free electron model and solution at the boundary. Discussion of energy gap using nearly free electron model. Tightly bound electron approximation, application to simple cubic, BCC and FCC lattices. Constant energy surfaces, Fermi surfaces. Square lattice. Overlapping of bands (as given in A. J. Dekker).

Superconductivity: Elementary ideas of BCS theory. Formation of Cooper pairs and explanation based on theory (as given in Ibach and Luth). Energy gap, Meissner effect, flux quantization, Josephson tunnelling, Josephson junction. Theory for DC and AC bias. High T_c superconductors. (as given in Ibach and Luth)

Elastic constants of crystals: Definition of elastic strains and stresses in a solid. Elastic compliance and stiffness constants, applications to cubic crystals and isotropic solids. Elastic waves and experimental determination of elastic constants. (as given in C. Kittel)

[16 hours]

References

- Dekker A. J., Solid state physics, Prentice Hall, 1985.page no. 133-157,185-209.
- Kittel C., Introduction to solid state physics, 7th Edn., John Wiley, New York, 1996.
- Ashcroft N.W. and Mermin N. D., Solid state physics, Saunders College Publishing, 1996.
- Iback H. and Luth H., Solid state physics, Narosa, New Delhi, 1996.
- Pillai S. O., Solid state physics, New Age International Publications, 2002.
- Wahab M. A., Solid state physics, Narosa Publishing House, New Delhi, 1999.

PHY305: Theoretical Physics 1

General theory of relativity: Tensor calculus and Riemannian geometry: Covariant differentiation, parallel transport, geodesies, the curvature tensor.

Riemannian geometry: Riemannian space, the determinant of $g_{\mu\nu}$. Metrical densities, the connection of a Riemannian space: Christoffel symbols, geodesies in a Riemannian space, the curvature of a Riemannian space: the Riemann tensor.

[16 hours]

Gravitational field: The principle of equivalence, the field equations of general relativity, metrics with spherical symmetry, the Schwarzschild solution. Geodesies in the Schwarzschild space, advance of the perihelion of a planet, the deflection of light rays, red shift of spectral lines, the Schwarzschild sphere. Gravitational collapse. Black holes.

[16 hours]

Quantum field theory-1: Classical and quantum fields: Particles and fields, discrete and continuous mechanical systems, classical scalar fields, Maxwell fields.

Quantum theory of radiation: creation, annihilation and number operators, quantized radiation field, Fock states, emission and absorption of photons by atoms, Rayleigh scattering, Thomson scattering and the Raman effect.

[16 hours]

References

- Papapetrov A., Lectures on general relativity, D. Reidel Publishing Company, USA, 1974.
- Dirac P. A. M., The general theory of relativity, John Wiley and Sons, New York, 1975.
- Adler R., Bazin M. and Schiffer M., Introduction to general relativity, McGraw-Hill Kogakusha, Ltd. New Delhi, 1965.
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- Sakurai J. J., Advanced quantum mechanics, Addison-Wesley, Harlow, England, First ISE Reprint, 1999.
- Griffiths D., Introduction to elementary particles, John Wiley and Sons, New York, 1987.
- Gasiorowicz S., Elementary particle physics, John-Wiley, New York, 1966.
- Muirhead H., The physics of elementary particles, Pergamon Press, London, 1965.

PHY306: Accelerator Physics

Ion sources: Brief introduction to ion sources for positive and negative ions. Ion production. Semi classical treatment of ionization, Townsend theory-comparison of theory and experiment for ion production. Examples of ion sources-properties of ion sources. Insulation at high voltages-Spark voltage. Paschen's law for gas breakdown. Breakdown in electronegative gases, time lags for breakdown, streamer theory of breakdown in gases, breakdown in non-uniform field and corona discharges.

Ion optics and focusing: Focusing properties of linear fields. Electrostatic and magnetic lenses.

[16 hours]

Particle accelerators: Introduction, historical development and classifications, applications in research: CERN experiments (ALICE, ATLAS, CMS and LHCb), accelerators in India (TIFR-BARC, VECC, and IUAC), medicine and industry. Electromagnetic theory and relativistic mechanics (Maxwell's equations in accelerator contexts, Lorentz transformations, Relativistic particle motion in cylindrical coordinates).

Direct voltage accelerators: Cockroft-Walton generator, Van de Graff generator, Tandem accelerators and pelletron. Resonance accelerators: Cyclotron-fixed and variable energy - principles and longitudinal dynamics of the uniform field cyclotron, Linear accelerators, synchrotron radiation (Radiation from Relativistic Particles, Damping of Oscillations, Quantum Fluctuations and Equilibrium Beam Size).

[16 hours]

Electron accelerators: Betatron: principles, construction and working, energy expression for the electron, beam focusing and betatron oscillation, X-ray generation in a betatron, microtron: principles, construction and working, derivation of energy of the electron. Synchronous accelerators: Principle of phase stability, mathematical theory for principle of phase stability. Electron synchrotron. Proton synchrotron. Alternating gradient machines: Alternating gradient principle, AG proton synchrotron. Accelerator shielding - safety aspects of accelerators, Accelerators in radiation therapy and industrial applications.

[16 hours]

References

- Townsend P. D., Kelly J. C. and Hartley N. E. W., Ion implantation, sputtering and their applications, Academic Press, London, 1976.
- Humphrey S. Jr., Principles of charged particle acceleration, John Wiley, 1986.
- Arya A. P., Fundamentals of nuclear physics, Allyn and Bacon, USA, 1968.
- Ghoshal S. N., Atomic and nuclear physics, Vol. 2, S. Chand and Company, Delhi, 1994.
- Varier K. M., Joseph A. and Pradyumnan P. P., Advanced experimental techniques in modern physics, Pragathi Prakashan, Meerut, 2006.
- Naidu, M. S., and Kamaraju, V., High voltage engineering. Mc. Graw Hill., 6th Edition, 2020.
- Edwards D. A. and Syphers M. J., An Introduction to the physics of high energy accelerators, John Wiley & Sons. Inc., 1993.
- Herwig S. and Luigi D. L., 60 years of CERN experiments and discoveries, World Scientific Publishing Co. Pte. Ltd., 2015.
- Divatia A. S., and Ambasankaran C., Accelerator development in India, Pramana, Vol. 24, Nos 1 & 2, pp. 227-244, 1985.
- Bhawalkar D. D. and Rajarao A. S., Recent and future accelerator activities in India, proceedings of the second Asian particle accelerators conference, Beijing, China, 2001.

PHY307: Astrophysics

Basic concepts of Astronomy: Co-ordinate system, time system - solar and sidereal times, apparent and absolute magnitudes, trigonometric parallax, atmospheric extinction, optical telescopes and their characteristics, modern optical telescopes, astronomical instruments - photometer, spectrographs, charge coupled detector.

[16 hours]

Stellar properties: Observational properties of stars - spectral and luminosity classification of stars - H-R diagram, Saha equation, star formation - Jeans mass, Jeans length and free fall timescale, main sequence evolution, mass-luminosity relation, white dwarfs - Chandrasekhar's limit, neutron stars, pulsars, supernovae, stellar black holes.

[16 hours]

Solar atmosphere and active regions: Overview of sun, location of sun, sun's spectrum, Solar interior structure - Energy generation, radiative zone, convection zone, observing the sun, solar telescopes, satellite missions, solar polarimetry, solar radio astronomy. solar atmosphere - photosphere - active regions, sunspots - solar cycle, active and quiet sun, granulation, faculae, chromosphere - diagnostics, radiative transfer, heating, supergranulation, solar flares - properties, classification, occurrence, prominences, corona - basic facts, observational features, CME, radio bursts, solar wind and interplanetary magnetic field.

[16 hours]

References

- Zeilik M. and Gregory S. A., Introductory astronomy and astrophysics, Saunders College Publication, 1998.
- Bowers R. and Deeming T., Astrophysics I & II, Bartlett, 1984.
- Schwarzschild M., Structure and evolution of stars, Dover.
- Shapiro S. and Teukolsky S., Black holes, white dwarfs and neutron stars, John Wiley, 1983.
- Hanslmeier, The sun and space weather, Springer, 2007.

PHY308: Atmospheric Physics

Structure and composition of the atmosphere: Vertical structure (troposphere to exosphere), atmospheric pressure, temperature and density profiles. Composition of dry air and trace gases.

Thermodynamics of the atmosphere: Gas laws; hydrostatic balance adiabatic processes; potential temperature atmospheric stability; lapse rates.

Cloud physics and precipitation: Nucleation, cloud formation, types of clouds Bergeron process, collision–coalescence process. Precipitation mechanisms and cloud classification.

Aerosols: Production and properties of aerosols. Aerosol optical depth, Beer's law - sun photometer. Optical filters.

[16 Hours]

Equations of atmospheric motion: Continuity, momentum and thermodynamic equations. Coriolis force, geostrophic and gradient winds, global circulation and weather systems: General circulation of the atmosphere. Hadley, Ferrel and Polar cells. Jet streams, monsoons, trade winds.

Radiation: Radiative transfer in the atmosphere, blackbody radiation, Planck's law, solar and terrestrial radiation, greenhouse effect and radiative forcing.

Climate systems and climate change: Earth's energy balance, climate feedbacks and sensitivity. Anthropogenic climate change and mitigation policies.

[16 Hours]

Atmospheric electricity: The generation of an ion near the earth's surface, the mobility of ions, ion size. Recombination of ions. Ions in an electric field, ionizing agencies, radioactivity. The conductivity of the atmosphere and its origin, measurement of conductivity of the atmosphere near the ground. Relationship between ions and conductivity. Relation between atmospheric electric conductivity, field and air earth current. Global electric circuit.

Observational techniques: Atmospheric optics and remote sensing: Scattering, absorption and emission satellite meteorology; radiometers and spectrometers LIDAR, RADAR and other observational tools.

