Aliah University

KOLKATA

DEPARTMENT OF PHYSICS

Structure and Syllabus for 5 year Integrated
M. Sc in Physics

SESSION: 2011-2012

FIRST YEAR

Semester-I

SUBJECT	Paper Code	L	T	P	Credit
Physics-I	**PH-101**	**2**	**0**	**0**	**2**
Chemistry-I	**CH-101**	**2**	**0**	**0**	**2**
Mathematics-I	**MA-101**	**3**	**1**	**0**	**4**
Mechanics-I	**CE-101**	**3**	**1**	**0**	**4**
Basic Electrical & Electronics-I	**EE-101**	**3**	**1**	**0**	**4**
Elementary Arabic-I	**AR-101**	**2**	**0**	**0**	**2**
English Language & Communication-I	**EN-101**	**2**	**0**	**0**	**2**
Physics Laboratory-I	**PH-191**	**0**	**0**	**3**	**2**
Chemistry Laboratory-I	**CH-191**	**0**	**0**	**3**	**2**
Basic Electrical & Electronics Laboratory-I	**EE-191**	**0**	**0**	**3**	**2**
Engineering Drawing / Physics-IA	**CE-191/ PH-103**	**0**	**0**	**3**	**2**
					28

Semester-II

SUBJECT	Paper Code	L	T	P	Credit
Physics-II	**PH-102**	**2**	**0**	**0**	**2**
Chemistry-II	**CH-102**	**2**	**0**	**0**	**2**
Mathematics-II	**MA-102**	**3**	**1**	**0**	**4**
Mechanics-II	**ME-102**	**3**	**1**	**0**	**4**
Basic Electrical & Electronics-II	**EE-102**	**3**	**1**	**0**	**4**
Introduction to Computer to Computer Programming	**CSE-101**	**2**	**0**	**0**	**2**
Elementary Arabic-II	**AR-102**	**2**	**0**	**0**	**2**
English Language & Communication -II	**EN-102**	**2**	**0**	**0**	**2**
Physics Laboratory-II	**PH-192**	**0**	**0**	**3**	**2**
Chemistry Laboratory-II	**CH-192**	**0**	**0**	**3**	**2**
Computer Programming Laboratory	**CSE-192**	**0**	**0**	**3**	**2**
Workshop Practice / Physics-IIA	**ME-192 / PH-104**	**0**	**0**	**3**	**2**
					30

SECOND YEAR

Semester-III

SUBJECT	Paper Code	L	T	P	Credit
Mathematical Physics –I & Advance Classical Mechanics-I	PH-201	3	1	0	4
Physical Optics & Geometrical Optics	PH-203	3	1	0	4
Heat & Thermodynamics	PH-205	3	1	0	4
Chemistry-III	CH-231	3	1	0	4
Mathematics-III	MA-231	3	1	0	4
Environment Science	ES-201	2	0	0	2
Islamic Studies-I	IS-201	2	0	0	2
Physics Laboratory-III	PH-291	0	0	3	2
Chemistry Laboratory-III	CH-261	0	0	3	2
					28

Semester-IV

SUBJECT	Paper Code	L	T	P	Credit
Current Electricity	PH-202	3	1	0	4
Electrostatics	PH-204	3	1	0	4
Electrodynamics –I	PH-206	3	1	0	4
Chemistry-IV	CH-232	3	1	0	4
Mathematics-IV	MA-232	3	1	0	4
Islamic Studies-II	IS-202	2	0	0	2
Physics Laboratory-IV	PH-292	0	0	3	2
Chemistry Laboratory-IV	CH-262	0	0	3	2
					26

THIRD YEAR

Semester-V

SUBJECT	Paper Code	L	T	P	Credit
Quantum Mechanics -I	PH-301	3	1	0	4
Statistical Mechanics-I	PH-303	3	1	0	4
Solid state Physics-I	PH-305	3	1	0	4
Electronic measurements & Instrumentation	PH-307	3	1	0	4
Atomic physics–I	PH-309	3	1	0	4
Physics Laboratory-V	PH-391	0	0	3	2
Physics Laboratory-VI	PH-393	0	0	3	2
					24

Semester-VI

SUBJECT	Paper Code	L	T	P	Credit
Photonics	PH-302	3	1	0	4
Nuclear and Particle Physics-I	PH-304	3	1	0	4
Measurements Of Non-Electrical Quantities	PH-306	3	1	0	4
Digital Electronics & Microprocessor-I	PH-308	3	1	0	4
Physics Laboratory-VII	PH-392	0	0	3	2
Physics Laboratory-VIII	PH-394	0	0	3	2
Microprocessor Laboratory -I	PH-396	0	0	3	2
Project Presentation	PH-372	0	0	0	2
					24

FOURTH YEAR

Semester-VII

SUBJECT	Paper Code	L	T	P	Credit
Mathematical Physics-II	**PH-401**	**3**	**1**	**0**	**4**
Advance Classical Mechanics-II	**PH-403**	**3**	**1**	**0**	**4**
Quantum Mechanics-II	**PH-405**	**3**	**1**	**0**	**4**
Electrodynamics-II	**PH-407**	**3**	**1**	**0**	**4**
Numerical Analysis & Computation	**PH-409**	**3**	**1**	**0**	**4**
Physics Laboratory-IX	**PH-491**	**0**	**0**	**3**	**2**
Computer Laboratory-I	**PH-493**	**0**	**0**	**3**	**2**
					24

Semester-VIII

SUBJECT	Paper Code	L	T	P	Credit
Solid State Physics -II	**PH-402**	**3**	**1**	**0**	**4**
Semiconductor Physics and Device	**PH-404**	**3**	**1**	**0**	**4**
Quantum Mechanics-III	**PH-406**	**3**	**1**	**0**	**4**
Special Theory of Relativity	**PH-408**	**3**	**1**	**0**	**4**
Advanced Experimental Physics and Measurements	**PH-4010**	**3**	**1**	**0**	**4**
Advanced Physics Laboratory-X	**PH-492**	**0**	**0**	**3**	**2**
Computer Laboratory-II	**PH-494**	**0**	**0**	**3**	**2**
					24

FIFTH YEAR

Semester-IX

SUBJECT	Paper Code	L	T	P	Credit
Statistical Mechanics-II	PH-501	3	1	0	4
Atomic Physics-II and Molecular Physics	PH-503	3	1	0	4
Nuclear and Particle Physics-II	PH-505	3	1	0	4
Microprocessor-II & Microcontroller	PH-507	3	1	0	4
Advanced Physics Laboratory-XI	PH-591	0	0	3	2
Microprocessor Laboratory-II	PH-593	0	0	3	2
Grand Viva	PH-581	0	0	0	2
					22

Semester-X

SUBJECT	Paper Code	L	T	P	Credit
Special Paper-I	PH-502	3	1	0	4
Special Paper-IA	PH-504	3	1	0	4
Special Paper-II	PH-506	3	1	0	4
Special Paper-IIA	PH-508	3	1	0	4
Elective Paper	PH-552	3	1	0	4
Special Laboratory-XII	PH-592	0	0	3	2
Project Work and Seminar	PH-572	0	0	0	4
					26

FIRST YEAR

Semester-I

Paper PH-101 (50 Marks) LECTURES 30 + 10 Tutorial
PHYSICS-I

1. Vectors: Vector in three dimension; Axial and polar vectors; dot and cross product, scalar triple product and vector triple product; scalar and vector fields – gradient, divergence and curl; concept of line, surface and volume integrals, statement of Stokes' theorem, Divergence theorem and Green's theorem; 2^{nd} order differential equation and its application in vibration and electrical circuits.
2. Mechanics of a Single particle: Velocity and acceleration of a particle in plane polar co-ordinates, radial & transverse components of velocity & acceleration, tangential & normal acceleration; time and path integral of force; work and energy; conservative force and concept of potential; conservation of energy, dissipative forces; conservation of linear and angular momentum; motion of variable mass.
3. Mechanics of a system of Particles: Linear momentum, angular momentum and energy, center of mass decomposition; equation of motion, conservation of linear and angular momentum.

Paper PH-103 (50 Marks) LECTURES 30 + 10 Tutorial
PHYSICS-IA

1. Gravitation: Newton's law of Gravitation, Gravitational potential and intensity due to thin uniform spherical shells and solid sphere – application of Gauss' theorem and Laplace's equation in simple symmetric problems.
2. Elasticity: Hook's law, Elastic moduli and Poisson's ratio and their interrelations – Torsion of a cylinder – Bending of beams, Bending moment and shearing force;
Stress and strain tensor in a continuous medium; Review of problems of cantilever and beam supported at both ends, strain energy of a bent beam.
3. Viscosity: Review of Kinematics of fluid motion – Newton's law of viscous fluid.- stream line and turbulent flow - Critical velocity – Reynold's number –Newtonian and non-Newtonian fluids - Poiseuille's equation**;** stoke's law' terminal velocity.
4. Mechanics of Ideal fluids: Equation of continuity, Euler's equation- Bernoulli's theorem and its application.
5. Surface Tension: Surface energy and surface tension, – molecular theory – angle of contact – capillary rise – Excess-pressure inside a spherical bubble and drop**.**

Paper PH-191
PHYSICS LABORATORY-I (50 Marks)

1. Determination of Young's modulus of the material of a beam by the method of flexure.
2. Determination of the refractive index of a liquid by using a plane mirror and a convex lens.
3. Determination of the rigidity modulus of the material of the wire by static method.
4. Determination of the rigidity modulus of the material of the wire by dynamic method.
5. Determination of thermal conductivity of a bad conductor by Lee's method.
6. To determine the coefficient of linear expansion of a given sample by Pullinger's apparatus.

Semester-II

Paper PH-102 (50 Marks) LECTURES 30 + 10 Tutorial
PHYSICS-II

1. **Moment of Inertia:** Moment of inertia and radius of gyration; Parallel and perpendicular axes theorem; calculation of moment of inertia for simple symmetrical system; rotational kinetic energy.
2. **Thermal Conduction :** Thermal conductivity – Diffusivity – Fourier equation of heat conduction and its application to rectilinear, spherical and cylindrical flow of heat.
3. **Thermal Radiation :** Emissive and absorptive powers, Kirchoff's law, black body radiation, radiation pressure. Stefan-Boltzmann law, Newton's law of cooling – Wien's and Rayleigh-Jean's law –Planck's law (No deduction) –solar temperature and radiation pyrometer.
4. **Waves :** Linear equation of plane progressive wave motion in one dimension, and in three dimensions ; plane wave and spherical wave solutions ; intensity of a plane progressive wave ; dispersion in wave propagation – group velocity and phase velocity.
5. **Sound :** Quality of sound, Noise and musical sound – Intensity and Loudness – Units of sound's intensity measurements – Acoustics of hall – Reverberation – Production, detection and application of ultrasonic waves – Doppler effect – shock waves.

