UNIVERSITY OF CALCUTTA

SYLLABI

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THREE-YEAR HONOURS AND GENERAL
DEGREE COURSES OF STUDIES

PHYSICS

2010

Honours

Part – I

1st year : **Paper I (100 Marks)**
Unit-01: 50 Marks- Mathematical Methods I & Mathematical Methods II
Unit-02: 50 Marks- Waves and Optics I & Electronics I
Paper IIA (50 Marks)
Unit-03: 50 Marks- Classical Mech.I & Thermal Physics I
Paper IIB (50 Marks)
Unit-04: 50 Marks- Laboratory

Part – II

2nd year : **Paper III (100 Marks)**
Unit-05: 50 Marks- Electronics II & Electricity and Magnetism
Unit-06: 50 Marks- Electrostatics & Waves and Optics II
Paper IVA (50 Marks)
Unit-07: 50 Marks- Quantum Mech.I & Thermal Physics II
Paper IVB (50 Marks)
Unit-08: 50 Marks- Laboratory

Part – III

3rd year : **Paper V (100 Marks)**
Unit-09: 50 Marks- Classical Mechanics II & Special Theory of Relativity
Unit-10: 50 Marks- Quantum Mech.II & Atomic Physics
Paper VI (100 Marks)
Unit- 11: 50 Marks- Nuclear and Particle Physics I & Nuclear and Particle Physics II
Unit- 12: 50 Marks- Solid State Physics I & Solid State Physics II
Paper VIIA (50 Marks)
Unit- 13: 50 Marks- Statistical Mechanics & Electromagnetic Theory
Paper VIIB (50 Marks)
Unit- 14: 50 Marks- Laboratory
Paper VIIIA (50 Marks)
Unit- 15: 50 Marks- Laboratory
Paper VIIIB (50 Marks)
Unit- 16: 50 Marks- Computer laboratory

Paper I

Unit - I

MATHEMATICAL METHODS I (25 Marks) **LECTURES: 25 + 5 Tutorial**

1. Preliminary Topics

Infinite sequences and series - convergence and divergence, conditional and absolute convergence, ratio test for convergence. Functions of several real variables - partial differentiation, Taylor's series, multiple integrals. Random variables and probabilities - statistical expectation value, variance; Analysis of random errors: Probability distribution functions (Binomial, Gaussian, and Poisson) (10)

2. Vector Analysis

Transformation properties of vectors; Differentiation and integration of vectors; Line integral, volume integral and surface integral involving vector fields; Gradient, divergence and curl of a vector field; Gauss' divergence theorem, Stokes' theorem, Green's theorem - application to simple problems; Orthogonal curvilinear co-ordinate systems, unit vectors in such systems, illustration by plane, spherical and cylindrical co-ordinate systems only. (10)

3. Matrices

Hermitian adjoint and inverse of a matrix; Hermitian, orthogonal, and unitary matrices; Eigenvalue and eigenvector (for both degenerate and non-degenerate cases); Similarity transformation; diagonalisation of real symmetric matrices. (5)

MATHEMATICAL METHODS II (25 Marks) **LECTURES 25 + 5 Tutorial**

1.Ordinary Differential Equations

Solution of second order linear differential equations with constant coefficients and variable coefficients by Frobenius' method (singularity analysis not required); Solution of Legendre and Hermite equations about x=0; Legendre and Hermite polynomials - orthonormality properties. (7)

2. *Partial Differential Equations*

Solution by the method of separation of variables; Laplace's equation and its solution in Cartesian, spherical polar (axially symmetric problems), and cylindrical polar (`infinite cylinder' problems) coordinate systems. (11)

3. Fourier Series

Fourier expansion – statement of Dirichlet's condition, analysis of simple waveforms with Fourier series. Introduction to Fourier transforms; the Dirac-delta function and its Fourier transform; other simple examples. Vibration of stretched strings- plucked and struck cases. (7)

Paper I

Unit-II

WAVES & OPTICS I (25 Marks) **LECTURES 25 + 5 Tutorial**

1. Linear Harmonic Oscillator

LHO. Free and forced vibrations. Damping. Resonance. Sharpness of resonance. Acoustic, optical, and electrical resonances: LCR circuit as an example of the resonance condition. A pair of linearly coupled harmonic oscillators --- eigenfrequencies and normal modes. (7)

2. Waves

Plane progressive wave in 1-d and 3-d. Plane wave and spherical wave solutions. Dispersion: phase velocity and group velocity. (5)

3. Fermat's principle

Fermat's principle and its application on plane and curved surfaces. (3)

4. *Cardinal points of an optical system*

Two thin lenses separated by a distance, equivalent lens, different types of magnification : Helmholtz and Lagrange's equations, paraxial approximation, introduction to matrix methods in paraxial optics – simple application. (5)

5. *Wave theory of light*

Huygen's principle; deduction of law of reflection and refraction. (5)

ELECTRONICS I (25 Marks) **LECTURES 25 + 5 Tutorial**

1. *Network*
Thevenin Theorem, Norton theorem, Maximum power transfer theorem, Superposition principle, T and Π networks. (3)

2. *Semiconductor diodes*:
p-n junction diode, I-V characteristics, Zener diode and its applications, optoelectronic diodes: LED, photo diodes. (2)

3. *Bipolar junction transistors (BJT)*
pnp and npn structures; active and saturation regions, characteristics of BJT, common emitter configuration, input and output characteristics, α and β of a transistor and their interrelation, common base configuration, output characteristics. Two port analysis of a transistor, definition of h-parameters, loadline concept, emitter follower, biasing methods, stability factor, low frequency model. Comparison of CB, CC and CE amplifiers. (6)

