**M.Sc. (Physics) Semester I**

**PHYC-101**

**MATHEMATICAL PHYSICS -I (4 Credits)**

**UNIT I (13 Lectures)**

Fundamental laws of Algebra on complex numbers, polar form of complex numbers, Properties of moduli and arguments, Regions in the complex plane **(04 Lectures)**

Continuity and differentiability of complex functions, Analytic (regular) functions, The Cauchy-Riemann equations, Polar form of Cauchy-Riemann equations **(04 Lectures)**

Laplace's equations, Harmonic functions, Entire function, Branch cuts and branch points, Problems on the above topics **(05 Lectures)**.

**UNIT II (13 Lectures)**

Line integral in complex plane, Cauchy's theorem, Morera's theorem **(03 Lectures)**

Cauchy's integral formula, Taylor's and Laurent's expansions, Liouville's theorem, singularities, Zeroes and poles **(05 Lectures)**

Residue theorem and count our integration of simple functions, Jordan's lemma, Problems on the above topics **(05 Lectures)**.

**UNIT III (12 Lectures )**

Ordinary point and singularities of a linear differential equation **(02 Lectures)**

Power series, solution of second order differential equations (Hyper- geometric, Bessel, Legendre, Laguerre and Hermite equations) **(05 Lectures)**

Orthonormality, Rodrigue's formula and other properties of Legendre, Associated Legendre, Bessel and Laguerre functions and polynomials **(05 Lectures)**

**UNIT IV (13 Lectures )**

Methods of numerical analysis: Finite difference with equal and unequal intervals, Interpolation formulae **(07 Lectures)**.

Errors and accuracy tests in numerical analysis, the iterative algorithms for solving equations and finding roots**(04 Lectures)**

Discrete Fourier Transform, Fast Fourier Transform **(02 Lectures)**.

**M.Sc. (Physics) Semester I**

**PHYC-102**

**CLASSICAL MECHANICS (4 Credits)**

**UNIT-I (12 Lectures)**

Mechanics of a system of particles, Constraints, Classification of Constraints, Generalized Co ordinates **(04 Lectures)**

Virtual displacement and principle of virtual work, D'Alembert Principle **(02 Lectures)**

Lagrange's Equations, Generalized momenta, Cyclic Co ordinates, Conservation Laws **(06 Lectures)**

**UNIT-II (13 Lectures)**

Calculus of variation- Euler- Lagrange Equation **(02 Lectures)**

Application of Variational Principle, Shortest distance problem, brachistrochrone, Geodesics of a Sphere **(03 Lectures)**

Variation under constraints-Lagrange's multipliers **(02 Lectures)**

Hamilton's principle, Lagrange's equations from Hamilton's principle, Principle of least action **(06 Lectures)**

**UNIT-III (13 Lectures)**

Hamilton's equations, Canonical Transformation, Generating function, Infinitesimal canonical transformation, Conditions for canonical transformation and problems **(06 Lectures)**

Poisson Brackets and their properties, Invariance of Poisson Bracket under canonical transformation **(03 Lectures)**

Hamilton-Jacobi Equations, Hamilton's principle and characteristic function, Action and Angle Variables **(04 Lectures)**

**UNIT-IV (12 Lectures)**

The Rigid body motion- Euler Angles, Inertia Tensor and Moment of Inertia, Euler's Equation of motion, Motion of heavy symmetrical Top **(06 Lectures)**

Theory of small oscillations- Free vibration of a linear tri-atomic molecule, Transition from a discrete to a continuous system, Field Equation- Klein Gordan Equation **(06 Lectures)**

**M.Sc. (Physics) Semester I**

**PHYC-103**

**ELECTROMAGNETIC THEORY (4 Credits)**

**UNIT I (12 Lectures)**

Maxwell's Equations in vacuum and matter, Maxwell's correction to Ampere's law for non-steady currents and concept of Displacement current. **(06 Lectures)**
Boundary conditions for electromagnetic fields, Poynting's theorem, Conservation of energy and momentum for a system of charged particles and electromagnetic field. **(06 Lectures)**