Paper PH-104 (50 Marks) LECTURES 30 + 10 Tutorial
PHYSICS-IIA

1. **Vectors-:** Line, Surface and Volume integrals-- application in simple symmetric cases; statement & proof of Gauss' theorem, Stokes' theorem and Green's theorem–application to simple symmetric problems; Orthogonal curvilinear co-ordinate systems, unit vectors in spherical and cylindrical polar co-ordinate systems; Concept of tensor
2. **Vibrations :** Linear harmonic oscillator- differential equation and its solutions; Free and forced vibrations of a damped harmonic oscillator; resonance; sharpness of resonance; a pair of linearly coupled harmonic oscillators- eigenfrequencies and normal modes; Lissajous figure.
3. **Transverse vibration in stretched strings :** Wave equation – Plucked and struck strings – eigenfrequencies and eigenmodes, energy of transverse vibrations.
4. **Central force problem :** Motion under central force – two constants of motion – nature of orbit under inverse square attractive field, Kepler's laws of planetary motion, Rutherford's scattering.
5. **Rigid body rotation :** Moment of inertia about any axis – ellipsoid of inertia and inertia tensor, location of principal axes in simple symmetric cases. Angular momentum and kinetic energy; Inertial and non-inertial frame, Rotating frame of reference, Coriolie's and centrifugal force – illustration with simple examples. Euler's theorem – Euler's equation of motion – Force free motion of rigid bodies – Eulerian angles – free spherical top and free symmetric top.

Paper PH-192
PHYSICS LABORATORY-II (50 Marks)

1. Determination of the surface tension of a liquid by capillary tube method and verification of Jurin's law.
2. Determination of the co-efficient of viscosity of a liquid by its flow through a capillary tube (Poiseuillie's method).
3. Determination of the focal length of a convex lens by displacement method by using an optical bench.
4. Determination of unknown frequency of a tunning fork by using sonometer and drawing *n-l* curve.
5. To determine the moment of inertia of a body about an axis passing through its centre of gravity and to determine the rigidity modulus of the material of the suspension wire.
6. Verification of Kirchhoff's current and voltage law.

SECOND YEAR

Semester-III

Paper PH-201 (50 Marks) **LECTURES 45 + 15 Tutorial**

MATHEMATICAL PHYSICS-I

1. Differential Equations: Second order differential equations, solvability, regular and irregular singularities; The hyper geometric equation and functions; Confluent hyper geometric equation and functions; Representation of Legendre, Bessel, Hermite and Laguerre functions; Gamma and Beta functions.

2. Partial differential equations : Solution by the method of separation variables. Laplace's equation and its solution in Cartesian, Spherical polar and cylindrical polar co-ordinal systems. Wave equation – its plane and spherical wave solution.

3. Integral transformation: Laplace transformation and inverse Laplace transformation; Solution of differential equation using Fourier transforms and Laplace transformation; Dirac delta function and its FT.

Fourier expansion - statement of Dirichlet's condition, analysis of simple wave form, Fourier transformations, Convolution theorem;

4. Matrix : Hermitian adjoint and inverse matrix , Hermitian and unitary matrices, Eigen values and Eigen vector, similarity transformation, Diagonalisation of real symmetric matrix with non-degenerative Eigen – values.

ADVANCE CLASSICAL MECHANICS-I

Generalised coordinates, constraints and degrees of freedom; D'Alembert'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.

Paper PH-203 (50 Marks) **LECTURES 45 + 15 Tutorial**

PHYSICAL OPTICS:

1. Wave theory of light: Huygen's principle, deduction of laws of reflection and refraction.

2. **Interference of light waves:** Young's Experiment, Conditions of producing sustained interference of light, Principle of superposition, Calculation of intensity distribution due to superposition of coherent waves & to find condition of constructive and destructive interference, hence to calculate fringe width, Fresnel's biprism experiment. Spatial and temporal coherence, coherent sources by division of wave front and by division of amplitude, Stokes' method to show change of phase due to reflection. Interference in thin film, fringes of equal inclination & equal thickness, Newton's ring, Michelson's interferometer and its use. Multiple beam interference – reflected and transmitted pattern, Fabry – Perot interferometer and application to fine structure study.

3. Diffraction of light waves: Fresnel and Fraunhoffer classes of diffraction, Fresnel's half period zone, explanation of rectilinear propagation of light, zone plate. Fraunhoffer diffraction at a single slit, double slit circular aperture (qualitative). Plane transmission diffraction grating, Rayleigh criterion of resolution, Resolving power of prism, telescope, microscope and transmission grating.

4. Polarization of waves: Different states of polarization, Double refraction, Huygens construction for propagation through uni-axial crystals. Polaroid's and their uses. Nicole prism & its use as polarizer and analyser production and analysis of plane, circularly and elliptically polarized light by retardation plates (half wave & quarter wave plate). Optical activity – Fresnel's explanation of optical activity, Biquartz and half – shade polarimeter.

GEOMERTICAL OPTICS :

1. Refraction: Generalized Snell's Law of refraction, Refraction at single curved (Spherical surface), lens formula, combination of thin lens and equivalent lens.

2. Fermat's Principle: laws of reflection and refraction from Fermat's principle, both for plane and spherical surface.

3. Cardinal points of an optical system, Location of cardinal points of a single thick lens – hence to locate cardinal points of a thin lens. Cardinal points of system of two thin co-axial lenses separated by a distance, equivalent lens. Different type of magnification, Helmholtz and Lagrange's relation. Introduction of matrix methods in paraxial optics - simple application.

4. Dispersion, Dispersive power of lens, prism. Chromatic aberration in lenses – methods of reduction of chromatic aberration in lenses, achromatic doublet.

5. Qualitative discussions of monochromatic or siedal aberration in lenses and short discussion on reduction of siedal aberration in lenses.

6. Optical instruments – Field of view, entrance and exit pupil, compound eyepieces – Ramsden & Huygens type, working principle of Telescope and microscope.

Paper PH-205 (50 Marks) **LECTURES 45 + 15 Tutorial**

HEAT & THERMODYNAMICS

1. Kinetic theory of gases: (i) Deduction of perfect gas laws – Maxwell's distribution law – r.m.s, mean and most probable velocity, (ii) Maxwell's distribution law both in terms of velocity and energy, finite size of molecules, collision probability, distribution of free path and mean free paths from Maxwell's distribution, (iii) principle of equipartition of energy: application to specific heat, Dulong and Petit's law. Equation of states – defect of ideal gas laws – van der walls' equation – critical constants, law of corresponding state; Virial coefficients.

2. Transport Phenomenon: Viscosity, thermal conductivity and diffusion in gases.
Brownian motion, Einstein's theory, Determination of Avogadro number (Perrin's work).

3. Concept of thermodynamics: Microscopic and Macroscopic points of view: thermodynamic variables of a system, state function, exact and inexact differentials.
Isolated system, closed system, open system, extensive and intensive properties.

4. Zeroth law and First Law of Thermodynamics : Thermal equilibrium, zeroth law and the concept of temperature; Thermodynamic equilibrium, internal energy, external work, review of 1st law of thermodynamics and it's applications. Perpetual motion of first kind.

5. Second Law of Thermodynamics: Reversible and irreversible processes, Indicator diagram, Spontaneous process, review of various statement of second law of thermodynamics. Carnot-cycle, and it's efficiency, Carnot's theorem, Kelvin or thermodynamic scale of temperature and it's relation with perfect gas scale, Clausius inequality, entropy, change of entropy in simple reversible and irreversible processes, entropy change in gases and mixture of gases, entropy and disorder, equilibrium and entropy principle, principle of degradation of energy, temperature entropy diagram.

6.Thermodynamic Functions and Maxwell's relation: Enthalpy, Helmholtz and Gibbs' free energies; Legendre transformations, Maxwell's relations and simple deductions using these relations; thermodynamic equilibrium and free energies.

7. Change of State: Equilibrium between phases, triple point, Gibb's phase rule (statement only) and simple applications. First and higher order phase transitions, Ehrenfest criterion. Clausius-Clapeyron's equation. Calculation of Joule-Thomson cooling and temperature of inversion.

8. Heat Engines: External combustion engine, Rankine cycle, Otto and Diesel cycle.

(i) Steam generators: classification, construction and functioning, mountings and accessories.

(ii) Refrigeration Cycles: Basics principles of air, vapour compression and vapour absorption refrigeration cycles.

Paper PH-231 (SUBSIDIARY) (50 Marks) LECTURES 45 + 15 Tutorial

Optics

1. Geometrical optics:

Fermat's principles; Laws of reflection and refraction at plane surface, Refraction at spherical surface, lens formula, combination of thin lenses – equivalent focal length.

Dispersion and dispersive power; chromatic aberration and its remedy. Different types of seidal aberration (qualitative) and their remedies, Eye-pieces, Principles of telescope and microscope.

2. Physical optics:

Light as an electromagnetic wave, full electromagnetic spectrum, properties of electromagnetic waves, Huygen's principle – explanation of the laws of reflection and refraction.

(i) Interference of light: Young's experiment, intensity distribution, conditions of interference in thin films – Newton's ring.

(ii) Diffraction: Fresnel and Fraunhofer class, Fresnel's half-period zones – zone plate. Fraunhofer diffraction due to single slit and plane transmission grating (elementary theory) – resolving power.

(iii) Polarization: different sets of polarization, Brewster's law, double refraction, retardation plate, Polaroid, optical activity.

Electrostatics & Electricity

Quantization of charge – Millikan's oil drop experiment, Coulomb's law, intensity and potential of point charge, Gauss's theorem – simple applications, potential and field due to an electric-dipole, mechanical force on the surface of the charged conductor.

Electric displacement, capacitor, parallel plates and cylindrical, energy stored in parallel plate capacitor.

Thermoelectricity, Magnetic effects of currents, Self-inductance, Mutual inductance, Transformer Electric circuit elements and AC, DC circuit analysis.

Electronic Devices

Intrinsic semiconductors, electrons and holes, Fermi level, Temperature dependence of electron and hole concentrations, doping, impurity states, n and p type semiconductors, conductivity, mobility, Hall effect, hall coefficient. Metal semiconductor junction, p-n junction, majority and minority carriers, diodes, Zener and tunnel diodes, transistor and solar cell.