4. *Field effect transistors (FET)*
Classification of various types of FETs, construction of junction FET, drain characteristics, biasing, operating region, pinch-off voltage. MOSFET: construction of enhancement and depletion type, principle of operation and characteristics. Elementary ideas of CMOS and NMOS. (7)

5. *Digital electronics*
Boolean theorem, Boolean identities, OR, AND, NOT, NAND, NOR gates, Ex-OR, Ex-NOR gates, universal gate, de-Morgan's theorem, 1's and 2's complement, binary number addition, subtraction and multiplication, functional completeness, S-O-P and P-O-S representation, Karnaugh map.
(7)

Paper IIA
Unit-I

CLASSICAL MECHANICS I (25 Marks) **LECTURES: 25 + 5 Tutorial**

1. *Mechanics of a Single Particle*

Velocity and acceleration of a particle in (i) plane polar coordinates - radial and cross-radial components (ii) spherical polar and (iii) cylindrical polar co-ordinate system; Time and path integral of force; work and energy; Conservative force and concept of potential; Dissipative forces; Conservation of linear and angular momentum.

(7)

2. *Mechanics of a System of Particles*

Linear momentum, angular momentum and energy - centre of mass decompositon; Equations of motion, conservation of linear and angular momenta. (6)

3. *Rotational Motion*

Moment of inertia, radius of gyration; Energy and angular momentum of rotating systems of particles; Parallel and perpendicular axes theorems of moment of inertia; Calculation of moment of inertia for simple symmetric systems; Ellipsoid of inertia and inertia tensor; Setting up of principal axes in simple symmetric cases. Rotating frames of reference - Coriolis and centrifugal forces, simple examples. Force-free motion of rigid bodies - free spherical top and free symmetric top. (12)

THERMAL PHYSICS I (25 Marks) **LECTURES 25 + 5 Tutorial**

1.Kinetic Theory of Gases

Basic assumptions of kinetic theory, Ideal gas approximation, deduction of perfect gas laws. Maxwell's distribution law (both in terms of velocity and energy), root mean square and most probable speeds. Finite size of molecules : Collision probability, Distribution of free paths and mean free path from Maxwell's distribution. Degrees of freedom, equipartition of energy (detailed derivation not required). (8)

2.Transport Phenomena

Viscosity, thermal conduction and diffusion in gases. Brownian Motion: Einstein's theory, Perrin's work, determination of Avogardo number. (4)

3.Real Gases

Nature of intermolecular interaction : isotherms of real gases. van der-Waals equation of state, Other equations of state (mention only), critical constants of a gas, law of corresponding states; Virial Coefficients, Boyle temperature. (4)

4.Conduction of Heat

Thermal conductivity, diffusivity. Fourier's equation for heat conduction – its solution for rectilinear and radial (spherical and cylindrical) flow of heat. (3)

Radiation :

Spectral emissive and absorptive powers, Kirchoff's law, blackbody radiation, energy density, radiation pressure. Stefan-Boltzmann law, Newton's law of cooling, Planck's law (no detailed derivation). (6)

Paper III

Unit-I

ELECTRONICS II (25 Marks) **LECTURES 25 + 5 Tutorial**

1. *Amplifier*
   Voltage and current gain, principle of feedback, positive and negative feedback, advantages of negative feedback, multistage amplifier, frequency response of a two stage R-C coupled amplifier, gain and band width and their product, operating point of class A, amplifier, analysis of single tuned voltage amplifier, requirement of power amplifiers (4)

2. *Oscillators*
   Barkhausen criterion for sustained oscillation, L-C, Weinbridge and crystal oscillators, relaxation oscillators- monostable, bistable and astable multivibrators. (4)

3. *Operational amplifier*
   Properties of ideal OP-AMP, differential amplifiers, CMRR, inverting and non-inverting amplifiers, mathematical operations. (4)

4. *Combinational logic*
   Half adder, full adder, digital comparator, decoder, encoder (ROM), multiplexure (5)

5. *Sequential logic*
   Flip-flops- RS, D, JK, JKMS flip-flops, edge triggering. Shift register, ripple counter(binary and decade). (5)

6. *Communication principles*
   Modulation and demodulation – elementary theory of AM, FM and PM, demodulation of AM (diode detector) and FM (slope detector) waves.
   (3)

ELECTRICITY AND MAGNETISM (25 Marks) **LECTURES 25 + 5 Tutorial**

1. *Magnetic effect of steady current*
   Lorentz force and concept of magnetic induction; force on linear current element; Biot-Savart's law. $\nabla . \mathbf{B}=0$; magnetic vector potential; calculation of vector potential and magnetic induction in simple cases – straight wire, magnetic field due to small current loop; magnetic dipole; field due to a dipole; magnetic shell; Ampere's theorem; Ampere's circuital law – simple illustrations; force between long parallel current carrying conductors; $\nabla \times \mathbf{B} = \mu \mathbf{J}$; comparison between static electric and magnetic fields. (8)

2. *Field and magnetic materials*
   Free current and bound current; surface and volume density of current distribution; magnetisation; nonuniform magnetisation of matter; $\mathbf{J}_b = \nabla \times \mathbf{M}$; Ampere's law in terms of free current density and introduction of **H**; line integral of **H** in terms of free current; boundary conditions for **B** and **H**; permanently magnetized body; magnetic scalar potential; application of Laplace's equation to the problem of a magnetic sphere in uniform magnetic field; hysteresis and energy loss in ferromagnetic material; magnetic circuit; energy stored in magnetic field. (9)

3. *Electromagnetic induction*
   Faraday's and Lenz's law; motional e.m.f.-simple problems; inductances in series and parallel; reciprocity theorem LR, CR and LCR circuits- transient and sinusoidal emf cases, calculation of self and mutual inductance in simple cases. (8)