[16 Hours]

References:

- Murry L. S., Fundamentals of atmospheric physics, Academic Press, San Diago California, USA, 2006.
- Frederick K. L., and Edward K. T., The atmosphere: An introduction to meteorology, 1986.
- Holton J. R., Dynamic meteorology, 3rd edition, Academic Press, USA, 1992.
- Keshvamurthy R. N. and Shankar Rao M., The physics of monsoons, Allied Publishers, 1992.
- Iqbal M., An introduction to solar radiation, Academic Press, USA, 1983.
- Tom L. and Prillscott, Principles of air pollution meteorology, CBS publishers & Distributors (P) Ltd.
- Israel H., Atmospheric electricity - Vol II, Israel program for scientific translations, Jerusalem, 1973.
- Wallace J. M., and Hobbs, P. V., Atmospheric science: An introductory survey, 2nd edn. Elsevier Academic Press, 2001.
- Ahrens C. D., Meteorology today: An introduction to weather, climate, and the environment, 10th edn, Cengage Learning, 2012.
- Stull R. B., An introduction to boundary layer meteorology, Springer, 1988.
- Liou K. N., An introduction to atmospheric radiation, 2nd edn, Academic Press, 2002.
- Das P. K., The monsoons. National Book Trust, India, 1968.

PHY309: Numerical Techniques and Computational Physics

Experimental measurements and errors: Types and sources of experimental errors, significant digits in measurements, evaluation of errors in derived quantities with more than one variable, propagation of errors, mean and standard deviation, estimation of error, reporting experimental results with error bars.

Data fitting: Lagrange interpolation and least squares fit methods, specific example of fitting experimental data on exponential decay, goodness of fit.

Error analysis: Estimation of errors in the numerical integration and differentiation in the specific example of exponential decay.

[16 hours]

Numerical methods: Numerical linear algebra - LU decomposition, QR decomposition, eigenvalue solvers. From analytical methods to numerical approach, numerical differentiation: Euler's method, Runge-Kutta second and fourth order methods, Solution of a system of linear algebraic equations using Gauss elimination method without pivoting, Numerical integration: Trapezoidal and Simpson's rules, finding roots, bisection method, Newton-Raphson method.

[16 hours]

Computational approach in physics: Application of numerical differentiation, Newton's law of cooling and Euler and Runge-Kutta methods, numerical solution of freely falling body, effect of air-resistance.

Approximating an integral: Gauss-Legendre method; computing Legendre polynomials of order n using recursion relations.

Quantum states in a square-well: finding energy Eigen values based on trial and error search for roots - bisection and Newton-Raphson methods.

[16 hours]

References

- Atkinson K. E., An introduction to numerical analysis, John Wiley and Sons, 1989.
- Mark N., Computational Physics, 2nd edn, Oxford, 2012.
- Rubin H. L., Manuel J. P., and Cristian C. B., Computational physics, problem solving with computers, Wiley, 2007.
- Lecture notes on computational physics, Morten Hjorth-Jensen, Univ of Oslo, 2014.
- NOC: Numerical Analysis, IIT Bombay Prof. S. Baskar, https://nptel.ac.in/courses/111101165

PHY316: Materials Synthesis and Characterization

X-ray powder diffraction: Geometry of a diffractometer, X-ray source and optics, detector, specimen, diffraction pattern, sources of information. Phase diagram determination. Long range order determination. Determination of crystallite size and strain.

Electrical and thermal characterization: Electrical analysis: DC electrical characteristics of semiconductor devices, crystals and polymeric materials. C-V and DLTS characterization of semiconductor devices. Thermal analysis: Basic principles of TGA, DTA and DSC. The differences between DTA and DSC. Instrumentation; Power compensated DSC, heat flux measurement in DSC.

[16 hours]

Spectrochemical characterization: Elemental analysis, identification of different elements present in a sample; Mass spectroscopy, instrumentation, measurement of accurate molecular weight and isotopic abundance; Nuclear magnetic resonance spectroscopy, instrumentation, assignments of ^{1}H and ^{13}C NMR peaks, structural elucidation of organic compounds using NMR spectroscopy; Fourier transform infrared spectroscopy, ATR enabled FTIR spectrometer, identification of different functional groups; UV-visible spectroscopy, dual beam UV-visible spectrometer, estimation of energy gap using UV-visible spectrum.

Nonlinear optics: Theory of nonlinear optics, Z-scan technique, open aperture and closed aperture.

[16 hours]

Polymer physics: Crystal structure of polymers, morphology of crystalline polymers, crystallization and melting, strain induced morphology, viscous flow, kinetic theory of viscous flow, viscoelasticity, glass transition and mechanical properties of crystalline polymers.

Nanotechnology: Nanoparticles synthesis and characterization, solution combustion method, hydrothermal technique, electrochemical technique. Dynamic light scattering (DLS), scanning electron microscopy, transmission electron microscopy, atomic force microscopy, Raman spectroscopy. Energy dispersive X-ray spectroscopy (EDS).

[16 hours]

References

- Azaroff L., and Buerger M. J., The powder method in X-ray crystallography, McGraw-Hill, USA, 1958.
- Suryanarayana C., and Grant Norton M., X-ray diffraction, A practical approach, Plenum Press, UK, 1998.

- Schroder D., Semiconductor materials and device characterization, John Wiley and Sons, USA, 1990.
- Brown M. E., Introduction to thermal analysis: Techniques and applications, Chapman and Hall, USA, 1988.
- Hohne G., Hemminger W. F., and Flammersheim H. J., Differential Scanning Calorimetry (2nd Edition), Springer, USA, 2003.
- Kemp W., Qualitative organic analysis: spectrochemical techniques, McGraw-Hill, New York, 1986.
- Banwell C. N., and McCash E. M., Fundamentals of molecular spectroscopy, McGraw-Hill, New York, 1994.
- Gunther H., NMR spectroscopy: Basic principles, concepts and applications in chemistry, John Wiley and Sons, USA, 2013.
- Woodward L. A., Introduction to the theory of molecular vibrations and vibrational spectroscopy, Oxford University Press, UK, 1972.
- Perkampus H. H., UV-Vis spectroscopy and its applications, Springer Science and Business Media, 2013.
- Billmeyer F. W., Text book of polymer science, Wiley New York, 2005.
- Fried J. R., Polymer science and technology, prentice hall of India, India, 2000.
- Chattopadhyaya K. K., Banerjee A. N., Introduction to nanoscience and nanotechnology, PHI Learning Private Limited, New Delhi, 2009.

PHY310: Theoretical Physics 1

General theory of relativity: Tensor calculus and Riemannian geometry: Covariant differentiation, parallel transport, geodesies, the curvature tensor.

Riemannian geometry: Riemannian space, the determinant of $g_{\mu\nu}$. metrical densities, The connection of a Riemannian space: Christoffel symbols, Geodesies in a Riemannian space, the curvature of a Riemannian space: the Riemann tensor.

[16 hours]

Gravitational field: The principle of equivalence, the field equations of general relativity, metrics with spherical symmetry, the Schwarzschild solution. Geodesies in the Schwarzschild space, advance of the perihelion of a planet, the deflection of light rays, red shift of spectral lines, the Schwarzschild sphere. Gravitational collapse. Black holes.

[16 hours]

Quantum field theory-1: Classical and quantum fields: Particles and fields, discrete and continuous mechanical systems, classical scalar fields, Maxwell fields. Quantum theory of radiation: Creation, annihilation and number operators, Quantized radiation field, Fock states, emission and absorption of photons by atoms, Rayleigh scattering, Thomson scattering, and the Raman effect.

[16 hours]

References

- Papapetrov A., Lectures on general relativity, D. Reidel Publishing Company, USA, 1974.
- Dirac P. A. M., The general theory of relativity, John Wiley and Sons, New York, 1975.
- Adler R., Bazin M. and Schiffer M., Introduction to general relativity, McGraw-Hill Kogakusha, Ltd. New Delhi, 1965.
- Hartle J. B., Gravity: An introduction to Einstein's general relativity, Benjamin- Cummings Pub. Co., USA, 2002.
- Sakurai J.J., Advanced quantum mechanics, Addison-Wesley, Harlow, England, First ISE Reprint, 1999.
- Griffiths D., Introduction to elementary particles, John Wiley and Sons, New York, 1987.
- Gasiorowicz S., Elementary particle physics, John-Wiley, New York, 1966.
- Muirhead H., The physics of elementary particles, Pergamon Press, London, 1965.

PHY311: Nuclear Physics Lab

Any eight of the following experiments

- Half-life of Indium-116 measurement.
- Energy Resolution of a NaI(Tl) scintillation spectrometer.
- Compton scattering—determination of the rest energy of an electron.
- Beta absorption coefficient measurement.
- Dekatron as a counter of signals.
- Gamma-ray absorption coefficient measurement.
- End-point energy of Beta particles by half thickness measurement.
- Common Source amplifier.
- Astable multivibrator using timer IC 555.
- Dead time of the G.M. counter.

*Total work load :*2 day(s) per week × 4 hours × 16 weeks 128 hours

PHY312: Condensed Matter Physics Lab

- Determination of the paramagnetic susceptibility of the given salt by Quincke's method.
- Study of mercury spectrum by superimposing it on brass spectrum.
- Sodium spectrum analysis by using Edser-Butler fringes.
- Temperature coefficient of resistance of a thermistor.
- Analysis of the powder X-ray photograph of a simple cubic crystal.
- Thermionic work function of a metal (Richardson-Dushmann formula).
- Energy gap of a semiconductor.

- Magnetic Hysteresis.
- Activation energy of the point defects.

*Total work load :*2 day(s) per week × 4 hours × 16 weeks 128 hours

PHY313: Nuclear Physics Lab 1

For those who have opted for PHY303

Any five of the following experiments:

- Cockroft-Walton voltage multiplier.
- Coincidence circuit.
- Linear pulse amplifier.
- Transistorized binary circuit.
- Pulse shaping circuits.
- Linear Gate.
- Randomicity of radioactive decay.
- Nomogram method: Measurement of endpoint energy of beta rays.
- Study of linearity of the NaI(Tl) gamma ray spectrometer with SCA and hence determination of energy of unknown gamma source.
- Determination of the rest mass energy of the electron using MCA.
- study of the variation of resolution of NaI(Tl) spectrometer as a function of energy.

*Total work load :*1 day(s) per week × 4 hours × 16 weeks 64 hours

PHY314: Solid State Physics Lab 1

For those who have opted for PHY304

Any five of the following experiments

- Optical rotatory dispersion of an uniaxial crystal.
- Birefringence of quartz using spectrometer.
- Paramagnetic susceptibility by Gouy balance method.
- Fermi energy of copper.
- Cell parameter(s) from an X-ray powder diffractogram.
- Study of frequency dependence of dielectric constant.
- Curie temperature of a ferroelectric material.
- Verification of Langmuir-Child's law.
- Study of variation of magnetoresistance.