Paper PH-291

PHYSICS LABORATORY-III (50 Marks)

1. To determine the focal length of a concave lens by combination method and hence to determine the refractive index of the material of the lens by measuring the radii of curvature of both lenses.
2. Determination of the horizontal component of the earth's magnetic field and the magnetic moment of a magnet by employing magnetometers.
3. Determination of the average resistance per unit length of the meter bridge wire by Carey-Foster's method and hence to determine an unknown resistance.
4. Verification of truth tables of OR,AND,NOT, NAND and NOR gates using diode and transistor.
5. Verification of OR, AND, NOT, XOR, XNOR, NAND and NOR gates using IC and also verification of universal gate.
6. To study the characteristics of curve of *p-n* junction diode and A.C and D.C resistance.
7. Determination of Planck's constant using light emitting diode.

Paper PH-261
PHYSICS LABORATORY-III (SUBSIDIARY) (50 Marks)

1. To determine the focal length of a concave lens by combination method and hence to determine the refractive index of the material of the lens by measuring the radii of curvature of both lenses.
2. Determination of the radius of curvature of the lower surface of a Plano-covex lens by using Newton's ring apparatus
3. Determination of the average resistance per unit length of the meter bridge wire by Carey-Foster's method and hence to determine an unknown resistance.
4. Determination of the horizontal component of the earth's magnetic field and the magnetic moment of a magnet by employing magnetometers.
5. To study the characteristics of curve of *p-n* junction diode and A.C and D.C resistance
6. Verification of truth tables of "OR", "AND", "NOT" gates using diode and transistor.
7. Determination of Planck's constant using light emitting diode.

Semester-IV

Paper PH-202 (50 Marks) LECTURES 45 + 15 Tutorial

CURRENT ELECTRICITY

1. Steady current: (a) Differential form of Ohm's law, Kirchhoff's laws, Thevenin and Norton's theorem, Maximum power transfer theorem, Superposition principle, T and Π networks.
(b) Wheatstone bridge- qualitative discussion on sensitivity of Wheatstone bridge, Application in P.O. Box, meter bridge, working principle of potentiometer.
(c) Thermoelectricity *:* Seebeck, Peltier, and Thomson effects, laws of thermoelectricity, thermoelectric curve --- neutral and inversion temperature, thermoelectric power .
2. Magnetic effect of steady current: Lorentz force and concept of magnetic induction; force on linear current element; Biot-Savart's law, $\nabla \cdot \mathbf{B}=0$; 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, moving coil galvanometer- Dead beat and Ballastic galvanometer, Ammeter and voltmeter.
3. Properties of Magnetic materials: Free current and bound current; surface and volume density of current distribution; magnetisation, non-uniform 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**, 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, magnetic circuits and it's applications.
4. Electromagnetic induction: Faraday's and Lenz's law; motional e.m.f.-simple problems calculation of self and mutual inductance in simple cases, inductances in series and parallel; reciprocity theorem, energy stored in an inductance.
5. Transient D.C. : Series L-R circuits, charging and discharging of a condenser in C-R circuits, L-C-R circuits.
6. Alternating current : Mean and r.m.s. values of current and emf with sinusoidal wave form; L-R, C-R and series L-C-R circuits, reactance, impedance, phase-angle, power dissipation in AC circuit power factor, vector diagram, resonance in a series and parallel circuit, Q-factor, principle of ideal transformer, A-C bridge- principle of generalized A.C. bridge, Anderson's bridge, theory of rotating magnetic field, induction motor.

Paper PH-204 (50 Marks) LECTURES 45 + 15 Tutorial

ELECTROSTATICS

1. Coulomb's law of electrostatics, intensity and potential, continuous charge distribution, delta function, 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.

2. Dipoles: Multipole expansion of scalar potential- monopole, dipole, quadrapole terms; Potential and field due to an electric dipole, work done in deflecting a dipole, dipole-dipole interaction (for both electric and magnetic dipoles); force on dipole in a non-homogeneous field.

3. Dielectrics: Polarization, 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.

4. Electrical Images: Uniqueness theorem, Solution of field problems in case of a point charge near a grounded conducting infinite plane. Boundary value problem : in uniform external field for (a) conducting spherical shell and (b) dielectric sphere, problems on earthed conducting sphere and insulated conducting sphere.

Paper PH-206 (50 Marks) LECTURES 45 + 15 Tutorial

ELECTRODYNAMICS-I

1. Generalization of Ampere's Law, Equation of continuity, 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.

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.

3. Electromagnetic Waves in Conducting medium, Reflection and transmission at metallic surface-skin effect and skin depth, Propagation of electromagnetic waves between parallel conducting plate-wave guides (rectangular only).

4. Dispersion - normal and anomalous, Equation of motion of an electron in a radiation field : Lorentz theory of dispersion Sellmeier's and Cauchy's formulae, absorptive and dispersive mode, half power frequency, band width.

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

Paper PH-232 (SUBSIDIARY) (50 Marks) LECTURES 45 + 15 Tutorial

Introduction to relativity: Postulates of special theory of relativity, inertial and non-inertial frames of reference, Length contraction, time dilation, velocity addition, mass variation and mass-energy equivalence.

Basic Statistical Physics : Phase space distribution functions, microcanonical, canonical and grand canonical ensembles. Boltzmann statistics and its applications to ideal gas. Bose-Einstein (BE) statistics, blackbody radiation (no-deduction), Fermi-Dirac (FD) statistics, Fermi gas and applications.

Introduction to Quantum Mechanics : Quantum theory of radiation, Planck's concept, radiation formula (statement only), qualitative discussion of photo-electric effect and Compton effect in support of quantum theory, Raman effect, wave nature of material particle, wave-particle duality, wavelength of deBroglie wave, Heisenberg's uncertainty principle, Schrodinger equation, particle in an one-dimensional infinite well – energy eigen value, wave function and its probabilistic interpretation.

Laser and Fiber Optics : Purity of spectral lines; coherence length and coherence time; time and spatial coherence of a source; Einstein's A and B coefficients; spontaneous and induced emissions, condition for laser action, population inversion, He-Ne laser; pulse laser and tunable laser, spatial coherence and directionality, laser applications.

Optical Fiber – core and cladding; total internal reflection; optical fiber and waveguide; communication through optical fiber, energy loss, attenuation and dispersion.

Atomic and Molecular Physics : Bohr's theory of hydrogen spectra, concept of quantum number, Pauli exclusion principle.

Solid State Physics : Crystalline nature of solid, diffraction of X-ray, Bragg's law, Mosley's law – explanation from Bohr's theory. Origin of the energy gap, band theory; metal, semiconductor and insulators; intrinsic and extrinsic semiconductors, Direct and indirect bandgap semiconductor.

Nuclear Physics : Binding energy of nucleus – Binding energy curve and stability, Radioactivity – successive disintegration – radioactive equilibrium, radioactive dating, radioisotope and their uses, Nuclear transmutation – fission & fusion – nuclear reactor, elementary idea on particle physics.

Paper PH-292

PHYSICS LABORATORY-IV (50 Marks)

1. Drawing the characteristics for a Zener diode and to study it as a voltage regulator.
2. Study of transfer characteristics (collector – current and collector – voltage) characteristics of transistor in CE mode (*p-n-p*/*n-p-n*) and determination of current gain and hybrid parameters.
3. To study the characteristics of half wave and full wave rectifier.
4. To draw the angle of incidence vs deviation curve of a prism with the help of spectrometer and hence to find the angle of minimum deviation and refractive index of the material of the prism.
5. Calibration of a polarimeter and hence to determine the specific rotation and the concentration of a sugar solution.
6. Determination of the radius of curvature of the lower surface of a Plano-covex lens by using Newton's ring apparatus.
7. Study the temperature dependence of total radiation and hence verify the Stefan's law.

Paper PH-262

PHYSICS LABORATORY –IV (SUBSIDIARY) (50 Marks)

1. Drawing the characteristics for a Zener diode and to study it as a voltage regulator.
2. Study of transfer characteristics (collector – current and collector – voltage) characteristics of transistor in CE mode (*p-n-p*/*n-p-n*) and determination of current gain and hybrid parameters.
3. To study the characteristics of half wave and full wave rectifier.
4. Investigation of an inductance in an a.c circuit.
5. Investigation of capacitance of an a.c. circuits.
6. Investigations on a series resonant circuits.
7. Study the temperature dependence of total radiation and hence verify the Stefan's law.

THIRD YEAR

Semester-V

Paper PH-301 (50 Marks) **LECTURES 45 + 15 Tutorial**

QUANTUM MECHANICS-I

1. **Elementary quantum mechanics:**
Black-body radiation, Planck's formula, Photoelectric effect, Compton effect.
de Broglie hypothesis, Electron double-slit experiment, Davisson-Germer experiment.
Heisenberg's uncertainty principle (statement) with some applications, Gamma-Ray Microscope. 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.

2. Postulates of quantum mechanics:
Dynamical variables as linear hermitian operators and eigen value equations, Momentum, energy and angular momentum operators. Measurement of observables, expectation values. Compatible observables and simultaneous measurements, Ehrenfest theorem.

3. Time-independent and Time-dependent Schrodinger's equation:
Eigenstates, normalization and orthonormality, completeness

4. Applications of Quantum Mechanics:
Free particle in one dimensional box, box normalization, momentum eigen functions of a free particle. 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. Linear harmonic oscillator, energy eigen values from Hermite differential equation, wave function for ground state, parity of wave function.

5. 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.

Paper PH-303 (50 Marks) LECTURES 45 + 15 Tutorial

STATISTICAL MECHANICS-I

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.

2. Classical statistical mechanics: Maxwell-Boltzmann distribution law. Calculation of thermodynamic quantities for ideal monoatomic gases. Law of equipartition of energy, its limit of validity and applications.

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.

4. Quantum statistical mechanics: Bose-Einstein statistics: Application to radiation – Planck's law. Rayleigh-Jeans and Wien laws as limiting cases, Stefan's law. Bose-Einstein condensation (only discussion). 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.

Paper PH-305 (50 Marks) LECTURES 45 + 15 Tutorial

SOLID STATE PHYSICS-I

1. Crystal Structure and X-ray diffraction: Definition of crystal, crystal translation vector, lattice, crystal planes and Miller indices, crystal structure, symmetry operation, point groups.
Diffraction of X-rays by crystals, reciprocal lattice, Bragg's law, Brillouin zones, atomic and geometrical structure factor, and experimental diffraction methods.

2. Lattice Vibration: Vibration of linear monatomic and diatomic lattices, excitation of optical branch in ionic crystals- the infrared absorption, localized vibrations, quantization of lattice vibrations, experimental determination of the dispersion relations, inelastic scattering on neutrons, inelastic scattering of X-rays.

3. Free electron theory of metals: Free electron gas model in metals, free electron gas in one dimensional box, free electron gas in three dimensional box, filling up of energy levels, density of states, the Fermi energy, average kinetic energy of an electron, average velocity of an electron, heat capacity of the electron gas, Boltzman transport equation, electrical conductivity, Drude Lorentz theory, Sommerfield theory, Hall effect, thermal capacity of metals, ratio of thermal to electrical conductivity, field emission.