Unit-II

ELECTROSTATICS (25 Marks) **LECTURES 25 + 5 Tutorial**

1. *Units and dimensions*
   CGS, Gaussian and SI units; conversion between Gaussian and SI units; dimension of various quantities. **(SI system to be followed for the rest of the syllabus)** (2)

2. *Gauss' law*
   Coulomb's law of electrostatics, intensity and potential; Gauss' theorem – its application; Poisson and Laplace's equations; Superposition theorem (statement only). Application of Laplace's equation to simple cases of symmetric spherical charge distribution. (7)

3.Multipole expansion

Multipole expansion of scalar potential – monopole, dipole and quadrupole terms; potential and field due to a dipole; work done in deflecting a dipole; dipole-dipole interaction (for both electric and magnetic dipoles); force on dipole in a non-homogeneous field. (6)

4. Dielectrics
Polarisation, electric displacement vector (**D**); Gauss's theorem in dielectric media; boundary conditions; electrostatic field energy; computation of capacitance in simple cases (parallel plates); spherical and cylindrical capacitors containing dielectrics – uniform and non-uniform. (6)

5. Electrical Images
Solution of field problems in case of a point charge near a grounded conducting infinite plane. Boundary value problem : in uniform external field for (i) conducting spherical shell and (ii) dielectric sphere. (4)

WAVES & OPTICS II (25 Marks) **LECTURES 25 + 5 Tutorial**

1. *Interference of light waves*

Young's experiment; spatial and temporal coherence; intensity distribution; Fresnel's biprism, interference in thin film; fringes of equal inclination and equal thickness; Newton's ring. Michelson's interferometer. Multiple beam interference – reflected and transmitted pattern. Fabry-Perot interferometer. (9)

2. *Diffraction of light waves*

Fresnel and Fraunhofer class, Fresnel's half period zones; explanation of rectilinear propagation of light; zone plate. Fraunhofer diffraction due to a single slit, double slit and circular aperture (qualitative). Plane diffraction grating (transmission). Rayleigh criterion of resolution; resolving power of prism, telescope, microscope and transmission grating. (10)

3. *Polarisation*

Different states of polarisation; double refraction, Huygen's construction for uniaxial crystals; polaroids and their uses.
Production and analysis of plane, circularly and elliptically polarised light by retardation plates and rotatory polarisation and optical activity; Fresnel's explanation of optical activity; Biquartz and half shade polarimeter. (6)

Paper IVA

Unit-I

QUANTUM MECHANICS I (25 Marks) **LECTURES 25 + 5 Tutorial**

1. *Old quantum theory*

Planck's formula of black-body radiation. Photoelectric effect. Bohr atom and quantization of energy levels. (5)

2. *Basic quantum mechanics*

de Broglie hypothesis. Electron double-slit experiment. Compton effect, Davisson-Germer experiment, Heisenberg's uncertainty principle (statement) with illustrations. Concept of wave function as describing the dynamical state of a single particle. Group and phase velocities, classical velocity of a particle and the group velocity of the wave representing the particle. Principle of superposition. Schrodinger equation. Probabilistic interpretation; equation of continuity, probability current density. Boundary conditions on the wave function. (10)

3. Basic postulates of quantum mechanics

Dynamical variables as linear hermitian operators and eigenvalue equations, Momentum, energy and angular momentum operators. Measurement of observables, expectation values. Commutation relations between operators. Compatible observables and simultaneous measurements, Ehrenfest theorem. (10)

THERMAL PHYSICS II (25 Marks) **LECTURES 25 + 5 Tutorial**

1. *Basic Concepts*

Microscopic and macroscopic points of view : thermodynamic variables of a system, State function, exact and inexact differentials. (2)

2. *First Law of Thermodynamics*

Thermal equilibrium, Zeroth law and the concept of temperature. Thermodynamic equilibrium, internal energy, external work, quasistatic process, first law of thermodynamics and applications including magnetic systems, specific heats and their ratio, isothermal and adiabatic changes in perfect and real gases. (5)

3. *Second Law of Thermodynamics*

Reversible and irreversible processes, indicator diagram. Carnot's cycles-efficiency, Carnot's theorem. Kelvin's scale of temperature, relation to perfect gas scale, second law of thermodynamics – different formulations and their equivalence, Clausius inequality, entropy, change of entropy in simple reversible and irreversible processes, entropy and disorder; equilibrium and entropy principle, principle of degradation of energy. (9)

4. *Thermodynamic Functions*

Enthalpy, Helmholtz and Gibbs' free energies; Legendre transformations, Maxwell's relations and simple deductions using these relations; thermodynamic equilibrium and free energies. (4)

5. *Change of State*

Equilibrium between phases, triple point : Gibbs' phase rule (statement only) and simple applications. First and higher order phase transitions, Ehrenfest criterion. Clausius-Clapeyron's equation. Joule-Thomson effect. (5)

Paper V

Unit-I

CLASSICAL MECHANICS II (25 Marks) **LECTURES 25 + 5 Tutorial**

1. Central force problem

Motion under central force; Nature of orbits in an attractive inverse square field; Kepler's laws of planetary motion. Rutherford scattering as an example of repulsive potential. (7)

2. *Mechanics of Ideal Fluids*

Streamlines and flowlines; Equation of continuity; Euler's equation of motion; Streamline motion - Bernoulli's equation and its applications. Definition of Newtonian and non-Newtonian fluids. (6)

3. Lagrangian and Hamiltonian formulation of Classical Mechanics

Generalised coordinates, constraints and degrees of freedom; D'Alembart's principle; Lagrange's equation for conservative systems (from D'Alembert's principle; variational principle not required) and its application to simple cases; Generalised momentum; Idea of cyclic coordinates, its relation with conservation principles; Definition of Hamiltonian, Hamilton's equation (derivation by Legendre transformation) and its application to simple cases. (12)