*Total work load :*1 day(s) per week × 4 hours × 16 weeks 64 hours

PHY315: Theoretical Physics Lab 1

For those who have opted for PHY305

Any five of the following experiments:

- Calculation of Christoffel symbols.
- Geodesics and curvature calculations.
- Exterior Schwarzschild metric calculations.
- Robertson-Walker metric calculations.
- Lagrangian and Hamiltonian, Euler Lagrange equations for Schrodinger field.
- Lagrangian for Maxwell's field and The field equations.
- Symmetries of the Lagrangian and Constants of motion.
- Operator algebra-BCH formula.
- Relativistic kinematics-1: Relations between center of momentum and laboratory frames.
- Relativistic kinematics-2: Non-relativistic limit of relativistic kinematics.

*Total work load :*1 day(s) per week × 4 hours × 16 weeks 64 hours

PHY320: Energy Science

Paper offered to Non-Physics Postgraduate Students

Renewable energy resources: Forms of energy. Basics of thermodynamics: Heat capacity. Heat transfer mechanism, entropy, first and second law of thermodynamics. Carnot cycle, Rankine cycle. Fossil fuels and time scale of fossil fuels. Solar energy: sun as a source of energy and its energy transport to the earth. Extraterrestrial and terrestrial solar radiations. Measurement techniques of solar radiations using pyranometer and pyrheliometer.

[16 hours]

Materials and solar cell technology: Single, poly and amorphous silicon, GaAs, CdS, fabrication of single and polycrystalline silicon solar cells, amorphous silicon solar cells, photovoltaic systems, and technical problems. Wind energy origin and classification of winds, aerodynamics of windmill: Maximum power and forces on the blades and thrust on turbines; Wind data collection and field estimation of wind energy, site selection, basic components of wind mill, types of wind mill, wind energy farm, hybrid wind energy systems: The present Indian scenario.

[16 hours]

Biomass energy and biogas technology: Nature of Biomass as a fuel, Biomass energy conversion processes, Direct combustion: heat of combustion, combustion with improved Chulha and cyclone furnace; Dry chemical conversion processes: pyrolysis, gasification, types of gasification Importance of biogas technology, anaerobic decomposition of biodegradable materials, Factors affecting Bio-digestion, Types of biogas plants, Applications of biogas.

[16 hours]

Tutorial [32 hours]

References

- Peter A., Advances in energy systems and technology, Academic Press, USA, 1986.
- Neville C. R., Solar energy conversion: The solar cell, Elsevier North-Holland, 1978.
- Dixon A. E. and Leslie J. D., Solar energy conversion, Pergamon Press, New York, 1979.
- Ravindranath N. H., Biomass, energy and environment, Oxford University Press, 1995.
- Cushion E., Whiteman A. and Dieterle G., World Bank Report, 2009.

PHY321: Nonlinear Optics

Introduction to NLO: Basic concepts of linear and nonlinear optics; definition of nonlinear polarization; expansion of polarization in terms of the electric field; physical origin of nonlinear response; orders of susceptibility. Introduction to second- and third-order nonlinear optical processes. Nonlinear wave propagation in isotropic and anisotropic media. Derivation of the wave equation in nonlinear media [Sutherland, p8-24, Boyd, p4].

[16 hours]

Second-order Nonlinear Processes: Second-harmonic generation (SHG), sum- and difference-frequency generation (SFG/DFG), Optical parametric oscillation, Phase-matching techniques [Boyd, p4-16, 79, Sutherland, p53-95].

Third-order Nonlinear Processes: Kerr effect, third-harmonic generation (THG), self-phase modulation, cross-phase modulation and four-wave mixing. Two-photon and multiphoton absorption processes [Sutherland, p368-389, 490-495, 580-594, Boyd, p375].

[16 hours]

NLO Techniques and its Applications: Kurtz and Perry powder technique. Z-scan technique for measuring the nonlinear refractive index (n_2) and nonlinear absorption coefficient (β). Applications: Optical limiting, optical bistability and switching, frequency conversion, optical modulation and photonic devices [Sutherland, p260-266, p456-474, 617-622, Boyd, p359].

[16 hours]

References

- Richard L. S, Handbook of nonlinear optics, 2nd Edition, CRC Press, 2003.
- Robert W. B., Nonlinear optics, 4th Edition, Academic Press, 2020.
- Powers P. E, and Haus J. W., Fundamentals of nonlinear optics, 2nd edition, CRC press, 2019.

PHY322: Minor Project

PHY401: Nuclear Physics 2

Nuclear fission: Nuclear fission, mass distribution and energy distribution of fission fragments, mechanism of nuclear fission, liquid drop model, spontaneous fission, condition for spontaneous fission, statistical model of fission and its limitations.

Reactor theory-1: Neutron and its interaction with matter - collision kinematics, differential elastic scattering cross sections; Neutron moderation theory-isotropic scattering, scattering law, average logarithmic energy decrement, slowing down power and moderating ratio.

Neutron Diffusion Theory **-** Neutron transport equation using elementary diffusion theory. continuous slowing down model and Fermi age equation; The criticality conditions for a reactor **-** multiplication factor through four factor formula, one-group critical equation, critical size on the basis of Fermi age theory, geometric and material buckling, Infinite multiplication factor.

[16 hours]

Reactor theory-2: Homogenous and heterogeneous reactors, one-group reactor theory, the effective multiplication factor. Critical size of homogeneous reactors of different geometry - Infinite slab reactors of finite thickness, rectangular parallelopiped reactors, spherical and cylindrical reactor.

Reflected reactors: Properties and effects of reflectors. Neutron flux behaviour at core–reflector boundary, one-group method of a homogeneous reactor with reflector, application to infinite plane slab and spherical reactors with reflectors, reflector savings. Reactor Multiplication parameters— Infinite multiplication factor, critical size and critical mass. Heterogeneous reactor system, calculation of thermal utilization factor. Fast breeder reactor, evaluation of Buckling using One-Group model.

[16 hours]

Beta decay: Classification of beta interactions. Matrix elements. Fermi and Gamow-Teller selection rules for allowed beta decay. Concept of parity, The non-conservation of parity in beta decay. Wu et al. experiment, the universal Fermi interaction.

Gamma decay: Electromagnetic interactions with nuclei. Multipole transitions. Transition probabilities in nuclear matter. Weisskopf's estimates. Structure effects. Selection rules. Internal conversion**,** Cross section for Photo disintegration of deuteron and radiative capture of neutron by proton.

[16 hours]

References

- Glasstone S. and Edlund M. C., Elements of nuclear reactor theory, D. Van Nostrand Co., USA, 9th Print, 1963. Unit 1 Chapter 5–6 page 90-135, Unit 2. Chapter 7 page 191-290.
- Garg S., Ahmed F. and Kothari I. S., Physics of nuclear reactors, Tata

McGraw- Hill, New Delhi, 1986. Unit 1.
- Roy R. R. and Nigam B. P., Nuclear physics, New Age International, New Delhi, 1986. Chapter 5, page 162-165.
- Hans H. S., Nuclear physics - Experimental and theoretical, New Age International Publishers, 2001. Unit 2
- Ghoshal S. N., Nuclear physics, Vol. 2., S. Chand and Company, Delhi, 1994. Chapter 15, page 714-730.

PHY402: Nuclear Physics 3

Deuteron physics and two-body nuclear forces: Binding properties of deuterons and other two-nucleon systems, internucleon forces and potentials. Deuteron in s-state central approximation, excited states of the deuteron. The deuteron as a mixture of *s* and *d* states, Rarita-Schwinger relations.

Nucleon-nucleon scattering processes: Theory of neuron proton scattering at low energies. Scattering length, spin-dependence of neutron-proton scattering. Effective range theory for n-p scattering. Effective range theory of proton-proton scattering. Analysis of n-p and p-p scattering. High energy n-p and p-p scattering. Pion-nucleon scattering experimental results.

[16 hours]

Nuclear reactions-1: Plane wave theory of direct reactions. Born approximation-(Plane wave)-Butler's theory. Partial wave method of calculations of cross section for nuclear scattering and reactions. Classical interpretation, shadow scattering, Breit-Wigner resonance formulae.

Nuclear reactions-2: Bohr's independence hypothesis. The compound nucleus (CN) reactions, Cross section for compound nucleus formation reaction, decay rates of CN, statistical theory of nuclear reactions. Evaporation probability and cross sections for specific reactions.

[16 hours]

Optical model: The physical background to the optical model, Kapur-Pearls' dispersion formula for potential scattering. Direct reactions: Kinematics of stripping and pickup reactions. Theory of stripping and pickup reactions.

Heavy ion physics: Special features of heavy ion Physics. Remote heavy ion electro- magnetic interactions. Coulomb excitations. Close encounters. Heavy ion scattering. Grazing interactions. Particle transfer. Direct and head on collisions, compound nucleus and quasi molecule formation.

[16 hours]

References

- Roy R. R. and Nigam B. P., Nuclear physics - Theory and experiment, New Age International Ltd, New Delhi, 1986.

- Hans H. S., Nuclear physics - Experimental and theoretical, New Age International Publishers 2001.
- Sachtler G. R., Nuclear reactions, Addison Wesley, New York, 1983.
- Mermier P. and Sheldon E., Physics of nuclei and particles, Academic Press, USA, 1971.
- Jackson D. F., Nuclear reactions, Chapman and Hall, London, 1975.
- Shivalingaswamy T., A Theoretical Introduction to Nuclear Fission Reactors, Starlet Publishing, New Delhi, 2020.

PHY403: Solid State Physics 2

X-ray diffraction by crystals: The reciprocal lattice. Ewald sphere and construction. Scattering by an electron and atom. Atomic scattering factor. Anomalous scattering. Geometrical structure factor of the unit cell. [Sherwood, p290– 302, p320–332, p342–358]. Fourier series in X-ray crystallography: One-dimensional function, one-dimensional function two- and three-dimensional functions, units of electron density; Generalized Fourier transform: Fourier transform of a molecule, Fourier transform of a unit cell (Ladd and Palmer, 2013). Convolution and diffraction, Convolution integral.