4. Band theory of solids: Wave functions in a periodic lattice and the Bloch theorem, the Kronig-Penny model, approximate solution near a zone boundary and band gap, the tight binding approximation, band theory of insulators and semiconductors, intrinsic semiconductors, band model. Extrinsic semiconductors, impurity states and band model.

Paper PH-307 (50 Marks) LECTURES 45 + 15 Tutorial

Electronic Measurements & Instrumentation

1. Semiconductor diodes:
p-n junction diode, I-V characteristics, analysis of half-wave and full-wave rectifiers, bridge rectifier with T and π-filter, avalanche and Zener breakdown, Zener diode and its applications, optoelectronic diodes: LED, photo diodes, 7 segment display.

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

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

4. Amplifier:
Voltage and current gain, principle of feedback, negative and positive 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,B,AB and C amplifier, analysis of single tuned voltage amplifier, requirement of power amplifiers, class B push-pull amplifier.

5. Oscillators:
Barkhausen criterion for sustained oscillation, L-C (Hartley, Colpitt), Weinbridge and crystal oscillators, relaxation oscillators- monostable, bistable and astable multivibrators.

6. Operational amplifier:
Properties of ideal OP-AMP, Input bias current, offset voltage, concept of virtual ground, differential amplifiers, CMRR, gain-band width product, inverting and non-inverting amplifiers, Instrumentation amplifier, mathematical operations.

7. Electronic Measuring Instruments : Electronic multimeter, Cathode-ray oscilloscope: Delay lines, CRO probes, Lissajous figures, CRT, brightness and focusing control, deflection sensitivity, vertical and horizontal amplifiers, time-base circuit , measurement of voltage, frequency and phase with CRO. digital multimeter, L and C measurements, counters.

Paper PH-309 (50 Marks) LECTURES 45 + 15 Tutorial

ATOMIC PHYSICS-I

1. Atomic Spectrum: Good quantum numbers, Bohr-Sommerfeld model and fine structure of H atom, Stern-Gerlach experiment and spin as an intrinsic quantum number. Incompatibility of spin with classical ideas. Study of fine structure by Michelson interferometer.

2. Vector atom model: Magnetic moment of the electron, Vector model – space quantization, L-S and j-j coupling schemes, spectroscopic terms of multi electron configurations, equivalent and non-equivalent electrons, Hund's rule, Lande g factor, Zeeman effect, selection rules, Paschen-back effect. Explanation from vector atom model.

3. Effects of external electric fields on one-electron spectra: Linear and quadratic Stark effects, atomic polarizability.

4. Structure and spectra of one-electron atoms: Quantum numbers, degeneracy, parity, atomic orbitals, exotic and Rydberg atoms.

Paper PH-391

PHYSICS LABORATORY- V (50 Marks)

1. Measurements of the slit width and the separation between the slits of a double slit by observing the diffraction and interference fringes.
2. 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.
3. Measurement of the reactance of a capacitor in C-R circuit using a volt meter.
4. Measurement of the reactance of a capacitor in L-R circuit using a volt meter.
5. To draw the resonance curve of a series L-C-R circuit and hence to determine the Q-factor of the circuit.
6. To draw the common source drain characteristics and the transfer characteristic of a JFET & hence to determine the FET parameters.
7. Study of standardization of the DC potentiometer and calibration of voltmeter and ammeter using DC potentiometer.

Paper PH-393

PHYSICS LABORATORY- VI (50 Marks)

1. To study the nature of dependence of r.i. (μ) of the material of a prism on the wavelength (λ) of the light used. Hence (i) To verify the Cauchy relation $(\lambda) = A+B/\lambda^2$ and to estimate the value of A and B. (ii) To plot a graph between $d\mu/d\lambda$ vs λ.
2. Determination of the resistance of a suspended coil galvanometer by half deflection method and hence to calculate the figure of merit of the galvanometer.
3. To determine the value of high resistance by leakage method.
4. To draw the B-H loop for the material of a anchor ring by ballistic galvanometer and to estimate the energy loss per cycle of magnetization.
5. To find the no. of lines per centimeter of the transmission grating and hence to measure the wavelength unknown spectral line and to measure the wavelength difference between D_1 and D_2 lines of sodium using of slit of adjustable width.
6. Verification of Thevenin, Norton and Maximum power transfer theorems using a resistive Wheatstone bridge, d.c. source and d.c. meters.
7. To study the variation of mutual inductance of a given pair of co-axial coils by using a ballistic galvanometer.

Semester- VI

Paper PH-302 (50 Marks) LECTURES 45 + 15 Tutorial

PHOTONICS

1. Photonics Information Processing: Optical Logic operations, Optical arithmetic operation With binary, tristate and modified tristate number.

2. Laser: Population inversion, Einstein's A and B coefficients; feedback of energy on a resonator; 3-level and 4-level systems. Ruby, He-Ne and semiconductor lasers, laser resonator, Threshold condition, saturation condition, classification of laser, Dye and Tunable laser, Quality factor.

3. Fiber Optics: Different types (single and multi mode) of step index and graded index optical fiber. Model propagation of Electromagnetic waves in optical fiber. Numerical aperture of optical fiber. Application of fiber in digital communication, pulse broadening in optical fiber.

4. Holography: Coherent light and application of coherent light in holography. Recording and reconstruction of wave front.

5. Non-linear optics: Non-linear optical phenomena, second and third harmonic generation, third order non-linearities, Parametric amplification and oscillation, Laser spectroscopy- stimulated Raman, Hyper-Raman, coherent anti-Stokes Raman scattering, application of Laser.

6. Optical fiber amplifier: Rare earth doped amplifier, dispersion compensation phenomena in optical fibers, dispersion & chirping. Non-linear phenomena in optical fibers- self phase modulation, cross phase modulation, optical solutions, non linear Schrodinger equation, principle of optical fiber directional coupler, Fiber Bragg gratings.

Paper PH-304 (50 Marks) LECTURES 45 + 15 Tutorial

NUCLEAR AND PARTICLE PHYSICS-I

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

2. Structure of Nucleus: 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).

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

(ii) 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.

(iii) Gamma decay : gamma ray spectra and nuclear energy levels, isomeric states. Gamma absorption in matter – photoelectric process, Compton scattering, pair production (qualitative).

4. 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.

5. 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.

6. Particle Accelerator and Detector: Cyclotron – basic theory, synchrotron, GM counter, Proportional counter, scintillation counter.

7. 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.

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

Paper PH-306 (50 Marks) LECTURES 45 + 15 Tutorial

MEASUREMENTS OF NON-ELECTRICAL QUANTITIES

1. Basic concept of measurement of Non-Electrical Quantities.
2. **Transducers and Sensors:** Resistance change, Inductance change, Capacitance change sensors, Opto-electric sensors, piezo-electric sensors, Thermal Expansion Sensors.
3. **Measurements of Temperature**: Definition of Absolute temperature scale, Practical scale of temperature. Expansion thermometers : Gas thermometers, pressure thermometers, bi-metallic thermometers.
   Resistance change thermometers : Platinum resistance thermometers , Thermistors.
   Thermo-electric thermometers.
   Low temperature measurements.
   High temperature measurements : Radiation pyrometers, optical pyrometers.
4. **Measurement of Pressure**: Absolute pressure, gauge pressure, differential pressure.
   Elastic pressure transducers :Diaphragm, Bellows, Bourdon tube – Secondary pressure transducers.
   Resistive pressure transducers – Inductive pressure transducers – Capacity pressure transducers.
   Low pressure measurements : McLeod Gauge, Pirani Gauge – Ionization Gauge – Thermocouple Gauge.
   High pressure measurements : Load cells.
5. **Measurement of Flow** : Pipe flow:
   Density- Bubbler method, radiation densitometer.
   Humidity- Hair hygrometer, resistance change hygrometer.
   Viscosity- Rotating cylinder, Saybolt viscometer.
   Level- Bubbler level gauge, Ultrasonic level gauge
   Orifice, Nozzle, Venturi tube, Pitot tube, Rotameter.
   Open-Channel Flow: Rectangular weirs, V-notches.
6. Elements of the measurements of Density, Viscosity, Moisture, Speed of Rotation, Liquid level.

Paper PH-308 (50 Marks) LECTURES 45 + 15 Tutorial

DIGITAL ELECTRONICS & MICROPROCESSOR-I

1. Boolean Algebra:
Binary, decimal and hexadecimal systems; conversion from one system to another; Boolean Algebra, 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.

2. Combinational logic:
Half adder, full adder, digital comparator (4 & 8 bit), decoder, encoder (ROM), multiplexure.

3. Sequential logic:
Flip-flops- RS, contact Deboundness, D, JK, JK-MS flip-flops, edge triggering. Shift register, ripple counter(binary and decade), Ring counter, MOD-N counter.

4. Communication principles:
Modulation and demodulation – elementary theory of AM, FM and PM, their relative advantage/disadvantage, demodulation of AM (diode detector) and FM (slope detector) waves.

5. Microprocessor:
Architecture, register structure, interrupts, bus structure. Interfacing concepts, memory interfacing. Basic concepts of programming a microprocessor, addressing data movement, arithmetic and logic instructions, (topic to be discussed with reference to 8085 microprocessor).

Paper PH-392

PHYSICS LABORATORY-VI I (50 Marks)

1. To determine the band gap energy of a given semi-conductor.
2. To draw the regulation characteristics of a bridge rectifier (i) without using filter and (ii) using a filter. Determine the ripple factor in both cases by measuring the ripple voltage with the help of a.c. meter.
3. (a) To draw the output characteristics of a silicon transistor and to calculate h_{oe} and h_{fc}. (b) To determine the hybrid parameters of a transistor using a.c. source.
4. To construct and study the frequency response of a voltage amplifier using a transistor in CE mode and to find its band width.
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 the electronic charge by Millikan oil drop apparatus.
7. Study and verification of image impedance of unsymmetrical T and Π networks and characteristic impedance of symmetrical T and Π networks.

Paper PH-394

PHYSICS LABORATORY- VIII (50 Marks)

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 source and to study its operational characteristic.
2. To design and test the following circuits using an OPAMP (i) Inverting and non-inverting amplifier (ii) Differential amplifier (iii) Adder (iv) Integrator (v) Differentiator etc.
3. 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.
4. To determine the Fourier spectrum of (i) square (ii) triangular and (iii) half sinusoidal wave form by CRO.
5. To various Boolean expressions using ICs.
6. To design half and full-adder circuits using basic gates and verify the respecter truth tables.
7. To design and to verify the following flip-flop operations using ballistic galvanometer : (i) S-R (ii) J-D (iii) D

Paper PH-396

MICROPROCESSOR LABORATORY -I (50 Marks)

Programming of Microprocessor 8085.