SPECIAL THEORY OF RELATIVITY (25 Marks) **LECTURES 25 + 5 Tutorial**

1. Introduction

Galilean transformation and invariance of Newton's laws of motion, non-invariance of Maxwell's equations. Michelson-Morley experiment and explanation of the null result. (4)

2. Special Theory of Relativity

Concept of inertial frame. Postulates of special theory; simultaneity; Lorentz transformation along one of the axes – length contraction, time dilatation and velocity addition theorem, Fizeau's experiment. Four vectors. Relativistic dynamics : variation of mass with velocity; energy momentum relationship. (10)

3. Vectors and Tensors

Covariant and contravariant vectors. Contraction. Covariant, contravariant, and mixed tensors of rank-2, transformation properties. The metric tensor (flat space-time only). Raising and lowering of indices with metric tensors. (Consistent use of any one convention --- diag(-1,1,1,1) or diag(1,-1,-1,-1).) Example of common four-vectors: position, momentum, derivative, current density, four-velocity. (6)

4. Invariant intervals

Concept of space-time: Euclidean and Minkowski. Invariant intervals in 1+1 and 3+1 dimensions (use Minkowski space-time). Space like, time-like and light like four vectors. Light cone. Causality and simultaneity in different frames. (5)

Unit-II

QUANTUM MECHANICS II (25 Marks) **LECTURES 25 + 5 Tutorial**

1. Time dependent and time independent Schrodinger equation

Eigenstates, normalization and orthonormality.
(4)

2. Simple applications of Quantum Mechanics

One dimensional potential well and barrier, boundary conditions, bound and unbound states. Reflection and transmission coefficients for a rectangular barrier in one dimension – explanation of alpha decay. Free particle in one dimensional box, box normalization, momentum eigenfunctions of a free particle. Linear harmonic oscillator, energy eigenvalues from Hermite differential equation, wave function for ground state, parity of wave function. (11)

3. Schrodinger equation in spherical polar coordinates

Angular momentum operators and their commutation relations; eigenvalues and eigenfunctions of L^2 and L_z; theorem of addition of angular momenta [statement with examples]. The hydrogen atom problem – stationary state wavefunctions as simultaneous eigenfunctions of H, L^2, and L_z; radial Schrodinger equation and energy eigenvalues [Laguerre polynomial solutions to be assumed]; degeneracy of the energy eigenvalues. (10)

ATOMIC PHYSICS (25 Marks) **LECTURES 25 + 5 Tutorial**

1. Atomic Spectrum

Good quantum numbers, and selection rules. Stern-Gerlach experiment and spin as an intrinsic quantum number. Incompatibility of spin with classical ideas. Bohr-Sommerfeld model. Fine structure. Study of fine structure by Michelson interferometer. (11)

2. Vector atom model

Magnetic moment of the electron, Lande g factor. Vector model – space quantization. Zeeman effect. Explanation from vector atom model.
(4)

3. Many electron model

Pauli exclusion principle, shell structure. Hund's rule, spectroscopic terms of many electron atoms in the ground state.
(2)

4. Molecular spectroscopy

Diatomic molecules – rotational and vibrational energy levels. Basic ideas about molecular spectra. Raman effect and its application to molecular spectroscopy (qualitative discussion only). (3)

5. Laser Physics

Population inversion, Einstein's A and B coefficients; feedback of energy on a resonator; 3-level and 4-level systems. (5)

Paper VI

Unit-I

NUCLEAR & PARTICLE PHYSICS I (25 Marks) **LECTURES 25 + 5 Tutorial**

1.Bulk properties of nuclei

Nuclear mass, charge, size, binding energy, spin and magnetic moment. Isobars, isotopes and isotones; mass spectrometer (Bainbridge). (5)

2. Nuclear structure

Nature of forces between nucleons, nuclear stability and nuclear binding, the liquid drop model

(descriptive) and the Bethe-Weizsacker mass formula, application to stability considerations, extreme single particle shell model (qualitative discussion with emphasis on phenomenology with examples). (9)

3. Unstable nuclei

(a) Alpha decay : alpha particle spectra – velocity and energy of alpha particles. Geiger-Nuttal law. (3)

(b) Beta decay : nature of beta ray spectra, the neutrino, energy levels and decay schemes, positron emission and electron capture, selection rules, beta absorption and range of beta particles, Kurie plot. (4)
(c)Gamma decay : gamma ray spectra and nuclear energy levels, isomeric states. Gamma absorption in matter – photoelectric process, Compton scattering, pair production (qualitative).
(4)

NUCLEAR & PARTICLE PHYSICS II (25 Marks) LECTURES 25 + 5 Tutorial

1. Nuclear reactions

Conservation principles in nuclear reactions. Q-values and thresholds, nuclear reaction cross-sections, examples of different types of reactions and their characteristics. Bohr's postulate of compound nuclear reaction, Ghoshal's experiment. (4)

2. Nuclear fission and fusion

Discovery and characteristics, explanation in terms of liquid drop model, fission products and energy release, spontaneous and induced fission, transuranic elements. Chain reaction and basic principle of nuclear reactors. Nuclear fusion: energetics in terms of liquid drop model. (5)

3. Elementary particles

(a) Four basic interactions in nature and their relative strengths, examples of different types of interactions. Quantum numbers – mass, charge, spin, isotopic spin, intrinsic parity, hypercharge. Charge conjugation. Conservation laws. (3)

(b) Classifications of elementary particles – hadrons and leptons, baryons and mesons, elementary ideas about quark structure of hadrons – octet and decuplet families. (4)