**UNIT II (12 Lectures)**

Vector and scalar potentials, Maxwell's Equations in terms of Electromagnetic Potentials, Electromagnetic wave equation **(04 Lectures)**
Non-uniqueness of Electromagnetic Potentials and Concept of Gauge. Gauge Transformations: Coulomb and Lorenz Gauge. **(04 Lectures)**
Green's Function for the Wave Equation, Transformation Properties of Electromagnetic Fields and Sources under Rotation, Spatial Inversion and Time-Reversal. **(04 Lectures)**

**UNIT III (13 Lectures)**

Propagation of Electromagnetic Plane Waves in Vacuum, Non-conducting Medium, Conducting Medium and Plasma, Dynamic value of conductivity. **(05 Lectures)**
Reflection, Refraction and Polarization of Electromagnetic Waves, Fresnel Formulae, Total internal reflection and critical angle. **(04 Lectures)**
Frequency Dispersion Characteristics of Dielectrics and Conductors; Normal and Anomalous Dispersion, Spreading of Pulse in Dispersive Media, Kramer-Kronig Relations. **(04 Lectures)**

**UNIT IV (12 Lectures)**

Basic concept of waveguide, Propagation of Electromagnetic Waves in Rectangular Waveguides, TE and TM Modes, Cut off frequency, Energy Flow and Attenuation. Modal Analysis of guided modes in a cylindrical waveguide, Cavity resonator. **(08 Lectures)**
Optical fiber as a waveguide, Wave propagation in optical fibers. **(02 Lectures)**
Field and Radiation due to an Oscillating Electric Dipole. Magnetic dipole and electric quadrupole fields. **(02 Lectures)**

**M.Sc. (Physics) Semester I**

**PHYC-104**

**INTRODUCTORY QUANTUM MECHANICS (4 Credits)**

**UNIT I (13 Lectures)**

Journey from Classical to Quantum Mechanics, Concept of normalized and orthogonal wave functions, expectation value of a dynamic variable, Equation of continuity, Coordinate and momentum representation, Schrodinger equation in momentum representation **(05 Lectures)**

Uncertainty Principle and its applications, Introduction to Dirac's bra ket notation, Operator formulations, Hermitian operators and their spectrum, Projection operator, Parity operator, Commutator algebra, Angular momentum commutation relations, **(05 Lectures)**

Eigen values and eigen functions of Linear harmonic oscillator by Schrodinger equation and by operator method **(03 Lectures)**

**UNIT II (13 Lectures)**

Motion in a central field, Schrodinger Equation in spherical coordinates, Hydrogen atom problem, Free particle in three dimensions **(05 Lectures)**

Eigen values and eigen functions of angular momentum operators $L^2$ and $L_z$, Spherical harmonics, Coupling of two angular momentum **(05 Lectures)**

Dirac delta function, Representations of the Dirac delta function-rectangle, Gaussian and integral. Derivative at a discontinuity, Important properties of Dirac delta function **(03 Lectures)**

**UNIT III (12 Lectures)**

WKBJ approximation method, The connection formulae, Application of the WKBJ solutions to tunneling probability calculations and alpha decay (Geiger Nuttel Law **(06 Lectures)**

Rayleigh-Schrodinger time-independent perturbation theory for non-degenerate and degenerate systems, First and second order perturbation, Anharmonic oscillator- perturbation in the form of $x^3$ and $x^4$ **(06 Lectures)**

## UNIT IV (13 Lectures)

Effects of magnetic field, Zeeman Effect-first order and second order, Normal and anomalous Zeeman effect of one electron system, Calculation of Zeeman patterns **(05 Lectures)**

First order Stark effect in hydrogen atom as an application to stationary degenerate perturbation theory, Polarizabilty of hydrogen atom **(04 Lectures)**

Wonders of the Quantum world-The Copenhagen Interpretation, Superposition, Schrodinger's cat, Quantum Teleportation **(04 Lectures)**