(a) Study of 8085 architecture (b) 8085 assembly language programming (c) Peripheral interfacing.

Paper PH-372

PROJECT PRESENTATION (25 Marks)

FOURTH YEAR

Semester- VII

Paper PH-401 (50 Marks) LECTURES 45 + 15 Tutorial

MATHEMATICAL PHYSICS-II

1. Complex Variable: Analytic functions, Cauchy-Riemann equation; Cauchy's integral formula; Taylor's expansion, Laurent's expansion; singularities, poles and branch points; Residue formulae.
2. Set and Group Theory: Definitions and operations involving sets, algebra of sets, union and inter section, Cartesian product of sets, mapping, closed and open sets, convergence and completeness.
Definition of groups, multiplication table, conjugate elements and classes, subgroups; direct product of groups; isomorphism & homomorphism, Permutation groups.
3. Linear space and operators: Vector space, inner propduct space, Schmidt's orthogonalisation method, Schwart inequality. Linear operators- matrix representation of operators. Special operators-conjugate operators, adjoint and self adjoint operators, unitary operators, orthogonality.
4. Tensors: General definition, contravariant, covariant and mixed tensors and their ranks; outer product of tensors, contraction of tensors, inner product of tensors; Symmetric and antisymmetric tensors; Kronecker delta. Metric tensor, raising and lowering of indices; Cartesian tensors.

Paper PH-403 (50 Marks) LECTURES 45 + 15 Tutorial

ADVANCE CLASSICAL MECHANICS-II

1. Lagrangian Mechanics: Review of D'Alembert's principle, Lagrange's equations, concept of symmetry, homogeneity and isotropy, conservation principles, Lagrange's equations for non holonomic systems, Lagrange's equations for impulsive forces.
2. Hamiltonian Formulation: Calculus of vibrations, Hamilton's principles, Lagrange's and Hamilton's equations from Hamilton's principles.
Canonical transformations, generating functions, example of canonical transformation. Poisson Bracket-relations of P.B., Conservation theorems in P.B. Formulation.
Hamilton-Jacobi equation, separation of variables, cyclic variables and the Kepler problem, Action angle variables, harmonic oscillator and Kepler problem in action-angle variables.
3. Rigid Body Dynamics: Euler angles, finite and infinetismal rotations, inertia tensor, motion of a heavy symmetric top rotating about a fixed point in the body under gravity.
4. Small oscillations: condition of stability near equilibrium, the eigenvalue equation & principal axes transformation, frequencies of free vibrations and normal coordinates, vibrations of molecules.

Paper PH-405 (50 Marks) LECTURES 45 + 15 Tutorial

QUANTUM MECHANICS-II

1. **Approximation methods for bound states:** Stationary perturbation theory, non degenerate and degerarate cases, Stark effect, Zeeman effect, variation method, ground state of Helium atom, WKB approximation, time dependent perturbation, theory of ionization of a hydrogen atom,Sudden approximation.
2. **Matrix formulation of Quantum Mechanics:** Hermitian and unitary matrices, transformation and diagonalization of matrices, transformation of the hamiltonian with unitary matrices, equation of motion in Schoridinger, Heisenberg and interaction picture, classical Lagrangian and hamiltonian equations of motion, Poisson brackers and commutator brackets, Matrix theory of the harmonic oscillator.
3. **Symmetry and Conservation laws:** Space and time displacement, rotations angular momentum matrices, space inversion parity.
4. **Angular momentum:** Angular momentum operators, spherical harmonics, commutation relations between angular momentum operators, angular momentum by operator method, raising and lowering operators, matrix representation for j=1/2 and j=1, Pauli spin matrices, addition of two angular momenta, Clebsch-Gordan coefficients.
5. **Symmetric in quantum mechanics**: conservation principles and degeneracy associated with symmetry, Continuous symmetries- spatial translation, rotation and time evolution, Discrete symmetries- Parity, time reversal and permutation, Rotation matrices, Spherical tensor operators, Wigner-Eckart theorem, Symmetry group and group representation.

Paper PH-407 (50 Marks) LECTURES 45 + 15 Tutorial

ELECTRODYNAMICS-II

1. Recapitulation of electrodynamics :
Recapitulation of field equations, scalar & vector potentials, Lorentz and Coulomb gauge, Conservation laws.

3. Field of moving charges and radiations:
Retarded potentials, Lienard Wichert potentials, Field produced by arbitrary moving charged particle at low velocity and at high velocity, angular distribution of radiated power.

4. Radiating System:
Oscillating electric dipole, radiation from an oscillating dipole, radiation from a linear antenna.

5. Radiation in material media:
Cherenkov effect, Thomson and Rayleigh Scattering, dispersion and absorption, Kramer Kroning dispersion relation.

Paper PH-409 (50 Marks) LECTURES 45 + 15 Tutorial

NUMERICAL ANALYSIS & COMPUTATION

1. Basic Concepts: Approximation of numbers, sources of error, significant figures, absolute, relative & percentage errors, generation and propagation of round off errors, Lagrangian interpolation problem and its advantages and disadvantages, Newton's forward and backward difference interpolation formula, Gaussian interpolation formulation.

2. Curve fitting: Polynomial least squares and cubic sp. Line fitting.

Numerical differentiation based on forward and backward interpolation formula, Lagrange's and central difference formula, Numerical integration based on trapezoidal and Simpson's 1/3 formula, Weddle's rule, Newton-Cotes formula, Gauss's method, Monte-Carlo evaluation of integrals.

3. Solution of Algebraic equation : Solution of Algebraic and Transcendental equations by the method of bisection, method of iteration, Regula Falsi method, Newton Raphson method, Roots of polynomial equations, convergence of solutions, Solution of system of linear equations by Gaussian elimination, iterative method, Matrix method, eigen values and eigen vectors of matrices, matrix diagonalization.

Numerical solution of ordinary differential equations by Euler's method, Piccard's method of successive approximation, Runge Kutta method.

Fundamentals of Optimization Techniques

Paper PH-491

PHYSICS LABORATORY –IX (50 Marks)

1. To find the e/m of an electron.
2. Measurement of the Hall coefficient of a given sample and calculation of its concentration.
3. To study experimentally the variation of resistivity of semi conductor with temperature and hence to find out the band calculation of its concentration.
4. To verify Fresnel's equations for reflection of electromagnetic waves.
5. Study of optical transducer.
6. Study of temperature transducer.
7. Determination of dielectric constant of different materials.

Paper PH-493

COMPUTER LABORATORY-I (50 Marks)

1. **Language (FORTRAN or C):** basic structure, character set, keyboards, identifiers, constants, variables, type declaration, operators—arithmetic, rational, logical, assignment, increment and decrement, operator precedence and associativity, arithmetic expression, evaluation and type conversion character I/O, escape sequence and formatted I/O, branching and looping, if, if-else, while, do-while, for arrays (one and two dimensional), function subprogram, subroutine
2. **Numerical Analysis:** Computer arithmetic and errors in floating point representation of numbers, different numerical for the following problems

Problems:

1. Sorting: arranging in ascending/descending order
2. Read N numbers, find their mean, median, mode
3. Solution of a quadratic equation with real/complex roots.
4. Solution of a quadratic equation with real/complex roots.
5. Sum of a G.P. series term by term
6. Matrix operations (addition, subtraction, multiplication, transpose)

Semester-VIII

Paper PH-402 (50 Marks) LECTURES 45 + 15 Tutorial

SOLID STATE PHYSICS-II

1. Dielectrics: Electronic, Ionic and Orientation Polarization, Internal field, Clausius-Mosotti equation, Ferro and Piezo electricity, Frequency dependence of dielectric constant, temperature dependence of dielectric constants and permanent molecular dipole moment, response of dielectric to an alternating fields.

2. Magnetism: 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. Magnetic exchange interaction-Ferro, antiferro & ferrimagnetism. ESR and NMR

3. Superconductivity : Basic phenomenology, Meissner effect, London's phenomenological theory and penetration depth, critical magnetic field, coherence length, type-I and type-II superconductors, magnetic flux quantization, entropy and specific heat, isotope effect, BCS theory, ac and dc Josephson effects, high temperature superconductors.

Paper PH-404 (50 Marks) LECTURES 45 + 15 Tutorial

SEMICONDUCTOR PHYSICS & DEVICE

1. Fundamentals of semiconductor: Idea of energy band, the Fermi level and energy distribution of carriers inside bands, temperature dependence of carrier concentration, carrier transport in semiconductors, generation and recombination process of excess carriers in semiconductor and idea of quasi Fermi levels, basic equation of semiconductor device operations.

2. P-N junction: diagrams, built in potential & depletion width, depletion layer capacitance, I-V characteristics for ideal diode, majority and minority carrier concentration, modification for real diodes, electrical breakdown in p-n junction.

3. P-N junction devices:

a) Majority carrier diodes

- Tunnel diodes: principle of operations & I-V characteristics
- Schottky barrier diodes: Metal semiconductor contacts, Schottky-Mott theory & surface states, Schottky effect, current flow mechanism, I-V characteristics, Ohmic contacts.

b) Microwave diodes:

- Varactor
- IMPATT
- TRAPATT

4. Transfer electron device: GUNN diode

5. BJT: Principle of operation, analysis of input & output characteristics for ideal transistor, modification for real transistor, high frequency performance.

6. JFET: Principle of operation, I-V characteristics of ideal model.

7. MOS device: Ideal MIS diode, surface space charge region, ideal MIS curves, Structure and operation of MOSFET, depletion & enhancement type, I-V characteristics, charge couple devices.

8. Optoelectronic devices:

- Photoconductor
- Solar cell
- Photodiode
- LED
- Semiconductor laser
- Phototransistor

9. Power rectifiers & Thyristors: Basic structures, I-V characteristics & applications.

10. Semiconductor measurements:

- Conductivity measurement: hot probe, four probe
- Hall measurement: Vander Pauw arrangement

Minority carrier lifetime measurement by photoconductive decay

Paper PH-406 (50 Marks) LECTURES 45 + 15 Tutorial

QUANTUM MECHANICS-III

1. Quantum theory of potential scattering: Laboratory and centre of mass frames, scattering cross-section amplitude, partial wave analysis, phase shift and resonance, scattering length, optical theorem, scattering by attractive square well and hard sphere, integral equation of scattering, Green's function, Lippmann-Schwinger equation, Born approximation, scattering by Yukawa potential, Coulomb scattering, introduction to S and T matrices.

2. Relativistic Quantum Mechanics: Klein- Gordon equation and its inadequacies, free particle Dirac equation, Dirac matrices, plane wave solution and its interpretation, negative energy states and hole theory, spin, helicity and magnetic moment of a Dirac particle, Dirac particle in central potential, relativistic angular momentum, radial Dirac equation and its solution for H-atom, non-relativistic limit of the Dirac equation, covariant formulation of Dirac equation, bilinear covariants.