4. Particle Accelerator and Detector

Cyclotron – basic theory, synchrotron, GM counter (3)

5. Nuclear Astrophysics

Primordial nucleosynthesis, energy production in stars, pp chain, CNO cycle. Production of elements (qualitative discussion) (6)

Unit-II

SOLID STATE PHYSICS I (25 Marks) LECTURES 25 + 5 Tutorial

1. Crystal Structure

Crystalline and amorphous solids, translational symmetry. Elementary ideas about crystal structure, lattice and bases, unit cell, reciprocal lattice, fundamental types of lattices, Miller indices, lattice planes, simple cubic, f.c.c. and b.c.c. lattices. Laue and Bragg equations. Determination of crystal structure with X-rays. (10)

2. Structure of solids

Different types of bonding- ionic, covalent, metallic, van der Waals and hydrogen. Band theory of solids, Periodic potential and Bloch theorem, Kronig-Penny model, energy band structure. Band structure in conductors, direct and indirect semiconductors and insulators (qualitative discussions); free electron theory of metals, effective mass, drift current, mobility and conductivity, Wiedemann-Franz law. Hall effect in metals : Phenomenology and implication. (15)

SOLID STATE PHYSICS II (25 Marks) **LECTURES 25 + 5 Tutorial**

1. *Dielectric properties of materials*

Electronic, ionic and dipolar polarizability, local fields, induced and oriented polarization – molecular field in a dielectric; Clausius-Mosotti relation. (4)

2. *Magnetic properties of materials*

Dia, para and ferro-magnetic properties of solids. Langevin's theory of diamagnetism and paramagnetism. Quantum theory of paramagnetism, Curie's law. Ferromagnetism : spontaneous magnetization and domain structure; temperature dependence of spontaneous magnetisation; Curie-Weiss law, explanation of hysteresis. (11)

3 *Lattice vibrations*

Elastic and atomic force constants; Dynamics of a chain of similar atoms and chain of two types of atoms; optical and acoustic modes; interaction of light with ionic crystals. Einstein's and Debye's theories of specific heats of solids. (5)

4. *Superconductivity*

Introduction (Kamerlingh-Onnes experiment), effect of magnetic field, Type-I and type-II superconductors, Isotope effect. Meissner effect. Heat capacity. Energy gap. Ideas about High-Tc superconductors. (5)

Paper VIIA

Unit-I (5)

STATISTICAL MECHANICS (25 Marks) **LECTURES 25 + 5 Tutorial**

1.Microstates and macrostates

Classical description in terms of phase space and quantum description in terms of wave functions. Hypothesis of equal *a priori* probability for microstates of an isolated system in equilibrium. Interactions between two systems – thermal, mechanical and diffusive. Statistical definition of temperature, pressure, entropy and chemical potential. Partition function of a system in thermal equilibrium with a heat bath. (6)

2. *Classical statistical mechanics*

Maxwell-Boltzmann distribution law. Calculation of thermodynamic quantities for ideal monoatomic gases. (2)

3. *Motivations for quantum statistics*

Gibbs' paradox. Identical particle and symmetry requirement. Derivation of MB, FD and BE statistics as the most probable distributions (micro-canonical ensemble). Classical limit of quantum statistics. (5)

4. *Quantum statistical mechanics*

Bose-Einstein statistics: Application to radiation – Planck's law. Rayleigh Jeans and Wien laws as limiting cases, Stefan's law. Fermi-Dirac statistics: Fermi distribution at zero and non-zero temperatures. Fermi energy and its expression in terms of particle density. Degenerate and non-degenerate Fermi gas. Electron specific heat of metals at low temperature. Saha equation for thermal ionization and its application to astrophysics. (12)

ELECTROMAGNETIC THEORY (25 Marks) LECTURES 25 + 5 Tutorial

1. *Generalization of Ampere's Law*

   Displacement Current, Maxwell's Field Equations, Wave equation for electromagnetic (EM) field and its solution – plane wave and spherical wave solutions, transverse nature of field, relation between **E** and **B**; energy density of field, Poynting vector and Poynting's theorem, boundary conditions. (8)

2. *EM Waves in an isotropic dielectric*

   Wave equation, reflection and refraction at plane boundary, reflection and transmission coefficients, Fresnel's formula, change of phase on reflection, polarization on reflection and Brewster's law, total internal reflection. (6)

3. *EM waves in conducting medium*

   Wave equation in conducting medium, reflection and transmission at metallic surface – skin effect and skin depth, propagation of E-M waves between parallel and conducting plates – wave guides (rectangular only). (5)

4. *Dispersion*

   Equation of motion of an electron in a radiation field : Lorentz theory of dispersion – normal and anomalous; Sellmeier's and Cauchy's formulae, absorptive and dispersive mode, half power frequency, band width. (3)

5. *Scattering*

   Scattering of radiation by a bound charge, Rayleigh's scattering (qualitative ideas), blue of the sky, absorption. (3)

PRACTICAL PAPERS

Marks Distribution

Part I	Paper IIB UNIT- 1	Full marks- 20
	UNIT- 2	Full marks- 30
Part II	Paper IVB	Full marks- 50
Part III	Paper VIIB	Full marks- 50
	Paper VIIIA	Full marks- 50
	Paper VIIIB	Full marks- 50

Laboratory Teaching Classes

One laboratory class (of 3 periods duration) per week should be devoted to teach the following topics during the first year. These lectures should be taken in laboratory and should be of interactive type so that students also participate in the learning process.

As the course on computer will be taught in early months of first year, students will get sufficient time to use computer in practical classes. During the three year period each student has to write a number of computer programmes and execute them on a computer. The programmes and the results should be collected in the form of a note book and that is to be submitted at the time of practical examination of Paper 16. This Computer Note Book [CNB] must be signed by the class teacher. During the practical examination of Paper 16, the examiners will check the CNB and ask questions on the report presented by the students in their CNB. The students will have to solve two problems during the examination of paper 16.