Experimental techniques: Absent reflections and space groups; Molecular weight determination. Low angle scattering. Reduction of intensities to structure amplitudes. Lorentz, polarization and other corrections. Absolute scale factor and temperature factor from statistical methods. Statistical method for finding the presence of center of symmetry [Stout and Jensen, p90–91, 94–106, 117–120, 122– 128, 148–156, 195–211]. [16 hours]

Structure analysis: Fourier analysis of electron density. Patterson synthesis. Harker sections and lines. Heavy atom methods. Direct methods for phase determination. The inequality relations. Difference Patterson synthesis and error Fourier synthesis. Figure of merit. Cyclic Fourier refinement, Difference Fourier synthesis. Refinement of structures: The least squares method. Accuracy of the parameters. Conformational analyses: Bond lengths and angles torsion angles, dihedral angles and least-square planes.

[16 hours]

Imperfections in solids: Different types of imperfections. Schottky and Frenkel defects. Expression for energy for the formation of Frenkel and Schottky defects. Diffusion in metals and alkali halides. Kirkendall effect. Ionic conductivity in pure and doped halides. Dislocations: Shear strength in single crystals; slip systems. Edge and Screw dislocations. Buerger's Vector. Energy of a dislocation. Surface imperfections: grain boundaries, twin boundary and stacking faults (as in Kittel and Wahab).

Synthesis and device fabrication of nanomaterials: Bottom-Up approach: Sol-gel synthesis, hydrothermal growth, thin-film growth, physical vapor deposition, chemical vapor deposition. Top-Down Approach: Ball milling, Microfabrication, Lithography, Ion-beam lithography (Page 129-142, Ramachandra Rao and Shubra Singh).

Luminescence: General remarks, excitation and emission. Franck-Condon principle. Decay mechanisms - temperature dependent and independent decays; power-law decay. Thermoluminescence and glow curve. Electroluminescence. The Gudden-Pohl effect (as in Dekker).

[16 hours]

References

- Stout G. H. and Jensen L. H., X-ray structure determination, MacMillan, USA, 1989.
- Ladd M. F. C. and Palmer R. A., Structure determination by X-ray crystallography, Plenum Press, USA, 2003.
- Kittel C., Introduction to solid state physics, 8th Edn., John Wiley, New York, 2005.
- Dekker A. J., Solid state physics, Prentice Hall, 1985.
- Sherwood D., Crystals, X-rays and proteins, Longman, London, 1976.
- Ramachandra Rao M. S. and Shubra Singh, Nanoscience and Nanotechnology, Wiley, 2013.
- Wahab M. A., Solid state physics, Narosa Publishing House, New Delhi, 1999.
- Azaroff L. V., Introduction to solids, McGraw-Hill Inc, USA, 1960.
- Weertman J. and Weertmann J. R., Elementary dislocation theory, McMillan, USA, 1964.
- Pillai S. O., Solid state physics, New Age International Publications, 2002.

PHY404: Solid State Physics 3

Free electron theory of metals: Boltzmann transport equation, Sommerfeld's theory of electrical conductivity, mean free path in metals, dependence of resistivity on temperature and impurities. Matthiessen's rule. Electron-phonon collisions. Thermal conductivity of insulators, Umklapp processes. Electrical conductivity of metals at high frequencies. Plasma frequency. Transparency of alkali metals to UV radiation. Anomalous skin effect. Plasmons. Field enhanced emission, Schottky effect. Hall effect and magnetoresistance in metals. Cyclotron frequency.

[16 hours]

Elemental and compound semiconductors: A brief discussion on elemental and compound semiconductors and their properties [Streetman, p61–95].

Impurity semiconductors: Carrier concentrations. Effect of temperature and impurity density. Electrical neutrality condition. Fermi energy. Variation of Fermi energy with temperature and impurity density, when the Boltzmann approximation is valid. Effect of impurity density at very low temperatures. Mobility of current carriers. Effect of temperature and impurity. Electrical conductivity. Effect of temperature, impurity concentration and the energy band gap. Impurity band conductivity. Hall effect in semiconductors: Expression for Hall co-efficient in terms of mobility of current carriers and carrier densities. Hall mobility and Hall factor. Effect of temperature, impurity concentration and magnetic field. Magneto-resistance phenomenon (qualitative).

Cyclotron resonance: Cyclotron resonance in Si and Ge semiconductors. Effective mass tensor. Variation of cyclotron resonance frequency with orientation of the crystal in the magnetic field [Mckelvey, p270–300].

[16 hours]

Excess carriers in semiconductors: Generation and recombination rates. Excess carriers. Continuity equations for excess carriers; Einstein equations, Expression for the diffusion length of electrons and holes [Mckelvey, p320–335]. High field transport in semiconductors: Hot electrons - The expression for electron temperature and mobility of electrons. Gunn effect, expression for drift velocity. Superlattice phenomenon [Roy, p29–39].

Semiconductor devices: The pn junction diode. Formation of space charge region. Theory of abrupt pn junction - Expressions for barrier potential and barrier thickness. Expressions for barrier potential and barrier thickness. Effect of the applied field on the above junction parameters. The expression for the electric field at the pn junction. Theory of forward and reverse biased pn junction rectifier using continuity equations for excess minority carriers. Transistors; expression for dc current gain of a pnp transistor. The effect of frequency on dc current gain and expressions of α and β cut-off frequencies [Mckelvey, p390–441]. MOSFET and its characteristics.

[16 hours]

References

- Dekker A. J., Solid state physics, Prentice Hall, 1985.
- Mckelvey J. P., Solid state and semiconductor physics, 2nd Edn., Harper and Row, USA, 1966.
- Roy D. K., Physics of semiconductor devices, University Press, Hyderabad, 1992.
- Schur M., Physics of semiconductor devices, Prentice-Hall of India, New Delhi, 1999.

- Wilson J. and Hawkes J. F. B., Optoelectronics - An introduction, 2nd Edn., Prentice-Hall of India, New Delhi, 1996.
- Streetman B. G., Solid state electronic devices, 2nd Edn., Prentice-Hall of India, New Delhi, 1983.
- Omar M. A., Elementary solid state physics, Addison Wesley, New Delhi, 2000.
- Wahab M. A., Solid state physics, Narosa Publishing House, New Delhi, 1999.

PHY405: Theoretical Physics 2

Quantum features of radiation field: Optical resonance, damping, Theory of chaotic light, coherence, temporal, spatial, mutual coherence, line broadening, natural and Doppler width, collision broadening. Quantized States of radiation field; Coherent states and their properties, BCH formula, P, Q and Wigner distribution functions, Squeezed states of light and their properties; applications. Correlation functions, Brown-Twiss correlations.

[16 hours]

Quantization of the Dirac field: Second quantization, positron operators and positron spinors, Electromagnetic and Yukawa couplings. Weak interactions and parity non-conservation: Classification of interactions, parity and hyperon decay, Fermi theory of beta decay, the two-component neutrino. Pion decay and the CPT theorem. [16 hours]

Covariant perturbation theory: Natural units and dimensions, S-matrix expansion in the Interaction representation. Unitarity, first order processes: Matrix element for electron scattering. Cross section for Mott scattering. Helicity change and spin projection operator. Pair annihilation, pair creation, hyperon decay. S-matrix for two photon annihilation, electron propagator, Matrix element for Compton scattering, Feynman rules. Cross section for two photon annihilation.

[16 hours]

References

- Loudon R., The quantum theory of light, Clarendon Press, Oxford, 1973.
- Mandel L. and Wolf E., Optical coherence and quantum optics, Cambridge University Press, 1995.
- Louisell W. H., Quantum statistical properties of radiation, John Wiley and Sons, New York, 1973.
- Sakurai J. J., Advanced quantum mechanics, Addison-Wesley, Harlow, England, First ISE Reprint, 1999.
- Griffiths D., Introduction to elementary particles, John Wiley and Sons, New York, 1987.
- Gasiorowicz S., Elementary particle physics, John-Wiley, New York, 1966.
- Muirhead H., The physics of elementary particles, Pergamon Press, London, 1965.

PHY406: Theoretical Physics 3

Angular momentum theory and applications: Angular momentum: Transformations under rotations. Coupling of three and four angular momenta. Racah coefficients,

Wigner 9j symbols, applications. Wigner-Eckart theorem. Projection theorem. j-j and L-S coupling. Angular momentum in nuclear reactions, Spherical tensors. Evaluation of matrix elements between coupled angular momentum states. Vector spherical harmonics. Gradient theorem (without proof). Multipole radiation.

[16 hours]

Density matrix: Pure states and mixed states. Density operator, properties and equation of motion. Polarization of light, states of polarized light, Jones matrices, Jones formalism, Stokes parameters, Poincare sphere, Mueller matrices and Mueller formalism, Mueller matrices and their characterization, Few illustrative examples; comparison of Jones and Mueller formalisms. Pancharatnam phase, dynamical phase, cyclic evolution of polarization state on Poincare sphere.

[16 hours]

Spin density matrix: The spin density matrix (ρ), multipole parameters, combined systems, Diagonalization of ρ. Oriented and non-oriented systems, Polarized and aligned systems, Spherical tensor basis and SU(N) basis. Spin and helicity in a relativistic process. Effect of Lorentz and discrete transformations on helicity states. Wick and Wigner rotations, pure rotation, pure boost and parity. Polarization in scattering of spin 1/2 particles.

[16 hours]

References

- Sakurai J. J. and Tuan S. F. (Editor), Modern quantum mechanics, Addison Wesley, India, 1999.
- Rose M. E., Elementary theory of angular momentum, John Wiley and Sons, USA, 1957.
- Edmonds A. R., Angular Momentum in Quantum Mechanics Princeton University Press, USA, 1996.
- Blum K., Density matrix theory and applications, Plenum Press, New York, 1981.
- Loudon R., The quantum theory of light, Clarendon Press, Oxford, 1973.
- Mandel L. and Wolf E., Optical coherence and quantum optics, Cambridge University Press, 1995.
- Pancharatnam S., Collected works, Oxford University Press, 1975.
- Louisell W. H., Quantum statistical properties of radiation, John Wiley and Sons, New York, 1973.
- Leader E., Spin in particle physics, Cambridge University Press, London, 2001.

PHY407: Quantum Mechanics 2

Time-dependent perturbation theory: Two-Level systems, emission and absorption of radiation, spontaneous emission. Rabi oscillations.

Adiabatic approximation: The adiabatic theorem, Berry's phase, sudden approximation.

Scattering: Introduction, scattering cross section, partial wave analysis, Bauyer's formula, optical theorem, hard sphere scattering Born approximation, Yukawa potential, Rutherford scattering. The Lippmann- Schwinger equation [Griffiths, Chap. 9–11].

