INVERTIS UNIVERSITY BAREILLY

Syllabus

Of

Pre-Ph.D. Course Work

In

Physics

Department of Physics
Invertis Institute of Humanities & Applied Sciences

INVERTIS UNIVERSITY
Invertis Village
Bareilly-Lucknow NH-24, Bareilly-243123, India

DPY-191 GENERAL PHYSICS

Mathematical Physics

Legendre equation: Generating function, recurrence relations and special properties, Orthogonally, Legendre polynomials. Bessel function of first and second kind, Generating function, recurrence relations for Bessel's functions Linear differential equation of first and second order and its applications (Electrical Circuits, SHM, Simple pendulum and oscillations of spring- free, forced and damped), Partial differential equations and its applications (Laplace, wave and heat equations).

Classical Mechanics

Newton's Laws and their meaning, simple applications conservation laws, Constraints and constraint forces, Principle of virtual work and D'Alembert's principle, Lagrange's equations, Integrals of motion, Rotating frames of reference and terrestrial applications.

Quantum Mechanics

Origin of quantum mechanics, de-Broglie matter waves, Phase and Group velocities, Davisson-Germer experiment, Heisenberg uncertainty principle and its applications, Wave function and its significance, Schrödinger's wave equation, Motion of particle in one dimensional box: Normalisation of wave function, Energy Eigen value of a particle.

Recommended Books:

1. Artken & Weber, *Mathematical methods for Physicist*, Academic Press- N.Y.
2. J. W. Brown, R.V .Churchill, *Complex Variables and Applications,* Mc-Graw Hill.
3. Classical Mechanics – Rana – Joag. TMH.
4. Mathematical Methods of Classical Mechanics – V. I. Arnold. Springer.
5. Quantum Mechanics: L.I. Schiff (McGraw Hill)
6. P. M. Mathews and K. Venkatesan, *A Text-book of Quantum Mechanics,* Tata mcgraw- Hill.

DPY 192 (1 to 9) PHYSICS: OPTIONAL

Note: Student has to choose one of the following papers. There is provision to add more optional papers subject to the availability of manpower in concerned field.

1. Atoms and Molecules
2. Classical Mechanics
3. Electrodynamics
4. Mathematical Methods in Physics
5. Nuclear Physics
6. Quantum Mechanics
7. Statistical Mechanics
8. Solid State Physics
9. Electronics

ATOMS AND MOLECULES

Quantum states of an electron in an atom; Electron spin; Stern-Gerlach experiment;

Spectrum of Hydrogen, helium and alkali atoms;

Relativistic corrections for energy levels of hydrogen; Hyperfine structure and isotopic shift; width of spectral lines; LS & JJ coupling; Zeeman, Paschen Back & Stark effect;

X-ray spectroscopy; Electron spin resonance, Nuclear magnetic resonance, chemical shift;Rotational, vibrational, electronic, and Raman spectra of diatomic molecules; Frank – Condon principle and selection rules;

Spontaneous and stimulated emission, Einstein A & B coefficients; Lasers, optical pumping, population inversion, rate equation; Modes of resonators and coherence length.

Books:

1. Quantum Physics of Atoms, Molecules, Solids, Nuclei and particles by R. Eisberg and R. Resnick (John Wiley)
2. The elements of Physical Chemistry by Atkins (Oxford)
3. Quantum Chemistry, by I. N. Levine (Prentice Hall)
4. Atomic and Molecular Physics by H. E. While (East-West Press).

CLASSICAL MECHANICS

Newton's Laws and their meaning, simple applications conservation laws, Constraints and constraint forces, Principle of virtual work and D'Alembert's principle, Lagrange's equations, Integrals of motion.

Rotating frames of reference, terrestrial applications.

Central forces, Conservation of energy and angular momentum, Characteristics of resulting motion, Characteristics of bounded orbits, Kepler problem, planetary orbits, Kepler equation, Conservation of electricity vector, Rutherford scattering formula, Conserved qualities.

Legendre transformations and Hamilton's equations, Phase portraits of simple systems.

Principle of least action, Hamilton's principle, Noether's theorem, Hamilton's principal and characteristics functions.

Canonical transformations, Generating functions examples.

Hamilton – Jacobi theory, H-J equation, Connection with CT, Examples, Actionangle variables.

Stable and unstable equilibrium, Small oscillations, Normal mode analysis, Normal coordinates.

Rigid body dynamics, Euler's theorem, Moment of Inertia calculations and theorems, Euler's equations of motion, Symmetric top.

Books –

a) Classical Mechanics – Rana – Joag. TMH
b) Mathematical Methods of Classical Mechanics – V. I. Arnold. Springer.