Laboratory Teaching

1. Demonstration lectures on use of vernier, micrometer, spherometer, barometer, common balance ,etc.; graph plotting -1 Lab-class
2.(i) Basic ideas of Probability & Statistics
(ii) Error analysis, significant figures, limits of accuracy of an Experiment-associated choice of equipments. -3 Lab-class
3. Measuring instruments (e.g. Galvanometer, Multimeter & CRO) to be used in the laboratory -2 Lab-class
4. Computer-Fundamentals and Programing in C or Fortran -6 Lab-class

Total = 12 Lab-class

In practical classes all data should be recorded directly in the Laboratory Note Book and signed regularly by the attending teachers. This Note Book should be submitted at the time of final practical examination. No separate fair L.N.B. need be maintained. The evaluation of the L.N.B. will be done by the external examiner.

PRACTICAL

PAPER – IIB
UNIT - I

Total Marks 20 **Time – 2 hours**

Distribution of Marks : LNB-5, VIVA-5, Experiment-10; Total = 20.

1. Determination of moment of inertia of metallic cylinder / rectangular bar about an axis passing through its C.G. and to determine the rigidity modulus of the material of the suspension wire.
2. Determination of refractive index of a liquid by using travelling microscope.
3. To estimate the temperature of a torch bulb filament from resistance measurement and to verify Stefan's law.
4. To convert a given ammeter into a voltmeter and a given voltmeter into an ammeter and hence to calibrate the device and measure the internal resistance in each case.
5. To measure the resistance per unit length of the wire of a bridge and to determine an unknown resistance by Carey Fosters bridge.
6. To measure the current flowing in a circuit by measuring the drop of potential across a known resistance in the circuit using a potentiometer (by measuring the resistance of the potentiometer with a P.O. Box).
7. To verify truth tables of different gates using discrete components abd I.C's

UNIT - II

Total Marks 30 **Time – 4 hours**

Distribution of Marks : LNB-5, VIVA-5, Experiment-20; Total = 30.

1. Adjustment of the Spectrometer for parallel rays by Schusters method and to determine the refractive index of the material of a prism by spectrometer from (i-δ) curve.
2. To study the variation of refractive index (μ) of the material of a prism with wave length and to verify Cauchy's dispersion formula and to find the dispersive power of the material of the prism by spectrometer.
3. To determine the specific heat capacity of a liquid by continuous flow (Callender and Barnes) method.
4. Determination of thermal conductivity of a bad conductor of heat by Lee's and Chorlton's method.
5. To study the nature of dependence of dipolar field of a short bar magnet on distance with the help of a deflection magnetometer and to determine the horizontal component of the Earth's magnetic field.
6. To draw the forward and reverse characteristics of a zener diode and to study its regulation characteristics. Estimate the a.c. resistances of the diode for different diode currents in both forward and reverse bias conditions.
7. To draw the regulation characteristics of a bridge rectifier (i) without using any filter and (ii) using a filter. Determine the ripple factor in both cases by measuring the ripple voltage with the help of an ac meter.
8. To execute half adders and full adders with basic gates and hence to verify addition of binary numbers.

PAPER – IVB

Total Marks 50 **Time – 6 hours**

Distribution of Marks : LNB-10, VIVA-10, Experiment-30; Total = 50

1. To determine the wavelength of a monochromatic light by Newton's ring method.
2. Measurement of the slit width and the separation between the slits of a double slit by observing the diffraction and interference fringes.
3. To calibrate a polarimeter and hence to determine the concentration of sugar solution.
4. To determine the boiling opoint of a liquid using a platinum resistance thermometer.
5. To calibrate a thermocouple with the help of potentiometer and hence (i) to measure the thermoelectric power

at a particular temperature , (ii) to measure an unknown temperature.
6. To study the variation of mutual inductance of a given pair of co-axial coils by using a ballistic galvanometer.
7. To calibrate a Hall probe with the help of a Ballistic Galvanometer and use the probe to study the variation of magnetic field of an electromagnet with (i) the magnetizing current and (ii) position in a transverse direction.
8. To measure the voltage across the inductance (L), capacitance (C) and resistance(R) of a series LCR circuit for different frequencies of the input voltage with the help of an A.C millivoltmeter. Hence (i) to study the variation of impedance of L and C with frequency of the impressed voltage, (ii) to draw the resonance curve of the series LCR circuit and to determine the Q-factor of the circuit.
9. Verification of Thevenin, Norton and Maximum power transfer theorems using a resistive Wheatstone bridge, d.c. source and d.c. meters.
10.To determine the band gap energy of a given semiconductor by four-probe method.
11. To draw the characteristics of a transistor in C-E mode and hence to determine the hybrid parameters using dc and ac sources .
12. a)To draw the characteristics of a JFET and hence to determine the relevant parameters and b) to design an amplifier using JFET.

PAPER – VIIB

Total Marks 50 **Time 6 hours**

Distribution of Marks : LNB-10, VIVA-10, Experiment-30;Total=50.

1. To determine the wavelength of a monochromatic light by Fresnel's biprism
2. Verification of Fresnel's equation of reflection of electromagnetic waves with the help of prism and two polaroids.
3. To find the number of lines per centimeter of the transmission grating and hence to measure the wavelength of an unknown spectral line and to measure the wavelength difference between D1 and D2 lines of sodium using a slit of adjustable width
4. To draw the B-H loop for the material of an anchor ring by ballistic galvanometer and to estimate the energy loss per cycle of magnetisation.
5. (a) To measure the self inductance of two coils by Anderson bridge .To find the total inductance of the above two coils connected in series and hence estimate the coefficient of coupling between the coils.
(b)To study the variation of inductance of two coils in series with angle between their planes by Anderson bridge.
6. To determine Fourier spectrum of (i) square, (ii) triangular and (iii) half sinusoidal waveform by C.R.O.
7. To study the diffraction pattern of a crossed grating with the help of a LASER source.