[16 hours]

Relativistic quantum mechanics: Klein Gordon equation, plane-wave solutions, negative energy. Equation of continuity. The difficulties of the Klein-Gordon equation.

The Dirac equation: The free-particle Dirac equation in the Hamiltonian form. The algebra of Dirac γ matrices, Plane wave solutions of the free-particle equation, the two-component form of the solution in the Dirac-Pauli representation, standard normalization of the solutions. Non-relativistic reduction and g factor.

[16 hours]

Spin of the Dirac particle: Non-conservation of the angular momentum operator $\vec{L}$; the spin operator $\vec{S}$ and the conservation of $J = \vec{L} + \vec{S}$. Helicity. Negative energy states and anti-particles. Dirac operators in the Heisenberg representation, velocity, zitterbewegung.

Field quantization: Lagrangian formulation for a classical field. Euler- Lagrange equations. Quantization of electromagnetic field (qualitative).

Quantum computing: Motivation and comparison with classical computing, Qubits vs classical bits, Bloch sphere representation, Dirac notation review, Superposition and entanglement.

Quantum gates and circuits: Single-qubit gates - Pauli gates, Hadamard, phase gate, two-qubit gates - CNOT, gate universality, quantum circuit notation and simple circuits to create superposition, entanglement.

[16 hours]

References

- Griffiths D. J., Introduction to quantum mechanics, 2nd Edition, Pearson, India, 2005.
- Sakurai J. J. and Tuan S. F. (Editor), Modern quantum mechanics, Addison Wes- ley, India, 1999.
- Sakurai J. J., Advanced quantum mechanics, Addison-Wesley, Harlow, England, 1999. Sons, New York, 1987.
- Gasiorowicz S., Elementary particle physics, John-Wiley, New York, 1966.
- Muirhead H., The physics of elementary particles, Pergamon Press, London, 1965.
- Thankappan V. K., Quantum Physics. New Age International (P) Limited, Publishers, New Delhi, 1993.

- Aruldhas, G., Quantum mechanics. PHI Learning Pvt. Ltd., 2008.
- Michael Nielsen & Isaac Chuang: Quantum Computation and Quantum Information.
- Eleanor Rieffel & Wolfgang Polak: Quantum Computing: A Gentle Introduction.

PHY411: Condensed Matter Physics Lab

For those who have completed PHY311

Any eight of the following experiments:

- Determination of the paramagnetic susceptibility of the given salt by Quincke's method.
- Study of mercury spectrum by superimposing it on brass spectrum.
- Sodium spectrum analysis by using Edser-Butler fringes.
- Temperature coefficient of resistance of a thermistor.
- Analysis of the powder X-ray photograph of a simple cubic crystal.
- Thermionic work function of a metal (Richardson-Dushmann formula).
- Energy gap of semiconductor.
- Determination of Stefan' constant.
- Frank Hertz experiment
- Magnetic hysteresis.
- Measurement of magneto resistance of semiconductors.

*Total work load :*2 day(s) per week × 4 hours × 16 weeks 128 hours

PHY412: Nuclear Physics Lab

For those who have completed PHY312

Any eight of the following experiments

- Half-life of Indium-116 measurement.
- Energy Resolution of a NaI(TI) scintillation spectrometer.
- Compton scattering determination of the rest energy of an electron.
- Beta absorption coefficient measurement.
- Dekatron as a counter of signals.
- Gamma-ray absorption coefficient measurement.
- End-point energy of beta particles by half thickness measurement.
- Common source amplifier.
- Astable multivibrator using timer IC 555.
- Dead time of the G.M. counter.

*Total work load :*2 day(s) per week × 4 hours × 16 weeks 128 hours

PHY415: Radiation Physics and Dosimetry

Radioactivity: Radioactive decay law, successive disintegration (No derivation), secular equilibrium, transient equilibrium, natural radioactive series, units of radioactivity.

Background radiation: Classification of radiation, background radiation, characteristic radiation, continuous radiation. Radioactivity in atmosphere. Radon, properties of radon, origin of radon, radon in the atmosphere.

[16 hours]

Interaction of photons with matter: General aspects, attenuation coefficients, classical, coherent and incoherent scattering, photoelectric effect, pair production. Interactions of charged particles with matter: General aspects, stopping power range, heavy charged particles, light charged particles, energy deposition, radiation yield, Bremsstrahlung targets.

[16 hours]

Dosimetric principles, quantities and units: Fluence and energy fluence, absorbed dose, Kerma, inter relationships, fluence and dose (electrons), energy fluence and kerma (photons), kerma and dose (electronic equilibrium), Kerma and exposure. Inhalation dose, ingestion dose, working level.

Radiation dosimeters and detectors: Desirable properties, ionization chambers and electrometers, environmental dosimeters, TLD, solid state nuclear track detectors.

[16 hours]

Tutorial [32 hours]

References

- Krane K. S., Introductory nuclear physics, Wiley, New York, 1955.
- Krane K., Modern physics, John Wiley and Sons, Inc. 1998.
- Evans R. D., The atomic nucleus, Tata McGraw Hill, New Delhi, 1980.
- Wilkening M., Radon in the environment, Elsevier Science Publishers, AE Amsterdam, The Netherlands, 1990.
- Kapoor S. S. and Ramamoorthy V., Nuclear radiation detectors, Wiley Eastern, Bangalore, 2007.

PHY416: Nuclear Spectroscopy Methods

Ion implantation and backscattering spectroscopy: Ion implantation, implantation technique, ion beam diffusion, thermal annealing and sputtering, analysis techniques. Backscattering, energy loss and straggling. Kinematics factor, differential scattering cross sections, depth scale, backscattering yield, instrumentation. Application to elemental and compound targets. Axial and planar half angles. Estimates of minimum yield. Lattice location of impurities, alignment procedures. Ion induced X-rays. Application of ion implantation.

[16 hours]

Compton scattering: Compton scattering from free electrons. Effects of external potential. Klein-Nishina cross sections for polarized and unpolarized radiation. Comp- ton profiles, momentum distributions and impulse Compton profiles. Calculation of Compton profiles for electron models. Relativistic profile corrections: experimentation. Discussion of methodology including sources, detectors and geometry. Data accumulation, analysis and multiple scattering corrections. Discussion of experimental results for some simple metals, ionic and covalent crystals.

[16 hours]

Positron annihilation spectroscopy: The positron and its discovery, Positronium, its characteristics, formation. Spur model and Ore gap model of positronium formation. Quenching and enhancement. Theory of 2-gamma and 3-gamma annihilations. Positron and positronium states in solids: trapping of positrons. Two state trapping model.

Experimental methods of positron annihilation spectroscopy: Positron life- time techniques (PLT), Angular Correlation of Annihilation Radiation (ACAR), Doppler broadening (DB) and Coincidence DB. Methods of data analysis: PATFIT, Contin and MELT. Experimental results of some metals and defected materials. PLS study of polymers. A brief mention of slow positron beams.

[16 hours]

References

- Townsend P. D., Kelly J. C. and Hartley N. E. W., Ion implantation, sputtering and their applications, Academic Press, London, 1976.
- Chu W. K., Mayer J. W. and Nicholate Mar A. O., Backscattering spectroscopy, Academic Press, New York, 1978.
- Mayer J. W. and Rimini B. (Eds.), Ion beam handbook for material analysis, Academic Press, 1977.
- Williams B. (Ed.), Compton scattering, McGraw-Hill, New York, 1977.
- Hautojarvi P. (Ed.), Positrons in solids, Springer Verlag, New York, 1979.
- Fava R. A. (Ed.), Methods of experimental physics, Academic Press, New York, 1980.
- Schradev D. M. and Jean Y. C., Positron and positronium chemistry, Elsevier Science Publication, Amsterdam, 1988.
- Jayaram B., Mass spectrometry -Theory and applications, Plenum Press, New York, 1966.

PHY417: Modern Optics

Polarization of light: Pure states and mixed states. Density operator, properties and equation of motion. Polarization of light, states of polarized light, Jones matrices, Jones formalism, Stokes parameters, Poincare sphere, Mueller matrices and Mueller formalism, Mueller matrices and their characterization, Few illustrative examples; comparison of Jones and Mueller formalisms. Pancharatnam phase, dynamical phase, cyclic evolution of polarization state on Poincare sphere; Applications of the concept of Pancharatnam phase,

[16 hours]

Quantum features of radiation field: Planck's law of radiation and Einstein coefficients, Thermal equilibrium, Semi-classical theory of two-level atoms, quantum theory of B coefficient, Optical resonance, damping, Theory of chaotic light, coherence, temporal, spatial, mutual coherence, line broadening, natural and Doppler width, collision broadening.

[16 hours]

Quantized radiation field: Quantization of radiation field, States of radiation field; Fock states and phase eigenstates; Interaction of radiation with matter, theory of spontaneous emission; Coherent states and their properties, BCH formula, P, Q and Wigner distribution functions, squeezed states of light and their properties; applications. Correlation functions, Brown-Twiss correlations.

[16 hours]

References

- Loudon R., The quantum theory of light, Clarendon Press, Oxford, 1973.
- Mandel L. and Wolf E., Optical coherence and quantum optics, Cambridge University Press, 1995.
- Louisell W. H., Quantum statistical properties of radiation, John Wiley and Sons, New York, 1973.
- Blum K., Density matrix theory and applications, Plenum Press, New York, 1981.
- Pancharatnam S., Collected works, Oxford University Press, 1975.

PHY418: Electronics

Semiconductor physics and devices: Carrier statistics: intrinsic and extrinsic semiconductors. Metal-semiconductor junctions: Ohmic and Schottky contacts. pn junction diodes: characteristics, applications, junction capacitance. Bipolar Junction Transistors (BJTs): operation, characteristics, biasing. Field Effect Transistors (FETs, MOSFETs): characteristics, applications. Heterojunction devices: basic structure and applications.

Optoelectronic devices: LEDs, photodiodes, solar cells - principle, I–V characteristics, spectral response. Applications in detection and energy conversion.

Analog and digital electronics: Operational amplifiers: characteristics, inverting/non-inverting configurations. Op-Amp applications: comparators, integrators, differentiators, active filters. Feedback, oscillators (RC, LC, Wien Bridge). Digital logic: combinational and sequential logic, Boolean algebra. Flip-flops, counters, registers, timers. ADC and DAC: working principles and interfacing basics.