ELECTRODYNAMICS

Electrostatics: Coloumb's law, Gauss's law, Electrostatic potential energy Poisson and Laplace's equations, Boundary value problems

Magnetostatics: Biot Savart's law, Ampere's law, Magnetostatic potential energy Multipole expansions of potentials, Linear dielectric and linear magnetic materials

Motion of a charged particle in uniform, static, electric, magnetic and combined fields

Time varying fields, Faraday's law, Maxwell's displacement current, Maxwell's equations, Poynting's theorem

Wave equations, Electromagnetic plane waves, Linear, circular and elliptic polarization Reflection and refraction of plane waves.

Books:

1. J. D. Jackson - Classical Electrodynamics
2. D. J. Griffiths – Introduction to Electrodynamics
3. J. R. Reitz, F. J. Milford, W. Christy – Foundations of Electromagnetic Theory

MATHEMATICAL METHODS OF PHYSICS

Vector calculus; Vector spaces, Linear transformations, Self-adjoint and unitary transformations, Inner product, orthogonality and completeness, matrices, similarity transformations, Eigenvalues and Eigenvectors of Hermitian and Unitary transformations, diagonalization using analytical and numerical methods

Linear differential equations and introduction to Special functions (Hermite, Bessel, Laguerre and Legendre); Solutions of differential equations using numerical techniques like Runge-Kutta method and other predictor-corrector methods

Fourier series, Fourier and Laplace transforms; Numerical evaluation

Elements of complex analysis: Cauchy-Riemann conditions, Laurent series-poles, residues and evaluation of integrals.

Books:

1. Complex Analysis by Churchil
2. Mathematical Methods for Physicist by Arfken and Weber
3. Finite dimensional Vectror Spaces, P. Halmos
4. Mathematics of Classical and Quantum Physics by F. W. Byron and R.. W. Fuller

NUCLEAR AND PARTICLE PHYSICS

Basic nuclear properties: size, shape, charge distribution, spin and parity; Binding energy, semiempirical mass formula; Liquid drop model

Fission and fusion; Nature of the nuclear force, form of nucleon-nucleon potential; Charge in dependence and charge-symmetry of nuclear forces; Isospin

Deuteron problem; Evidence of shell structure, single- particle shell model, its validity and limitations; Rotational spectra

Elementary ideas of alpha, beta and gamma decays and their selection rules

Nuclear reactions, reaction mechanisms, compound nuclei and direct reactions; Classification of fundamental forces

Elementary particles (quarks, baryons, mesons, leptons); Spin and parity assignments, isospin, strangeness; Gell-Mann-Nishijima formula; C, P, and T invariance and applications of symmetry arguments to particle reactions, parity non-conservation in weak interaction; Relativistic kinematics.

Books:

1. Concepts of Nuclear Physics, B. L. Cohen (Tata McGraw Hill)
2. Nuclear Physics - An Introduction, S. B. Patel
3. Subatomic Physics, Frauenfelder and Hanley (Prentice-Hall)
4. Nuclear Physics, I. Kaplan
5. Nuclei and Particles, Emilio Segre
6. Nuclear Radiation Detectors, S. S. Kapoor, V. S. Ramamurthy
7. Techniques for Nuclear and Particle Physics Experiments, W R Leo
8. Radiation Detection and Measurement, G F Knoll

QUANTUM MECHNAICS

One dimensional problems: potential wells, steps and barriers, Harmonic oscillator, Hydrogen Atom, Spherically symmetric potentials: Bound States and scattering, Partial wave method, the Born approximation, Time-independent and Time-dependent perturbation theory, WKB approximation, Symmetry in Quantum Mechanics, Identical particles and spin.

Quantization of the electromagnetic field in the Transverse gauge, Kramers-Heisenberg formula with applications to Thomson, Raleigh and Raman scattering.

Elementary introduction to relativistic quantum mechanics: the Klein Gordon and Dirac equations, Interpretations; Antiparticles.

Books:

1. Quantum Mechanics: L.I. Schiff (McGraw Hill)
2. Quantum Mechanics: A.S. Davydov (Pergamon)
3. Quantum Mechanics: Cohen-Tannaudji *et al.* (Wiley VCH)
4. Modern Quantum Mechanics: J.J. Sakurai (Addison-Wesley)
5. Relativistic Quantum Mechanics: J. Bjorken and S. Drell (McGraw Hill).
6. Advanced Quantum Mechanics, J. J. Sakurai (Addison-Wesley)
7. Relativistic Electron Theory, M. E. Rose (John-Wiley & Sons).
8. Quantum Electrodynamics, R. P. Feynman (Benjamin Cummings).
9. Lectures on Quantum Mechanics, G. Baym (Benjamin).
10. Quantum Field Theory, L. Ryder (Academic).