3. Second Quantisation: Quantisation of non relativistic Schrodinger equation, Occupation number representation, Radiation field theory- electromagnetic field as oscillators, and vacuum quantization and its application in Lamb shift, energy and momentum of field quantum, interaction of atom with quantised radiation field, spontaneous and induced emission.

Paper PH-408 (50 Marks) LECTURES 45 + 15 Tutorial

SPECIAL THEORY OF RELATIVITY

1. Introduction: Concept of inertial frame and non-inertial frame. 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.

2. Special Theory of Relativity: Postulates of special theory of relativity; simultaneity; Lorentz transformation along one of the axes – length contraction, time dilation, Twin paradox and velocity addition theorem, Fizeau's experiment. Four vectors. Relativistic dynamics : variation of mass with velocity; energy momentum relationship, Doppler effect.

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.

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. Four Force and energy equations, Lagrangian and Hamiltonian of relativistic particles.

5. Relativistic electrodynamics: Transformation equation for f and J, transformation equations for A and f the electromagnetic field tensor, transformation equations for field vectors and covariance of Maxwell equations in 4 vector form, covariance and transformation law of Lorentz force, self energy of electron.

Paper PH-4010 (50 Marks) LECTURES 45 + 15 Tutorial

ADVANCE EXPERIMENTAL PHYSICS & MEASUREMENTS

1. Introduction to Experimental Physics : Theory of measurements calibration and standardization.
2. Static and Dynamic characteristics of Instruments : 1^{st} & 2^{nd} Order
3. Data Analysis: Basic statistical concepts, Normal distribution, curve fitting techniques, CHI-Sq. test
4. Gas Analysis : Thermal Conductivity method, Infra-red method, Paramagnetic Oxygen Analyzer, Gas chromatograph.
5. Microscopy : Compound microscopes, Electron microscopes (SEM, TEM, AFM).
6. X-Ray Methods: XRD.
7. Spectroscopy : UV, VIS, IR, X-ray, Raman, Florescence spectroscopy applications, atomic absorption spectro-photometer (AAS)**.**
8. Nuclear Magnetic Resonance, Mass spectrometry, computerized Tomography, positron emission Tomography

Paper PH-492 (50 Marks)
ADVANCE PHYSICS LABORATORY-X

1. Determination the Lande-g factor for a given sample using ESR.
2. Determination of wavelength of monochromatic light using He-Ne laser by Michelson's Interferometer.
3. Determination of wavelength of laser using diffraction grating.
4. To determine the numerical aperture of the PMMA fiber cable.
5. To study characteristics of LDR.
6. Study of LVDT
7. Study of strain Gauge.

Paper PH-494 (50 Marks)
COMPUTER LABORATORY-II
Problems:

1. Solution of simultaneous linear equations by Gauss-Siedel method
2. Least square fit of a given set of data to a straight line, application to exponential [$y=\exp(bx)$] and [$y=ax^b$] power laws.
3. Finding zeroes of a given function by the method of bisection and Newton-Raphson
4. Interpolation by Lagrange's method
5. Integration by trapezoidal and Simpson's rule
6. Least square technique: problems of linear least squares fit, applications
7. Error analysis
8. Solution of eigenvalue problems

FIFTH YEAR

Semester-IX

Paper PH-501 (50 Marks) LECTURES 45 + 15 Tutorial

STATISTICAL MECHANICS-II

1. Fundamentals of statistical mechanics: specification of states of a system, contact between statistics and thermodynamics, classical ideal gas, entropy of mixing and Gibb's .
Microcanonical ensemble, phase space, density of states, Liouville's theorem, canonical and grand canonical ensembles, partition function, calculation of statistical quantities, energy and density fluctuations.
2. Density matrix, statistics of ensembles, statistics of indistinguishable particles, Maxwell-Boltzman, Fermi-Dirac and Bose-Einstein statistics, properties of ideal Bose and Fermi gases, Bose-Einstein condensation.
Cluster expansion for a classical gas, Virial equation of state, Ising model, mean field theories of the Ising model in three, two and one dimensions , exact solution in one dimension.
3. Landau theory of phase transition, critical indices, scale transformation and dimensional analysis.
4. Correlation of space-time dependent fluctuations, fluctuations and transport phenomena, Brownian motion, Langevin theory, fluctuation dissipation theorem, the Fokker-Planck equation.

Paper PH-503 (50 Marks) LECTURES 45 + 15 Tutorial

ATOMIC PHYSICS-II & MOLECULAR PHYSICS

1. **Fine-structure in hydrogenic spectra:** Mass-velocity, spin-orbit and Darwin corrections, Lamb shift, hyperfine interactions.
2. **Interaction of one-electron atoms with radiation:** Transition probability and selection rules, allowed and forbidden transitions, atomic oscillator strengths and sum rule, atomic life-time and metastable states, atomic line-broadening mechanisms.
3. **Spectra of alkali atoms:** Spin-orbit interaction and fine-structure.
4. **Many-electron theory:** Identical particles, symmetric and anti-symmetric wave function, Pauli exclusion principle, Central-field approximation and corrections to it, Thomas-Fermi approximations, Slater determinant, Hartree, Hartree-Fock, Density functional theory.
5. **Spectra of two-electron atoms:** ortho and para states of He, energy of ground and excited configurations
   Types of molecules and molecular spectra, Born-Oppenheimer approximation.
   Rotational spectra of diatomic molecules- rigid and non-rigid rotator models, intensity; Symmetric top molecule. Vibrational spectra of diatomic molecules- harmonic and anharmonic oscillator models, Morse potential, Rotation-Vibration coupling, different branches, intensity; Frank-Condon principle; Raman spectroscopy- rotational and vibrational Raman spectrum-theory.

Paper PH-505 (50 Marks) LECTURES 45 + 15 Tutorial

NUCLEAR & PARTICLE PHYSICS-II

1. Nuclear Interactions and Nuclear Reactions: Nucleon interaction, exchange forces and tensor forces, Meson theory of nuclear forces, nucleon-nucleon scattering, effective range theory, spin dependence of nuclear forces, charge independent and charge symmetry of nuclear forces, isospin formalism, Yukawa interaction.

2. Direct and compound nuclear mechanisms: cross-sections in terms of partial wave amplitudes, compound nucleus, scattering matrix, reciprocity theorem, Breit-Wigner one level formula, resonance scattering.

3. Alpha decay: Gamow's theory.

4. Beta decay: Angular momentum and parity selection rules, allowed and forbidden transitions, selection rules, parity violation, two component theory of neutrino decay, detection and properties of neutrino, Gamma decay, multiple transitions in nuclei, angular momentum and party selection rules, internal conversion, nuclear isomerism.

Two nuclear problem, deuteron ground state, nuclear scattering, sources on neutrons, its detection, measurement of energy, neutron diffraction application, interaction of neutron with matter.

5. Elementary Particle Physics: Symmetry and conservation laws, elementary ideas of CP and CPT invariance, classification of hadrons, Lie algebra, SU(2), SU(3) multiplets, quark model, Gell-Mann-Okubo mass formula for octet and decuplet hadrons, charms, bottom and top quarks.

6. Nuclear Astrophysics:

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

Paper PH-507 (50 Marks) LECTURES 45 + 15 Tutorial

MICROPROCESSOR-II & MICROCONTROLLER

1. Introduction to Microprocessors: The evolution of microprocessors (from 4 bits onwards). Basic functions of a microprocessor. Programmer's model, data formats.

2. Architecture of 8085 microprocessors: Pin-out configuration o 8085, Instruction timing & execution, Demultiplexing & buffering of system buses of 8085 CPU. Instruction set, classification of instructions, addressing modes, software model of 8085 CPU.

3. Assembly Language Programming using 8085 CPU: Program writing for different arithmetic operation with 8-bit & 16-bit binary numbers and BCD numbers, program for searching & sorting. Code conversion, concept of look-up table. Use of SID and SOD pins of 8085, writing program using time delays & calculation of T-states. Stacks & Sub-routines.

Interrupt structure of 8085 & their uses.

4. Memory & their interfacing: Interfacing of RAM, ROM, EPROM & DRAM etc.Battery backup of memories, EPROM programming algorithm & its software implementation.

5. I/O interfacing technique: Addressing the I/O devices, I/O mapped I/O & memory mapped I/O, data transfer schemes-synchronous & asynchronous data transfer, interrupt driven data transfer, DMA.

6. Support chips: 8255, 8253, 8251, 8279, 8259, 8237,8212, 8257.

Interfacing of DAC, ADC, keyboards, printer, and displays using 8255.

7. Architecture of 8086/8088 microprocessors: 8086-pin assignment, addressing modes, software model, instruction sets, classification of instructions, assembly language programming, memory interfacing, interrupts, I/O interfacing, interfacing of support chips, interfacing of ADC, DAC , keyboards, displays etc.

8. Introduction to Microcontroller: 8051 microcontroller, 8051 pin description connection, I/O ports memory & memory organization, addressing modes & instruction set, 8051 assembly language programming, interrupts-a few applications of Microcontroller.

9. Industrial applications of Microcontroller: Traffic Control, Stepper motor, Scrolling Display.

Paper PH-591 **(50 Marks)**

ADVANCE PHYSICS LABORATORY-XI

1. To study V-I characteristics of LED.
2. Obtain X-ray Debye Scherrer photograph and determination of unit cell dimensions of a crystal.
3. Obtain the Laue photograph of a single crystal and drawing gnononic projectional and indexing the spots.
4. Pressure Transducer explorer.
5. To determine the wavelength of monochromatic light using Fresnel's biprism.
6. To determine the velocity of light in air.
7. Determination of barrier potential of p-n junction/p-n-p transistor.

Paper PH-593 **(50 Marks)**

MICROPROCESSOR LABORATORY-II

Programming of Microprocessor 8086.