[16 hours]

Microprocessor and microcontroller basics: Architecture of 8085 microprocessor. Instruction types, addressing modes, simple programs. Basics of 8051 microcontroller: architecture, memory, I/O interfacing. Concept of embedded systems: applications in instrumentation. Overview of timers, interrupts, and serial communication.

Signal conditioning, recovery and measurement systems: Transducers: types and applications (temperature, pressure, optical, vibration, magnetic, particle). Signal amplification: op-amp-based, instrumentation amplifiers. Impedance matching, feedback control. Filtering (low-pass, high-pass, band-pass). Noise reduction techniques: shielding and grounding.

Data acquisition and error analysis: Precision and accuracy; propagation of errors. Curve fitting: linear and nonlinear. Chi-square test; least squares method. Measurement control systems: basics of data logging, display, and control.

[16 hours]

Fourier analysis and signal modulation: Fourier series and Fourier transforms: conceptual and numerical applications. Signal modulation: AM, FM – principles and applications. Demodulation and detection techniques. Lock-in amplifiers: principles and applications. Boxcar integrators.

High-frequency devices and instrumentation: RF and microwave generators. Detectors: Schottky diodes, tunnel diodes. Oscilloscopes (CRO and DSO): block diagram, waveform measurements. Frequency counters, phase meters. Basics of spectrum analyzers and function generators.

Instrumentation and automation: Automated measurements using microcontrollers or PC-based systems. Data interpretation tools and interfacing basics. Concept of real-time signal monitoring and control systems. Safety protocols in electronics labs and shielding practices.

[16 hours]

References

- Malvino A., Electronic principles, McGraw-Hill, Inc., 1998.
- Boylestad R. L., and Louis N., Electronic devices and circuit theory. Pearson Education, 2002.

- Gaonkar, R. S., Microprocessor architecture, programming, and applications with the 8085. Prentice-Hall, Inc., 1998.
- Malvino, A. P., Bates, D. J., and Hoppe, P. E., Electronic principles, Glencoe, 1993.
- Kalsi, H. S., Electronic instrumentation, Tata McGraw-Hill, New Delhi, 2010.
- Horowitz, P., Hill, W., and Robinson, I. The art of electronics, Cambridge: Cambridge university press, 1989.
- Streetman, B. G., and Banerjee, S. Solid state electronic devices, New Jersey: Prentice hall, 2000.

PHY419: Biophysics

The broad characteristics of a typical cell: Cell organelles. The molecular composition of a cell. Biological molecules and their general character - Cell behavior-viruses - genetics and biophysics. Molecular physics. The conservation of energy in biological process. Metabolism or chemical energy turnover. Statistical thermodynamics and biology. The theory of absolute reaction rates. Thermal inactivation. The entropy transfer of living organisms. Information theory. Relation between information and entropy. Information content of some biological systems. Information content of a bacterial cell.

[16 hours]

Determination of size and shape of molecules: Random motion diffusion sedimentation. Optical methods. Rotational diffusion and birefringence. X-ray analysis and molecular structure. Diffraction of X-rays crystal structure and the unit cell. Diffraction patterns of some protein fibers, the structure of globular proteins, the structure of polypeptide chains, the pleated sheets and beta-keratin, the alpha-helix and alpha-keratin, the structure of nuclei acids polymers, the structure of nucleoproteins, the analysis of virus structures.

[16 hours]

Absorption spectroscopy: Vibrations of polyatomic molecules, characteristic bond frequencies, Raman spectra and the dipolar nature of amino acids, the vibrational spectra of proteins, the energy levels of hydrogen bonded structures. Absorption coefficient and cross section. Experimental techniques for absorption measurements. Absorption by oriented dipoles-dichroic ratios of proteins and nucleic acids electronic spectra of poly- atomic molecules. Ultraviolet absorption by proteins and nucleic acids. The fine structure in spectra. Polarized ultra violet light, electron spin resonance (briefly). Nuclear magnetic resonance (brief).

[16 hours]

References

- Setlow R.B. and Pollard E. C., Molecular biophysics, Pergamon Press, London- Paris 1962.
- Volkenshtein M. V., Biophysics, Mir Publishers, Moscow, 1983.
- Sam K., Biophysics, Rajat Publication, 2005.
- Rodney C., Biophysics, John-Wiley, 2004.

- Glaser R., Biophysics-An introduction, Springer, 2004.
- Nihaluddin, A Textbook of biophysics, Sonali Publications, 2009.

PHY421: Nuclear Physics Lab 2

For those who have completed PHY313

Any five of the following experiments:

- Schmitt trigger.
- Variable delay line.
- Pulse recorder.
- Internal conversion using MCA.
- Feather analysis: End-point energy of beta rays measurement.
- Z dependence of external Bremsstrahlung radiation.
- Fermi-Kurie plot: Determination of the end-point energy of beta rays using a plastic scintillation detector.
- Dead time of a GM counter by two source method.
- Determination of source strength by gamma-gamma coincidence.
- Determination of source strength by beta-gamma coincidence.

*Total work load :*1 day(s) per week × 4 hours × 16 weeks 64 hours

PHY423: Solid Stater Physics Lab 2

For those who have completed PHY314

Any five of the following experiments:

- Photovoltaic cell.
- Photoconductive cell.
- Hall effect in semiconductors.
- Determination of the energy gap of semiconductors by four-probe method.
- Temperature variation of the junction voltage of a p-n diode.
- Temperature variation of the reverse saturation current in a p-n diode.
- Depletion capacitance of a junction diode.
- Determination of material constant of an intrinsic semiconductor.
- Study of temperature dependence of dielectric constant.
- Determination of Curie temperature of a magnetic material.

*Total work load :*1 day(s) per week × 4 hours × 16 weeks 64 hours

PHY425: Theoretical Physics Lab 2

For those who have completed PHY315

Any five of the following experiments:

1. Density matrix description of polarization of light.
2. Double scattering of spin-1/2 particles on spin-zero targets.
3. Second order QED processes (Compton scattering).
4. Evolution of matrix elements between coupled angular momentum states.
5. Dirac matrix representations.
6. Algebra of Dirac matrices.
7. Electron-proton scattering, Rosenbluth formula.
8. Relativistic kinematics-3: Study of decay and production processes.
9. Feynman diagrams and calculations.
10. Energy matrix calculation.

Total work load: 1 day(s) per week × 4 hours × 16 weeks 64 hours

PHY431: Minor Project

List of Faculty Members

1. Prof. Sridhar M. A.
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   Email: gnanaprakash@physics.uni-mysore.ac.in
4. Prof. Chandrashekara M. S.
   Email: msc@physics.uni-mysore.ac.in
5. Prof. Krishnaveni S.
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6. Prof. Ravikumar H. B.
   Email: hbr@physics.uni-mysore.ac.in
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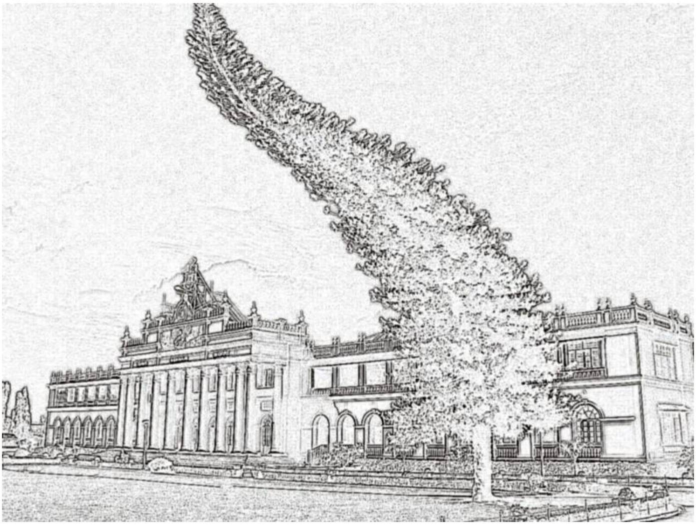
https://uomphysics.net

for additional information about the department.



University of Mysore was established on 27.07.1916 by the then Maharaja of Mysore, His Highness Nalvadi Krishnaraja Wodeyar (1884–1940). It was the sixth university to be established in India and the first in the state of Karnataka (then Mysore). It has a long tradition of excellence which is reflected in its motto taken from Bhagavadgita,

ನ ಹಿ ಜ್ಞಾನೇನ ಸದೃಶಂ (ಪವಿತ್ರಮಿಹ ವಿದ್ಯತೇ)

(*na hi jñānena sadṛśaṃ pavitramiha*

vidyate) Nothing is comparable to knowledge.

https://uni-mysore.ac.in

University of Mysore
Department of Studies in Physics, Manasagangotri, Mysore – 570 006

Prof. A. P. GNANA PRAKASH e-mail:gnanaprakash@physics.uni-mysore.ac.in
Chairman, BoS in Physics (CB) 9590583920 (M)

Proceedings of the Annual meeting of the *Board of Studies in Physics (CB)* held on May 17, 2025 at the Council Room, Department of Studies in Physics, Manasagangotri, Mysuru at 10:30 a.m.

1	Prof. A. P. Gnana Prakash	Chairman	Gnana [signature]
2	Prof. M. A. Sridhar	Member	[signature]
3	Prof. N. K. Lokanath	Member	[signature]
4	Prof. M. S. Chandrashekara	Member	[signature]
5	Prof. S. Krishnaveni	Member	[signature]
6	Prof. C. G. Renuka	Member	Approved through email
7	Prof. Ashok Lamani	Member	Approved through e-mail
8	Prof. A. R. Usha Devi	Member	Absent
9	Sri. H. B. Shiva	Member	Shiva HB
10	Prof. T. Shivalingaswamy	Member	[signature]

1) The meeting started with a welcome by the BoS Chairman.

2) The syllabi for UG III and IV Semesters Physics programs for the year 2025-26 were framed as per University guidelines.

3) Question paper pattern (UG) for theory and practical papers (with breakup for practical) was prepared.

4) The syllabus of PG programs for 2025-26 is updated. Three new elective papers were introduced.

5) The panel of examiners for M. Sc., and Ph. D. Entrance/Course work examinations was prepared.

6) The meeting ended with the Chairman thanking all the members.