STATISTICAL MECHANICS

Probability distribution functions: Binomial, Gaussian, Poisson distribution functions, Probability density, probability for continuous variables. Brownian motion using 1-d Langevin equation, calculation of mean square displacement (MSD)

Maxwell-Boltzmann gas velocity and speed distribution, Chemical potential, Free energy and connection with thermodynamic variables, First and Second order phase transition; phase equilibrium.

Maxwell-Boltzmann, Bose-Einstein, Fermi-Dirac gases, Statistics of occupation numbers, Evaluation of partition functions, Ideal gases in the classical limit.

Thermodynamics of Black body radiation, Stefan-Boltzmann law, Wien's displacement law, Specific heat of solids (Einstein and Debye models).

Ideal Fermi System: Thermodynamic behavior of an ideal Fermi gas, degenerate Fermi gas, Fermi energy and mean energy, Fermi temperature, Fermi velocity of a particle of a degenerate gas.

Books:

1. *Fundamentals of Statistical and Thermal Physics,* F. Reif (International Student Ed.) McGraw Hill.
2. *Statistical Mechanics*, K. Huang, John Wiley & Sons, 2nd Ed.
3. *Statistical Mechanics,* R. K. Pathria, (Pergamon Press).
4. *Fundamentals of Statistical Mechanics,* B. B. Laud, (New Age International Edition).
5. *Heat and Thermodynamics*, by Mark W. Zemansky and Richard H. Dittman (McGraw Hill)
6. *Statistical Physics*. (Vol. V) by Frederick Reif and R. A. Sevenich (Berkeley Physics Course)
7. *Statistical Mechanics* (Parts I and II) by. L. D. Landau and E. M. Lifshitz .
8. *Statistical Mechanics* (Frontiers in Physics) by Richard P. Feynman
9. *Thermodynamics and Statistical Physics* by P. V. Panat (Narosa)

SOLID STATE PHYSICS

Superconductivity

Temperature dependence of resistivity in superconducting materials, Effect of magnetic field (Meissner effect), Type I and Type II superconductors, Temperature dependence of critical field, London's Equation and Penetration Depth, Idea of BCS theory (Qualitative), High temperature superconductors, Characteristics of superconductors in superconducting state, Applications of Super-conductors Electrodynamics of superconductors, tunnelling and Josephson effect.

Nano materials

Quantum Wells, Wires and Dots, Preparation of Quantum Nanostructure, Size and Dimensionality effect, Fermigas, Potential wells, Partial confinement, Excitons, Single electron Tunneling, Infrared detectors, Quantum dot laser Superconductivity.

Magnetic ordering, anisotropy, Thermal excitations of Magnons, Spin waves, FMR and NMR, Magnetoresistance effect, Spintronics.

Thermodynamics and ferroelectric domain formation, Piezoelectric effect, Multiferroics.

Books.

1. Introduction to Solid State Physics by C Kittel
2. Solid State Physics by N W Ashcroft and N D Mermin
3. Solid State Physics by A.J. Dekker

ELECTRONICS

Network Theorems:

Thevenin, Norton, Superposition, and Maximum power transfer theorem

Digital Circuits

Logic gates; Half adder; Full adder; Comparators; Decoders; Multiplexers; Demultiplexers; Design of combinational circuits; Sequential circuits; Flip Flops; Counters; Registers; A/D and D/A conversion characteristics.

Modulation

Amplitude Modulation, Spectrum of the modulated signal, Limitations of Amplitude Modulation. Frequency Modulation **,** Analysis and frequency Spectrum, Generation and Detection of FM, Comparison of AM and FM. Digital Communication**,** Digital Line Waveforms, Pulse Modulation: Pulse Amplitude, Pulse Code, Pulse Frequency, Pulse Time, Pulse Position and Pulse Width Modulation; Differential PCM; Delta Modulation, Digital Communication Systems, Digital Carrier System, Frequency Shift Keying, Digital Multiplexing.

Fiber Optic Communication

Fundamental ideas about optical fiber, Types of fibers, Acceptance angle and cone, Numerical aperture, Propagation mechanism and communication in optical fiber, Attenuation, Signal loss in optical fiber and dispersion.

Books:

1. Analog & Digital by R.P. Sing and S.D. Sapre, *Communication Systems*, Tata mcgraw Hill.
2. G. Kennedy and B. Davis, *Electronic Communication Systems*, Tata mcgraw Hill.
3. Milman J. And Halkias C.C., *Electronic Devices and Circuits,* Tata McGraw Hill.
4. Malvino A.P., *Electronic Principles,* Tata McGraw Hill.
5. Malvino and Leach, *Digital Electronics,* Tata McGraw Hill.