PAPER – VIIIA

Total Marks 50 **Time 6 hours**

Part-B. Electronics Experiment : LNB-10, VIVA-10, Expt-30; Total = 50

1. To construct a regulated power supply on a bread board, using
   (i) a power transistor as pass element,
   (ii) a second transistor as a feedback amplifier and
   (iii) a zener diode as a reference voltage source and to study its operational characteristics.
2. To design and draw the output waveform of an astable multivibrator and hence to verify the time period of oscillation.
3. To construct and study the frequency response of a voltage amplifier using a transistor in CE mode and to find its bandwidth.
4. To design and test the following circuits using an OPAMP
   (i) Inverting and non inverting amplifier
   (ii) Differential amplifier
   (iii) Schmitt trigger
   (iv) Integrator
   (v) Differentiator.
5. To construct Wein Bridge oscillator on a bread board using OPAMP and to study the wave form of the oscillator and calibrate it using CRO.

6. To design and fabricate a temperature controller and to study its performance characteristics.
7. To design and verify the following digital circuits using basic gates:
   i) S-R flip-flops , ii) J-K flip-flops, iii) 4 input multiplexer iv) 7-segment demultiplexer
   v) Mod-5 and decade counters.

USE OF PREFABRICATED CIRCUIT PROHIBITED

PAPER –VIIIB

Total Marks 50 **Time 3 hours**

Distribution of Marks : CNB-10, Viva-10; Experiment : 30 TOTAL = 50.

Apart from executing the programmes prescribed in the syllabus, students should be encouraged to execute other problems of Physics particularly associated with practical with the help of computer, using available software packages (e.g. graph plotting etc.).

1. Language (FORTRAN or C)

Constants and variables. Assignment and arithmetic expressions. Logical expressions and control statements, loops, array, input and output statements (with I, F and E formats), function subprogram, subroutine.

2. Numerical analysis

Computer arithmetic and errors in floating point representation of numbers, different numerical methods for the following problems:

Group A
(i) Sorting.
(ii) Read N numbers, find their mean, median, mode
(iii) Find whether a number is prime, factorize a number
(iv) Sum of different types of series term by term with a specified accuracy
(v) Matrix operations (addition, subtraction, multiplication,transpose)

Group B
(vi) Solution of simultaneous linear equations by Gauss-Siedel method
(vii) Least square fit of a given set of data to a straight line, application to exponential ($y=ae^{bx}$) and power ($y=ax^{b}$) laws.
(viii) Finding zeroes of a given function by the method of bisection and Newton-Raphson
(ix) Interpolation by Lagrange's method
(x) Integration by trapezoidal and Simpson's rule.

The above basic types of programs should be explained in practical classes before performing the experiments. **Each student will have to solve one problem each from Group A and Group B (each of 15 marks) during the examinations.**

RECOMMENDED BOOKS (B.SC. HONOURS CURRICULUM)

Paper I: Mathematical Methods I, II

1. Introduction to Mathematical Physics - C. Harper (Prentice-Hall of India).
2. Mathematical Methods - M. C. Potter and J. Goldberg (Prentice-Hall of India).
3. Vector Analysis - M. R. Spiegel, (Schaum's Outline Series) (Tata McGraw-Hill).
4. Tatwiya Padartha Bidyar Bhumika – S. Sengupta, Asok Ghosh and D. P. Roychaudhuri (W.B. State Book Board (WBSBB)).
5. Mathematical Physics – P.K. Chattopadhyay (Wiley Eastern)

Papers I and III: Waves and Optics I, II

1. Advanced Acoustics - D. P. Ray Chaudhuri (Chayan – Kolkata).
2. Waves and Oscillations - Rathin N. Chaudhury (New Age Publ.).
3. Waves- J R Crawford (Tata McGraw Hill)
4. Fundamentals of Optics - F. A. Jenkins and H. E. White (Mc Graw Hill, Kogakusha).
5. Geometrical and Physical Optics - B. S. Longhurst (Orient Longmans).
6. Optics – A. K. Ghatak (Tata Mc Graw Hill).
7. Optics – Hecht and Zajac (Addison-Wesley)
8. Optics – B. K. Mathur.
9. Bhauta Alok Bigyan – B. S. Basak (WBSBB).

Papers I and III: Electronics I, II

1. Integrated Electronics – J. Millman and C. C. Halkias (Mc Graw Hill).
2. Electronic Fundamentals and Applications – D. Chattopadhyay and P. C. Rakshit (New Age International)
3. Electronics Fundamentals and Applications – J. D. Ryder (PHI Pvt. Ltd).
4. Electronic Device and Circuit Theory – R. Boylestad and L. Nashelsky (Prentice – Hall).
5. Integrated Electronics – J. Millman and C. C. Halkias (Mc Graw Hill).
6. Digital Logic and Computer Design – M. Moris Mano, (PHI (Pvt.) Ltd.).
7. Electronics – R.K. Kar (**Books and Allied (P) Ltd.**).
8. Digital Electronics – D. Ray Chaudhuri (Platinum Publishers)
9. Basic Electronics – K. K. Ghosh (Platinum Publishers)