Gnana Prakash [signature]
Prof. A.P. Gnana Prakash
Chairman-BOS in Physics
University of Mysore

Curriculum

of

BSc in Physics

3rd & 4th Semesters

2025-26

University of Mysore, Mysuru

III Semester B.Sc Physics Syllabus

PHY 301 (Major) : Waves, Acoustics and Optics

(Course duration: 16 weeks with 3 hours of instruction per week)

Part – A

Waves: Plane and spherical Waves. Longitudinal and transverse waves. Characteristics of wave motion. Differential equation of wave motion. Relation between amplitude and intensity. Group and phase velocity, relation between group and phase velocity. Expression for velocity of progressive waves in a medium-Newton's formula, Laplace's correction. Expression for frequency of vibration of a stretched string – harmonics, longitudinal vibrations in a rod. Kundt's tube experiment. Numerical problems. [8 hours]

Simple harmonic motion: Superposition of two perpendicular simple harmonic motions of equal frequency- Lissajous' figures. Equation for damped vibrations. Forced vibration-solution in exponential form. Resonance-expression for amplitude and phase at resonance. Numerical problems. [5 hours]

Analysis of complex waves: Fourier theorem. Evaluation of Fourier co-efficients. Analysis of square wave and saw tooth wave. [3 hours]

Part – B

Acoustics: Noise and music, limits of human audibility, intensity and loudness, bel and decibel, the acoustics of halls, absorption coefficient, Reverberation and reverberation time, Sabine's reverberation formula (derivation), Factors affecting acoustics in buildings, requisites for good acoustics. Ultrasonics: properties, production of ultrasonic waves-piezoelectric method, detection of ultrasonic waves. Determination of velocity of ultrasonic waves in liquids-acoustic grating. Applications of ultrasonics. Numerical problems. [8 hours]

Velocity of light: Kerr cell, Kerr effect. Determination of velocity of light by Kerr cell method. Numerical problems. [2 hours]

Interference: Review of basic concepts, coherent sources. Interference by division of wave front – theory of Fresnel's biprism, Interference by division of amplitude-thin films of uniform thickness-antireflective coatings, Newton's rings. Interference at a wedge. Michelson's interferometer - Measurement of λ and dλ. Numerical problems. [6 hours]

Part – C

Diffraction: Fresnel and Fraunhofer diffraction. Explanation of rectilinear propagation of light. Theory of the zone plate. Comparison with a convex lens. Fresnel diffraction at a straight edge. Fraunhofer diffraction at a single slit. Transmission grating-theory for the case of normal incidence, Resolving power and dispersive power of plane grating. Numerical problems. [8 hours]

Polarization: Double refraction in uniaxial crystals. Huygen's theory. Positive and negative crystal. Principal refractive indices. Huygen's constructions of O and E wave fronts in a uniaxial crystal – (i) optic axis in the plane of incidence and parallel to the crystal surface at normal incidence, (ii) optic axis in the plane of incidence and perpendicular to the crystal surface at normal incidence. Retarding plates. Production and analysis of linearly, Circularly and elliptically polarized light. Optical activity, Fresnel's theory of rotatory polarization. Interference of polarized light-expression for resultant intensity, calculation of thickness of wedge-shaped crystal plate (negative and positive), calculation of fringe width. Numerical problems. [8 hours]

References:

1. Halliday, D., Resnick, R., & Walker, J. (2014). *Fundamentals of physics* (10th ed.). Wiley. United States.
2. Subrahmanyam, N., & Lal, B. (2018). *Waves and oscillations* (2nd ed.). Vikas Publishing House. India.
3. Mittal, P. K., & Anand, J. D. (2007). *A textbook of sound*. Har-Anand Publications. India.
4. Kalsi, H. S. (2012). *Electronic instrumentation* (3rd ed.). McGraw-Hill Education India. India.
5. Bhattacharya, A. B., & Bhattacharya, R. (2020). *Undergraduate physics: Volume I*. The Info Library. India.
6. Subrahmanyam, N., Lal, B., & Avadhanulu, M. N. (2006). *A textbook of optics* (24th rev. ed.). S. Chand & Company Ltd. India.
7. Khanna, D. R., Gulati, H. R., & Kumar, A. (2021). *Fundamentals of optics* (15th ed.). R. Chand & Co. India.
8. Murugeshan, R., & Sivaprasath, K. (2010). *Optics and spectroscopy* (17^{th} rev. ed.). S. Chand & Company Ltd. India.

III Semester BSc Physics Practicals

PHY302 (Major) : Physics Practicals 3

Course Duration: 16 weeks with 4 hours of lab work per week.

Any EIGHT of the following experiments:

1. Kundt's tube experiment – velocity of sound in air at room temperature.
2. Study of stationary wave on a stretched string – Determination of speed of the transverse waves over the sonometer wire.
3. Newton's rings – Determination of radius of curvature of a plano convex lens.
4. Air wedge – Determination of thickness of a thin paper/diameter of a thin wire.
5. Helmholtz resonator – Determination of frequency of a tuning fork.
6. Diffraction grating – Determination of grating constant and wave length (minimum deviation method).
7. Diffraction at a straight wire – Determination of diameter of a wire.
8. Cauchy's constants using spectrometer.
9. Polarization – Determination of unknown concentration of sugar solution by graphical method using a polarimeter.
10. Determination of refractive indices of calcite and quartz crystal using spectrometer and sodium light.
11. To determine dispersive power and resolving power of a plane diffraction grating.
12. To determine wavelength of sodium light using Fresnel biprism.

III Semester B.Sc Physics Syllabus

PHY303 (Elective): Analog and Digital Electronics

(Course duration: 16 weeks with 3 hours of instruction per week)

(This paper should not be offered to students studying Electronics Major)

Part – A

Semiconductors: concept of bands in solids, energy level diagram. Effect of temperature on semiconductors. Intrinsic and extrinsic semiconductors. Concept of doping. P and N type semiconductors with examples. Majority and minority charge carriers, PN junction, properties of PN junction-depletion region, biasing a PN junction-forward bias and reverse biased PN junction diode. V-I characteristics of PN junction diode. PN junction fabrication. [8 hours]

Semiconductor diode applications: Rectifier diode, half-wave rectifier. Centre-tapped and bridge full-wave rectifiers, calculation of ripple factor and rectification efficiency, filters, Zener diode and voltage regulation. Principle, structure and characteristics of LED, photodiode and solar cell, qualitative idea of Schottky diode and tunnel diode. [8 hours]

Part – B

Transistors: N-P-N and P-N-P Transistors. I-V characteristics of CB and CE configurations. Active, cutoff and saturation regions. Current gains α and β. Relations between α and β. Load line analysis of transistors. DC load line and Q-point. Physical Mechanism of current flow. FET, UJT working and its characteristics. [8 hours]

Amplifiers: h-parameters A.C. equivalent circuit of a transistor in terms of the h-parameters. Derivation of the expressions for voltage gain. Current gain, power gain, input resistance and output resistance for CE mode. [4 hours]

Oscillators: Positive and negative feedback. Barkhausen's criterion for self-sustained oscillations. RC phase shift oscillator, determination of frequency. Hartley oscillator. [4 hours]

Part – C

Digital circuits: Difference between analog and digital Circuits. Binary Numbers. Decimal to binary and binary to decimal conversion, AND, OR and NOT Gates. NAND and NOR gates as Universal gates. XOR and XNOR Gates. De Morgan's theorems. Boolean laws. Simplification of logic circuit using Boolean Algebra. Binary addition. Binary subtraction using 2's complement method.

[8 hours]

Combinational & sequential circuits: Half adder, full adder using basic gates & Ex-OR gates, RS and JK flip flop (clocked version). [3 hours]

Analog to digital converters: Counter comparator ADC, successive approximation type ADC. [3 hours]

Digital to analog converters: Weighted resistor DAC, Resistor ladder DAC.

[2 hours]

References:

1. Mehta, V. K., & Mehta, R. (2020). *Principles of electronics* (12th ed., Low Priced Student Edition). S. Chand & Company Pvt. Ltd. India.
2. Malvino, A. P. (2008). *Electronic principles* (5th ed.). Tata McGraw-Hill. India.
3. Leach, D. P., Malvino, A. P., & Saha, G. (2015). *Digital principles and applications* (8th ed., 2nd reprint). McGraw Hill Education. India.
4. Theraja, B. L., & Sedha, R. S. (2015). *Principles of electronic devices and circuits (analysis and digital)* (Rev. ed.). S. Chand & Company Ltd. India.
5. Bapat, Y. N. (2012). *Electronic circuits and systems*. Tata McGraw-Hill. India.
6. Mottershead, A. (2013). *Electronic devices and circuits*. Prentice Hall of India Ltd. India.
7. Jain, R. P. (2015). *Modern digital electronics* (4th ed., 14th reprint). McGraw Hill Education. India.
8. Ryder, J. D. (2004). *Electronics: Fundamentals and applications*. Prentice Hall. United States.
9. Millman, J., & Halkias, C. C. (2010). *Integrated electronics: Analog and digital circuits and systems* (2nd ed.). McGraw-Hill Education (India).
10. Streetman, B. G., & Banerjee, S. K. (2009). *Solid state electronic devices* (6th ed.). PHI Learning Pvt. Ltd. India.
11. Salivahanan, S., & Kumar, N. S. (2012). *Electronic devices and circuits* (3rd ed.). Tata McGraw-Hill. India.
12. Sze, S. M. (2002). *Semiconductor devices: Physics and technology* (2nd ed.). Wiley India. India.

IV Semester B.Sc Physics Syllabus

PHY401 (Major) : Electricity and Electromagnetism

(Course duration: 16 weeks with 3 hours of instruction per week)

Part – A

Electrostatics: Mechanical force and electric pressure on a charged surface. The path traced by a charged particle in an electric field. The attracted disc electrometer-construction, theory and applications. Numerical problems.