(a) Study of 8086 architecture (b) 8086 assembly language programming (c) Working and interfacing of 8087 math coprocessor (d) Working and interfacing of 8089 I/O processor

Paper PH-581 (25 Marks)

GRAND VIVA

Semester-X

Paper PH-502 (50 Marks) **LECTURES 45 + 15 Tutorial**

Material Physics –I

1. **Material preparation and characterization:** Preparation of materials by different techniques: Bulk crystal growth, Epitaxial growth, Thermal and electron evaporation technique, Sputtering, CVD, Melt and quenching, Gel desiccation. Characterization of material by XRD, thermal methods (DSC, DTA), Optical method (IR. FTIR, Raman), Microscopic (SEM, TEM, STEM. AFM etc.). Mechanical and electrical methods. Non destructive testing.
   .
2. **Magnetic and superconducting materials:** Dia, para, ferro, ferri and antiferroelectric materials; Crystal field splitting, quenching of orbital angular momentum in iron group ions, cooling by isoentropic demagnetization of paramagnetic materials.
   Superconductivity: Electromagnetic properties of semiconducting states – critical temperature, zero resistance and persistent current, Meissner effect, London's phenomenological theory and penetration depth, critical magnetic field, coherence length, Type-I and Type-II superconductors, magnetic flux quantization. Thermodynamic properties – stabilization free energy, entropy, electronic specific heat. Isotope effect. Ginzberg – Landau theory. Microscope (BCS) theory of superconductivity - Cooper instability and formation of Cooper pairs. Superconductivity tunneling – ac and dc Josephson effects. High temperature superconductors.

Paper PH-504 (50 Marks) LECTURES 45 + 15 Tutorial

Material Physics –IA

1. **Structure of Materials:** Atomic structure and interatomic bonding, Structure of crystalline solids, structure of non-crystalline soilds (SRO and MRO); Radial distribution function, Solid solutions. Phases, Thermodynamic of solutions, Phase rule, Binary phase diagrams, Binary isomorphous systems, Binary eutectic systems, ternary phase diagrams, kinetics of solid state reactions.
2. **Physics of Semiconductors:** Semiconductor materials – elemental & compound semiconductors & their properties. Intrinsic and extrinsic semiconductors. Direct & indirect band gap semiconductors. Variation of energy bands for gr III-IV ternary, band gap semiconductors. Concepts of Fermi level, Drift & Diffusion of carriers conductivity & mobility. Effect of temperature and doping, Hall effect in semiconductors. Excess carriers in semiconductors – low & high level injection, Generation & recombination process, Direct and indirect recombination, Concept of 'quasi' Fermi level. Basic equation for semiconductor device operations. Continuity equation, Current flow equation, Carrier transport equation etc. Energy band diagram fro homo and hetro junctions, p-n junctions, Effect of bias, calculation of built-in potential, calculation of depletion width (W) and depletion layer capacitance, Current flow mechanism, Breakdown mechanism.

Paper PH-506 (50 Marks) LECTURES 45 + 15 Tutorial

Non-linear materials and Photonics

1. **Dielectric and optical properties:** Theory of Electronic polarization and optical absorption, Ionic polarization. Optical phonon mode in an ionic crystal: Interaction of electromagnetic waves with optical modes, Polariton, Dispersion curves of Transverse Optical (TO) phonon and optical photon in diatomic ionic crystal, LST relation. Dielectric function of the electron gas: Plasmon, Exciton, Metal-insulator transition.
2. **Ferroelectric crystal:** Theory of ferroelectric transition – first order and second order phase transitions. Antiferroelectricity, Pizo electricity, Electrostriction.
   Luminescence, Fluorescence, Phosphorescence, Raman scattering, Spectroscopic techniques.
3. **Physics of Laser and Laser applications:** Coherence and Monochrmaticity, Line shape function; Line broadening mechanisms: Natural broadening, Collision broadening. Principles of light amplification: Interaction of atoms with radiation, Lasing action, Population inversion, Role of feedback (Cavity), Threshold condition for population inversion.
4. **Laser rate equations:** Two, three and four level systems.
5. **Modes of Laser Oscillations**: Mode selection process: Transverse mode selection and Longitudinal mode selection. Production of giant pulse: Q switching technique.
6. **Different laser systems:** Gas lasers, Solid state and liquid state lasers, Operation principles, design and output characteristics

Paper PH-508 (50 Marks) LECTURES 45 + 15 Tutorial

Opto-electronics

1 **Optical fibers and characterization**: Transmission characteristics of fibers – Modal analysis of a step index fiber, single mode fibers – spot sizes, attenuation – absorption & scattering losses, bending loss, splice losses. Dispersion – inter and intra modal dispersion, material dispersion and wave-guide dispersion, design consideration of various fibers.
2 **Preparation of fibers:** Liquid phase techniques, vapor phase deposition, OVPO, VAD, MCVO, PCVD and design of optical fiber cables.
3 **Optoelectronic devices:** Optical processes in semiconductors, absorption: direct and indirect, generation and recombination and non-radiative processes, recombination efficiency.
4 **Optical sources:** LED – basic principles, characteristics, spectrum, structures, applications. Laser diodes – basic principles, characteristics, spectrum, structures, applications.
5 **Optical detectors:** photo-conductors, photo-diodes, Photo-transistors – basic principles, characteristics, spectral response, Speed of response structures, Band width, applications.

OR

Paper PH-502 (50 Marks) LECTURES 45 + 15 Tutorial

General Relativity

1. PRINCIPLES OF RELATIVITY
Overview of Special Relativity, spacetime interval and Lorentz metric, propertime, action for free particle, relativistic dynamics, four vectors, electrodynamics in 4 dimensional language. Introduction to general relativity (GR), equivalence principle, gravitation as a manifestation of the curvature of spacetime.
2. GEOMETRICAL FRAMEWORK OF GENERAL RELATIVITY:
Curved spaces, tensor algebra, dynamics of particles and affine connection, covariant derivatives and parallel transport, Physics in curved spacetime, Curvature - Riemann tensor, Bianchi identities, Action Principle, Einstein's field equations, Energy momentum tensors, Spacetime symmetries and Killing vectors, energy-momentum tensor for a perfect fluid, connection with Newton's theory.
3. SOLUTIONS TO EINSTEIN'S EQUATIONS AND THEIR PROPERTIES:
Spherical symmetry, derivation of the Schwarzschild solution, test particle orbits for massive and massless particles. The three classical tests of GR, Black holes.
4. APPLICATIONS OF GR:
Black holes: Kruskal-Szekeres metric, event horizon - one way membranes, introduction to the Kerr metric.
Gravitational Waves: Linearized field equations - Gravitational Waves-polarization, he-licity, energy momentum; Generation of Gravitational waves; effect on a test particle; Binary pulsar; detection of gravitational radiation.
Relativistic Astrophysics: Interior solution for a spherical star; Oppenheimer – Volkoff equation; Neutron stars and Black holes.
5. ADVANCED TOPICS:
Maxwell's equations in General Relativity; Reissner-Nordstrom solution, charged black hole. Kerr-Newmann black hole (no derivation of the metric required). Ergosphere, Penrose process. Laws of Black hole thermodynamics.

Paper PH-504 (50 Marks) LECTURES 45 + 15 Tutorial

Astrophysics -I

1. GRAVITY:

Newtonian gravity and basic potential theory; Simple orbits - Keplers laws and precession, flat rotation curve of galaxies and implications for dark matter; virial theorem and simple applications; role of gravity in different astrophysical systems

2. RADIATIVE PROCESSES:

Overview of radiation theory and Larmor formula; Different radiative processes: Thom- son and Compton scattering, Bremsstrahlung, Synchrotron [detailed derivations are not expected]; Radiative equilibrium, Planck spectrum and properties; line widths and transition rates in quantum theory of radiation; qualitative description of which radiative processes contribute in which waveband/astrophysical system; distribution function for photons and its moments; elementary notion of radiation transport through a slab; concept of opacities. (Some of these topics will also come up naturally in other modules like Stars and High energy Astrophysics).

3. GAS DYNAMICS:

Equations of fluid dynamics; equation of state in different regimes [including degenerate systems]; Models for different systems in hydrostatic equilibrium; Application to White dwarfs/Neutron stars; Simple steady fluid flows - application to Bondi accretion; supersonic flow and shocks; example of SN explosions and its different phases.

4. GALACTIC PHYSICS

Galaxies as self gravitating systems; Virial theorem, Potentials and orbits including epicyclic orbits (Expand or combine with module 1); Spiral galaxies including the Milky way galaxy; spiral structure; The collisionless-Boltzmann equation; Elliptical galaxies; Super massive black holes in galaxies; Active galactic nuclei.

Paper PH-506 (50 Marks) LECTURES 45 + 15 Tutorial

Cosmology

1. COSMOLOGICAL MODELS:

Cosmological Principle, Robertson-Walker metric, cosmological redshift, Hubble's law, Observable quantities – luminosity and angular diameter distances, Dynamics of Friedman-Robertson-Walker models: Solutions of Einstein's equations for sources with $p = \omega \rho$ and $\omega = -1$, 0, 1/3, discussion of closed, open and flat Universes.

2. PHYSICAL COSMOLOGY AND THE EARLY UNIVERSE:

Thermal History of the Universe, distribution functions in the early Universe – relativistic and non-relativistic limits; Decoupling of neutrinos and the relic neutrino background; Nu-cleosynthesis; Decoupling of matter and radiation ; Cosmic microwave background radiation (CMB); Inflation – Origin and growth of Density Perturbations; Formation of galaxies and large scale structures; Anisotropies in CMB; The Intergalactic medium and reionization.

Paper PH-508 (50 Marks) LECTURES 45 + 15 Tutorial

Astrophysics - II

1. STELLAR PHYSICS

Observational data on stars (HR diagram); Basic equations of stellar structure; Stellar energy sources; qualitative description of numerical solutions for stars of different mass; homologous stellar models; Stellar evolution; Evolution in the HR-Diagram; End state of stars, compact objects, White dwarfs, Neutron stars and Black holes.

2. HIGH ENERGY ASTROPHYSICS

High Energy Universe: Introduction to Supernova & supernova remnants, neutron stars, pulsars and magnetars, X-ray binaries, gamma-ray bursts & active galactic nuclei; Accretion process in astrophysics; Astrophysical jets - emission from jets, beaming and boosting; superluminal motion; Cosmic rays; Radio emission from the Galaxy.

3. SOLAR PHYSICS

Physical Characteristics of sun- basic data, solar rotation, solar magnetic fields, Photosphere - granulation, sunspots, Babcock model of sunspot formation, solar atmosphere chromosphere and Corona, Solar activity- flares, prominences, solar wind, activity cycle, Helioseismology

OR

Paper PH-502 (50 Marks) LECTURES 45 + 15 Tutorial

NANOSCIENCE AND NANOTECHNOLOGY-I

1. **Physics of Nanostructures:** Reviews of quantum mechanics in reduced dimensions and solid state physics, Optical properties of semiconductors, optical constants, optical absorption, radiative transition and luminescence, exciton effect etc. Ternary and quaternary compound semiconductors, heterostructures, quantum wells and superlattices, quantum effect devices. transport in low-D systems, optoelectronics of nanostructures, nanotubes and nanowires, clusters and nano-crystallites, molecular electronics.
2. **Nanomaterials: Science and Engineering:** Physics of nanoscale engineering, nanofabrication and nano characterization techniques, single electron devices, nano-magnetism and nano-electromechanical systems. Nano-scale phenomena and the related chemical, physical and transport properties, size effect and quantum mechanics, nano-thermodynamics and nano phase diagrams, interface and surface of nanoparticles and their effects, processing of organic, inorganic and bio-based nano particles, nano composites and thin films, advanced characterization of long range and short range orders, x-ray scattering, anomalous x-ray scattering, extended absorption fine structure.