Papers II and V: Classical Mechanics I, II

1. Theoretical Mechanics - M. R. Spiegel, (Schaum's Outline Series) (McGraw-Hill).
2. Mechanics - K. R. Symon (Addison-Wesley).
3. Introduction to Classical Mechanics - R. G. Takwale and P. S. Puranik (Tata McGraw-Hill).
4. Classical Mechanics – N. C. Rana and P. S. Joag (Tata McGraw-Hill).
5. Mechanics and General Properties of Matter – D. P. Roychaudhuri and S. N. Maiti (Book Syndicate).
6. Padarther Dharma - D. P. Ray Chaudhuri (West Bengal State Book Board).
7. The Feynman Lectures on Physics – Vol I (Addison-Wesley).
8. An Introduction to Mechanics – D. Keppner and R.J. Kolenkow (Tata McGraw-Hill).
9. Mechanics – H. S. Hans and S. P. Puri (Tata McGraw-Hill).
10. Classical Mechanics – J. Goldstein (Narosa Publ. House).
11. Classical Mechanics – A. K. Roychaudhuri (O. U. P., Calcutta).

12. Berkeley Physics Course, Vol – I (Mechanics) (Mc Graw Hill).

Papers II and IVA: Thermal Physics I, II

1. Heat and thermodynamics - Zemansky and Ditman (Mc Graw Hill, Kugakusha).
2. Kinetic theory of gases - Loeb (Radha Publ. House).
3. Thermodynamics – F. Fermi (Dover)
4. Tapgatividya – Asoke Ghosh (W.B.S.B.B).
5. A Treatise on Heat - Saha and Sribastava (The Indian Press Ltd).
6. Gaser Anabik Tattwa- Pratip Kumar Chaudhuri (W. B. S. B. B).
7.Thermal Physics – S. Garg, R. M. Bansal, C. K. Ghosh (Tata Mc Graw Hill).
8.Heat and Thermodynamics – H. P. Roy and A. B. Gupta (New Central Book Agency).

Paper III: Electricity and Magnetism
Paper III: Electrostatics
Paper VIIA: Electromagnetic Theory

1. Introduction to Electrodynamics – D. J. Griffith, (Prentice Hall, India Pvt. Ltd).
2. Berkeley Series Vol II (Electricity and Magnetism) E.M. Purcell (Tata McGraw-Hill).
3. The Feynman Lectures on Physics – Vol. II (Addison – Wesley).
4. Electricity and Magnetism - J. H. Fewkes and J. Yarwood (Oxford Univ. Press, Calcutta).
5. Electricity and Magnetism – Chatterjee and Rakshit.
6. Electricity and Magnetism – A. S. Mahajan and A. A. Rangwala (Tata McGraw-Hill).
7. Classical Electrodynamics – J.D> Jackson (Wiley India)

Papers IVA and V: Quantum Mechanics I, II

1. Quantum Mechanics – J. L. Powell and B. Crasemonn, (Oxford, Delhi).
2. Quantum Mechanics – F. Schwabl (Narosa).
3. Quantum Mechanics – A. K. Ghatak and S. Lokenathan (Macmillan, Delhi).
4. Introductory Quantum Mechanics - S. N. Ghoshal (Calcutta Book House).
5. A Textbook of Quantum Mechanics – P. M. Mathews and K. Venkatesan (Tata Mc Graw Hill).
6. Modern Quantum Mechanics – Sakurai (Persian Education)

Paper V: Atomic Physics

1. Laser Principles and Applications – A. K. Ghatak and K. Tyagrajan (Tata – Mc Graw Hill).

2. Optics and Atomic Physics – B. P. Khandelwal (Siblal Agarwala).

3. Physics of Atoms and Molecules – B. H. Bransden and C. J. Joachain(Pearson Education)

4. Atomic and Nuclear Physics – S. K. Sharma (Pearson Education).

Paper VI: Nuclear and Particle Physics I, II

1. Nuclear Physics – Cottingham and Greenwood (Cambridge University Press).
2. Concepts of Nuclear Physcics – R. Cohen (Tata-Mc Graw Hill).
3. Paramanu o Kendrak Gathan Parichay – S. N. Ghoshal (WBSBB).
4. Atomic and Nuclear Physics – S. N. Ghoshal (S. Chand).
5. Nuclear Physics – S. B. Patel (New Age).
6. Nuclei and Particles – E. Segre (Benjamin).
7.Nuclear Physics: Principles and applications – J.S. Lilley (Willey Eastern).

8. Fundamentals in Nuclear Physics: from Nuclear Structure to Cosmology – J. Basdevant, J. Rich and M. Spiro (Springer).

9. Particle Physics – Seiden (Persian Education)

Paper VI: Solid State Physics I, II

1. Introduction to Solid State Physics, C. Kittel (Wiley Eastern).
2. Elementary Solid State Physics – M. Ali Omar (Pearson Education)
4. Solid State Physics – A. J. Dekker (Mc. Millan)
4. Solid State Physics – S. O. Pillai (New Age International)
5. Elements of Solid State Physics – J. P. Srivastava (Prentice Hall)
6. An Introduction to Solid State Physics and Application – R.J. Elliot and A.F. Gibson (McMillan)
7. Solid State Physics – D.W. Snoke (Person Education)

Paper VIIA: Statistical Mechanics

1. Statistical Physics, F. Mandle (ELBS).
2. Fundamentals of Statistical and Thermal Physics, F. Reif, (Mc Graw Hill).

Paper VIIA: Special Theory of Relativity

1. Introduction to Special Theory of Relativity - R. Resnick (Wiley Eastern).
2. Special Theory of Relativity - A. P. French (ELBS).
3. Apekshikata Tattwa - Sriranjan Bandyopadhyay (W. B. S. B. B).
4. The Feynman Lectures on Physics, Vol I (Addison – Wesley).
5. Theory of Relativity – Nikhilendu Bandyopadhyay (Academic Publishers)