[4 hours]

Galvanometers: Moving coil galvanometer-construction, theory, damping correction, current sensitivity and charge sensitivity. Helmholtz galvanometer – Theory. Numerical Problems. [4 hours]

Thermo-electricity: Seebeck, Peltier and Thomson effects. Thermodynamic theory of thermoelectric effect. The law of intermediate metals and the law of intermediate temperatures. Thermocouple. Numerical Problems. [4 hours]

Network Theorems: Mesh analysis circuits using Kirchoff's voltage law and Kirchoff's current law. Statement and proof of Thevenin's theorem and Norton's theorem. Numerical problems. [4 hours]

Part – B

Alternating current: R.M.S. values. Response of LR, CR and LCR circuits to sinusoidal voltages (discussion using the 'j' symbols). Series and parallel resonance-half-power frequencies, band-width and Q-factor. Power in electrical circuits- power factor. Maximum power transfer theorem for ac circuits. Numerical problems. [8 hours]

Applications of ac circuits: ac bridges – Anderson's bridge, Maxwell's bridge, desauty bridge, Robinson's bridge. Numerical problems. [4 hours]

Electrical measurement: CRO–construction & working. Measurement of voltage, frequency and phase using a CRO. [2 hours]

Filters: High-pass and low-pass filters with RC combination. Expression for cut-off frequency. Numerical problems. [2 hours]

Part – C

Electromagnetism: Scalar and vector fields. The gradient of a scalar field. The divergence and curl of a vector field. The physical significance of gradient, divergence and curl. Statement and physical significance of Gauss and Stokes theorems. Numerical Problems. [4 hours]

Electromagnetic theory: Review of basic concepts. Equation of continuity, Maxwell's modification of Ampere circuital law- displacement current. Setting up of Maxwell's field equations. Maxwell's field equations in free space, Poynting vector (definition). Wave equation for the field vectors in free space and in isotropic dielectric. Energy density of electromagnetic wave and Poynting Theorem (Proof). Plane monochromatic electromagnetic waves – transverse nature. Helmholtz equation. Characteristic impedance of free space. Numerical Problems. [10 hours]

Production of electromagnetic waves: Accelerated charges and oscillating dipole. Hertz's experiment. Radiation loss - synchrotron radiation. [2 hours]

References:

1. Halliday, D., Resnick, R., & Walker, J. (2014). *Fundamentals of physics* (10th ed.). Wiley. United States.
2. Laud, B. B. (2010). *Electromagnetics* (2nd ed.). New Age International. India.
3. Griffiths, D. J. (2023). *Introduction to electrodynamics* (5th ed.). Cambridge University Press. United Kingdom.
4. Hayt, W. H., & Buck, J. A. (2018). *Engineering electromagnetics* (9th ed.). McGraw-Hill Education. United States.
5. Mehta, V. K., & Mehta, R. (2020). *Principles of electronics* (12th ed., Low Priced Student Edition). S. Chand & Company Pvt. Ltd. India.
6. Subrahmanyam, N., & Lal, B. (1999). *Electricity and magnetism* (9th ed.). Ratan Prakashan Mandir. India.
7. Bhattacharya, A. B., & Bhattacharya, R. (2008). *Undergraduate physics: Volume II*. New Central Book Agency, India.
8. Vasudeva, D. N. (2022). *Fundamentals of magnetism and electricity*. S. Chand & Company, India.
9. Tewari, K. K. (2007). *Electricity and magnetism* (Rev. ed.). S. Chand and Company, India.
10. Brij Lal, & Subrahmanyam, N. (2016). *A textbook of electricity and magnetism* (19th ed.). Ratan Prakashan Mandir, India.

IV Semester B.Sc Physics Practicals

PHY402 (Major) : Physics Practicals 4

Course Duration: 16 weeks with 4 hours of lab work per week.

Any EIGHT of the following experiments:

1. Anderson's Bridge – Determination of the self-inductance of the coil.
2. de-Sauty bridge – Verification of laws of combination of capacitances.
3. Variation of thermo-emf across two junctions of a thermocouple with temperature.
4. High resistance by leakage.
5. B_H using Helmholtz double coil galvanometer and potentiometer.
6. Capacity of a condenser using a BG.
7. LCR series circuit – Determination of L & Q factor.
8. Voltage triangle – Measurement of phase difference.
9. RC Low and High pass filters – Determination of the cut-off frequency.
10. LCR parallel circuit – Determination of L & Q factor.
11. To study the variation of X_C with f and determination of C.
12. CRO- determination of voltage and frequency.

IV Semester B.Sc Physics Syllabus

PHY403 (Elective): Communication Systems, Laser and Fibre optics

(Course duration: 16 weeks with 3 Hours of instruction per week)

Part – A

Signal & noise: Distinction between signal and noise. Signal to noise ratio and its importance in communication. [3 hours]

Electro-acoustic transducers: Microphone types- Carbon, Moving coil, condenser and ribbon microphones, sensitivity, directivity, phasing and testing. [6 hours]

Loudspeakers: Direct radiator dynamic type, expression for efficiency, radiated output power, horn loudspeaker, cutoff frequency, measurement of acoustic power and pressure response of a speaker. Numerical Problems. [7 hours]

Part – B

Laser basics: Coherence properties of laser light, temporal coherence, monochromaticity, spatial coherence, directionality, line width, brightness, divergence, line shape broadening, focusing properties of laser radiation, laser modes, axial and transverse, mode selection, single mode operation, selection of laser emission line. [5 hours]

Laser oscillator: Pumping schemes, gain, threshold conditions; optical resonators. Numerical problems. [3 hours]

Types of lasers: Construction and principles of working of Nd-YAG, CO_2 and dye lasers and semiconductor laser. [4 hours]

Laser diodes: Lasing conditions and gain in a semiconductor, selective amplification and coherence, materials for laser diodes, quantum well lasers, surface emitting lasers, characterization and modulation of lasers. Numerical problems. [4 hours]

Part – C

Fibre optics and dielectric wave guides: Waveguide – slab wave guide, modes, V number, modal material and waveguide dispersions, Numerical problems. [3 hours]

Optical fibre: Types, functions, light propagation, optical power, velocity of propagation, critical angle, acceptance angle, numerical aperture, mode of propagation. Numerical problems. [4 hours]

Index profile: Single mode step-index optical fibre, multimode step-index fibre, graded index fibre; advantages and disadvantages. Numerical problems. [3 hours]

Energy losses in optical fibre: Bit rate, dispersion optical fibre communication, and optical bandwidth, absorption and scattering, optocoupler. [6 hours]

References:

1. Roddy, D., & Coolen, J. (2008). *Electronic communications* (4th ed.). Pearson Education. India.
2. Tomasi, W. (2004). *Electronic communications systems: Fundamentals through advanced* (5th ed.). Pearson Education. India.
3. Kennedy, G., Davis, B., & Prasanna, S. R. M. (2011). *Kennedy's electronic communication systems* (5th ed.). McGraw-Hill Education. India.
4. Kinsler, L. E., Frey, A. R., Coppens, A. B., & Sanders, J. V. (2000). *Fundamentals of acoustics* (4th ed.). Wiley. United States.
5. Wilson, J., & Hawkes, J. F. B. (1998). *Optoelectronics: An introduction* (3rd ed.). Prentice Hall. United Kingdom.
6. Singh, J. (1996). *Optoelectronics: An introduction to materials and devices*. McGraw-Hill. United States.
7. Bhattacharya, P. (1997). *Semiconductor optoelectronic devices* (2nd ed.). Prentice Hall. United States.
8. Nambiar, K. R. (2004). *Lasers: Principles, types and applications*. New Age International. India.
9. Ghatak, A. K., & Thyagarajan, K. (2017). *An introduction to fiber optics* (Reprint ed.). Cambridge University Press. India.

IV Semester B.Sc Physics Syllabus

Compulsory (Practical Knowledge/Skill)

PHY404 (Practical) : Analog and Digital Electronics

(Course duration: 16 weeks with 4 Hours of instruction per week)

(This paper should not be offered to students studying Electronics Major)

Any EIGHT of the following experiments:

1. PN junction diode characteristics.
2. Zener diode characteristics and Zener diode as voltage regulator.
3. Transistor characteristics (CE mode).
4. Transistor characteristics (CB mode).
5. Phase shift oscillator.
6. CE Amplifier gain and bandwidth.
7. Hartley oscillator.
8. Negative feedback amplifier.
9. Basic logic gates using transistors.
10. Logic gates-AND, OR, NOT, NOR, and XOR using IC 7400 and 7402.
11. Bridge rectifier with C and Pi filter.
12. FET characteristics.
13. Half adder.
14. Full adder.

I, II, III & IV Semester Physics (Major) Question Paper Pattern

Max. Marks: 80 Time: 3 hours

PART – A

Answer any TWO of the following 2 x 10 = 20

(3 Long answer questions with two sub questions each (5+5/6+4)). Each question carrying 10 Marks to be asked from PART A.)

PART – B

Answer any TWO of the following 2 x 10 = 20

(3 Long answer questions with two sub questions each (5+5/6+4)). Each question carrying 10 Marks to be asked from PART B.)

PART – C

Answer any TWO of the following 2 x 10 = 20

(3 Long answer questions with two sub questions each (5+5/6+4)). Each question carrying 10 Marks to be asked from PART C.)

PART – D

Answer any FOUR of the following 4 x 5 = 20

(6 Numerical problems of 5 marks each, 2 from each PART to be asked.)

III & IV Semester Physics (Elective) Question Paper Pattern

Max. Marks: 80 Time: 3 hours

PART – A

Answer any TWO of the following 2 x 10 = 20

(3 Long answer questions with two sub questions each (5+5/6+4)). Each question carrying 10 Marks to be asked from PART A.)

PART – B

Answer any TWO of the following 2 x 10 = 20

(3 Long answer questions with two sub questions each (5+5/6+4)). Each question carrying 10 Marks to be asked from PART B.)

PART – C

Answer any TWO of the following 2 x 10 = 20

(3 Long answer questions with two sub questions each (5+5/6+4)). Each question carrying 10 Marks to be asked from PART C.)

PART – D

Answer any TEN of the following 10 x 2 = 20

(12 concept-based questions/problems of 2 marks each, 4 from each PART to be asked.)

Scheme of valuation for practical (Major & compulsory practical/skill paper)

C1 and C2 are internal tests to be conducted during 8th and 16th Weeks respectively of the semester. C3 is the semester-end examination conducted for 3 hours. The student will be evaluated on the basis of skill, comprehension and recording the results.

The student has to compulsorily submit the practical record for evaluation during C1 and C2. For C3, the record has to be certified by the Head of the Department.

The student is evaluated for 40 marks in C1, C2 and C3 as per the following scheme:

Component	Marks(C1)	Marks(C2)	Marks(C3)
Formula with proper units and explanation	5	5	5
Setting up the apparatus / circuit connections	5	5	5
Taking readings and tabulating	5	5	10
Calculations	5	5	5
Graph and accuracy of results	5	5	5
Record	5	5	--
Viva	10	10	10
Total	**40**	**40**	**40**
Reduced to	**5**	**5**	