Paper PH-504 (50 Marks) LECTURES 45 + 15 Tutorial

NANOSCIENCE AND NANOTECHNOLOGY-IA

Design and synthesis of nanostructure materials: Thin-film growth techniques, common techniques for nano-structure fabrication and characterization, Top down and bottom up approach, Chemical process: Sol-gel method, plating, ion exchanged and reduction electro deposition technique, L-B technique; Physical process: vaporization, sputtering, chemical vapour deposition, molecular beam epitaxy, hot-wall epitaxy and laser ablation, and related theories and technology for thin film growth, condensation, nucleation, phase stability and basic modes of thin film growth, zone models for evaporated and sputtered coatings, factors on properties of thin films, columnar structure and epitaxial growth, thin film reactions, optical and electrical properties.

Paper PH-506 (50 Marks) LECTURES 45 + 15 Tutorial

NANOSCIENCE AND NANOTECHNOLOGY-II

Nanostructured Materials and their Applications: Physics of thin film deposition, adsorption, surface deposition, nucleation growth and structure development; Surface structure, role of surfaces in nanosciences; Epitaxial growth, lattice mismatch and strain, growth modes, self organization, self aligned nanostructures, heterostructures; Growth of quantum structures, Q-wells, Q-wires and Q-dots, Multilayer superlattice structures, single photon sources, Bulk nanostructured materials, porous silicon, nanoparticles in zeolites, ferroelectric nano-materials and their applications; Metal Nanoclusters, Semiconducting Chalcogenide and oxide based nanocrystals and nanoparticles, nanowires, applications; Carbon clusters, Carbon nanotubes, applications; Polymers and polymer based composites, conducting polymers; Molecular and bio materials, biological nanostructures, Molecule based switches and logic devices; Bio-molecular electronic devices.

Paper PH-508 (50 Marks) LECTURES 45 + 15 Tutorial

NANOSCIENCE AND NANOTECHNOLOGY-IIA

Surface Physics: Production of high and ultrahigh vacuum, Diffusion, turbo-molecular ion and cryo pumping; Introduction to surfaces in ultrahigh vacuum; thermodynamic and statistical properties of clean surfaces; Concept of band gap engineering, Electron affinity, Work function; Interactions between light/ion/electron beams with surface and the surface analysis techniques derived from (including XPS, UPS, IR/Raman, RBS, SIMS, Auger, STM/AFM etc.); electronic, magnetic and optical properties at the surface; surface science in thin films, nanostructures and biomaterials; adsorption phenomena at surfaces; surface processes on nucleation and epitaxial growth; catalysis etc.
Nanostructured Catalysts Design and Organic Synthesis: Catalytic processes - synthesis of chemicals, materials, and pharmaceuticals. Strategies for surface modification and compositional design - characterization and use of nanostructured catalysts in organic synthesis - oxidation/reduction, hydrogenation, self-assembly.

Paper PH-552 (50 Marks) LECTURES 45 + 15 Tutorial

ELECTIVE PAPER

COMPUTER APPLICATION IN PHYSICS

7. **Introductory**: Brief introduction to operating systems
8. **Numerical Methods**: Spline interpolation, Rational interpolation, Gaussian quadrature formula, Solution of algebraic and transcendental equation, Solution of systems of linear equations, Least square fitting methods, Iterative algorithm for largest and smallest eigen values, Jacobi's method, Determination of eigen value, Ordinary differential equations-initial and boundary value problems, Pade Approximation, Partial differential equations – introduction to finite element methods.
9. **Solution of Physical Problems**: Simple Harmonic Oscillation, forced and coupled oscillation, motion of a body under central forces, computation of fields and a Gaussian wave packet, Determination of bound state energies and wave function in 1D & 3D, Scattering of wave packet by a step potential, Scattering in 3D, Function of random variables.
10. **Simulations**: Random numbers and Random variables, Pseudo random number generator, Monte-Carlo simulation – random walk problem, The approach of equilibrium, Calculation of entropy, Microcanonical ensemble 1D classical gas, Metropolis algorithm: Ising model diffusion limited growth models, Introduction to maps, fractals.

Paper PH-592 **(50 Marks)**

ADVANCE PHYSICS LABORATORY-XII

1. Determination of Ultrasonic velocity in some liquids at varying temperature by ultrasonic interferometer.
2. Determination of the gamma and beta ray absorption coefficients by using a G.M. counter.
3. Absorption / Transmission of thin films by using UV/Vis spectrophotometer.
4. Determination of susceptibility of paramagnetic solution(Ferric chloride and Manganese sulphate).
5. Dielectric and Curie temperature measurement of ferroelectric ceramic (Barium Titanate – $BaTiO_3$).
6. To measure the transition temperature of a high temperature superconductor and demonstrate the Meissner-Ochsenfeld effect.

Paper PH-572 **(50 Marks)**

PROJECT WORK & SEMINAR

RECOMMENDED BOOKS

Mathematical Physics

1. Mathematical Methods for Physics- Arfken & Weber (Elsevier)
2. Introduction to Mathematical Physics - C. Harper (Prentice-Hall of India).
3. Mathematical Methods - M. C. Potter and J. Goldberg (Prentice-Hall of India).
4. Vector Analysis - M. R. Spiegel, (Schaum's Outline Series) (Tata McGraw-Hill)
5. Mathematical Physics – P.K. Chattopadhyay (Wiley Eastern)
6. 6. Tatwiya Padartha Bidyar Bhumika – S. Sengupta, Asok Ghosh and D. P. Roychaudhuri (W.B. State Book Board (WBSBB)).
7. Mathematical Physics By: H.K. Dass, Dr.Rama Verma (S. Chand)
8. Mechanics & Mathematical Physics By: Murugeshan,R. (S. Chand)
9. Mathematical Physics By: B.S. Rajput (Pragati)
10. Mathematical Methods- Morse & Feshbach
11. Mathematical Physics- B.D. Gupta (Vikas Pub)
12. Mathematical and Experimental Physics – S. Jayalakshmi, J. Arokiaraj & others (Narosa)
13. 13. A Text book of Mathematical Physics – Suresh Chandra (Narosa)
14. Vector Spaces and Matrices in Physics – M.C.Jain (Narosa)

Classical Mechanics

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).
13. Mechanics By: Mathur,D.S., P.S. Hemne (S. Chand)
14. Classical Mechanics - Suresh Kr. Sinha (Narosa)
15. Classical Mechanics- N. Mukundo
16. Classical Mechanics- Sommerfeld

General Properties of Matter

1. Mechanics & General Properties of Mater- D.P.Roychowdhuri & S.N.Maiti
2. A Treatise on General Properties of Mater- Sengupta & Chatterjee (Central)
3. General Properties of Mater- A.B.Gupta
4. Advance Problems & Solutions in Physics- S.N. Goswami (Books & Allied Ltd.)
5. Properties Of Matter By: Murugeshan,R. (S. Chand)
6. Properties of Matter and Acoustics for B.Sc. By: Murugeshan,R., Kiruthiga Sivaprasath (S. Chand)

7. : Elements of Properties of Matter By: Mathur,D.S. (S. Chand)
8. Properties of Matter By: Brij Lal (S. Chand)
9. Physics for Degree Students for B.Sc. Second year By: C.L.Arora, P.S. Hemne (S. Chand)

Heat & Thermodynamics

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).
9. Text Book of B.Sc.Physics (Thermodynamic & Optics)
By: Anwar Kamal, R.B. Ramchander (S. Chand)
10. Thermal Physics By: Murugeshan,R., Kiruthiga Sivaprasath (S. Chand)
11. Heat, Thermodynamics And Statistical Physics
By: Dr.N.Subrahmanyam, Brij Lal, P.S. Hemne (S. Chand)
12. Basic Thermodynamics - E. Guha (Narosa)
13. Thermodynamics, Kinetic theory and statistical Thermodynamics – F.W.Sears, G.L. Salinger (Narosa)

Acoustics & Waves

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. A Text Book Oscillations,Waves & Acoustics By: M. Ghosh, D. Bhattacharya (S. Chand)
5. Sound - K. Bhattacharyya (Shreedhar Prakashani)

Optics

1. Fundamentals of Optics - F. A. Jenkins and H. E. White (Mc Graw Hill, Kogakusha).
2. Geometrical and Physical Optics - B. S. Longhurst (Orient Longmans).
3. Optics – A. K. Ghatak (Tata Mc Graw Hill).
4. Optics – Hecht and Zajac (Addison-Wesley)
5. Optics – B. K. Mathur.
6. Bhauta Alok Bigyan – B. S. Basak (WBSBB).
7. A Textbook Of Optics (M.E.) By: M.N.Avadhanulu, Dr.N.Subrahmanyam, Brij Lal (S. Chand)
8. Optics And Spectroscopy By: R. Murugeshan, (S. Chand)
9. Geometrical and Physical Optics – P.K. Chakrabati (New Central Book Agency)

Electricity & Magnetism

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 (Central Book)
6. Electricity and Magnetism – A. S. Mahajan and A. A. Rangwala (Tata McGraw-Hill).
7. Classical Electrodynamics – J.D. Jackson (Wiley India)
8. Electricity and Magnetism with Electronics By: Tewari,K.K. (S. Chand)
9. Fundamentals of Magnetism & Electricity By: Vasudeva,D.N. (S. Chand)
10. Electricity and Magnetism By: Tewari,K.K. (S. Chand)
11. Electromagnetic Field Theory and Wave Propagation - Uma Mukherji (Narosa)
12. Electromagnetic Theory and Applications – A.K. Saxena (Narosa)
13. Electronics : Circuits and Analysis - Dinesh C. Dube (Narosa)
14. Elementary Biophysics : An Introduction - P.K. Srivastava (Narosa)
15. Foundations of Electromagnetic Theory (3rd Edi.) J.R.Reitz, F.J.Milford & R.W.Christy (Narosa)
16. Magnetic Properties of High-Temperature Superconductors – M.R.Koblischka (Narosa)
17. Classical Electrodynamics- Philips & Panopsky
18. Principles of Electricity and Magnetism - S. Palit (Narosa)

Quantum Mechanics

1. Quantum Mechanics – J. L. Powell and B. Crasemonn, (Narosa)
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)
7. Quantum Mech,Statistical Mech,& Solid State By: Rakshit,P.C., Chattopadhyay,D. (S.Chand)
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