**M.Sc. (Physics) Semester I/II**

**PHYC-105**

**GENERAL ELECTRONICS EXPERIMENTS (4 Credits)**

**LAB I**

| ***S.No.*** | **EXPERIMENT** |
|---|---|
| **1** | SINGLE STAGE AMPLIFIER |
| **2** | ZENER DIODE |
| **3** | S.C.R. |
| **4** | IC REGULATED POWER SUPPLY |
| **5** | NEGATIVE FEED BACK |
| **6** | MODULATION & DELODULATION |
| **7** | P-N JUNCTION |

**DEPARTMENT OF PHYSICS (Semester I)**

**ELECTIVE PAPER**

**PHYE-101**

**INSTRUMENTS AND DEVICES -1 (3 credits)**

**UNIT I (10 Lectures)**

Internet for measurement and control: Introduction to Internet- Origin of

Internet – Overview of TCP / IP layers – IP addressing.– DNS – Packet switching – Routing – SMTP, POP, MIME, NNTP, ftp, Telnet, HTML,HTTP, URL, SNMP, RFCs, FYIs – STDs.

Access network – MODEMs, WILL, ISDN, XDSL, VSAT. Measurements through Internet: Web based data acquisition – Calibration of measuring instruments through Internet.

Internet based Control: Virtual laboratory – Web based Control – Tuning of controllers through Internet

**UNIT II (10 Lectures)**

Measurements through Internet: Web based data acquisition – Calibration of measuring instruments through Internet.
Internet based Control: Virtual laboratory – Web based Control – Tuning of controllers through Internet.

Optical fibers for communication: advantages and applications, fiber materials. Preform and fiber fabrication. Demonstration of laser beam collimation. Demonstration of optical communication.

**UNIT III (10 Lectures)**

Introduction to MASER, Basics of Laser, Einsteins coefficient, Design and working of laser systems, Ruby laser, He-Ne laser. Properties of a laser: directionality, monochromaticity, coherence, intensity, tunabilty, focusing property.Application of lasers: scientific, military, medical, industrial, commercial.Sensors, Fiber optic sensors -active/passive, intensity modulated sensors, interferometric sensors.

## UNIT IV (11 Lectures)

Basics of Continuous and Characteristics X-ray spectra, X-ray tubes: Conventional Coolidge tube, Sealed off tube , demountable tube , Problems in tube design, High Tension equipments, tube rating and tube life, Target: stationary target , rotating target

Operation of X-ray tube at high current, focal spot, line focus filament, windows for X-ray tubes, Synchrotron radiation as an X-ray source , Safety devices, X-ray detection: Ionization Detections methods , Solid state detectors, Intensity recording

**M.Sc. (Physics) Semester II**

**PHYC-201**

**MATHEMATICAL PHYSICS -2 (4 Credits)**

**UNIT I (13 Lectures)**

Partial differential equations, Lagrange's linear equation, Method of multipliers **(03 Lectures)**

Solutions of Laplace, Poisson, Diffusion and wave equations in cartesian, spherical and cylindrical co-ordinates **( 07 Lectures)**.

Physical applications of the above topics **(03 Lectures)**.

**UNIT II (13 Lectures)**

Inhomogeneous equations, Green's function for a free particle, Fourier series, Dirichlet's conditions, Even and odd functions, Parseval's identity for Fourier series **( 04 Lectures)**

Fourier integral, different forms of Fourier integrals, Fourier sine, cosine and complex transforms, Parseval's identity for Fourier integrals **(04 Lectures)** Beta and Gamma functions, Different forms of Beta and Gamma functions and relation between them **( 02 Lectures)**

Physical applications of the above topics **(03 Lectures)**.

**UNIT III (12 Lectures)**

Binary operation, Definitions of Group, Semi-Group and Abelian group, Multiplication table, Equivalence class, Conjugate elements and classes**(07 Lectures)**

Invariant subgroups, Permutation group, Cyclic group, Cosets of a subgroup**(03 Lectures)**

Finite and infinite group, Period of the group**(02 Lectures)**.

## UNIT – IV (13 Lectures)

Similarity transformations, Representation Character of Trace of the group, Schur's Lemma and the Orthgonality theorem **(05 Lectures)**

Examples of $C_{2v}$, Regular representation, Symmetrised basis functions for irreducible representation**(05 Lectures)**

Direct product of representation. Applications to simple vibrational problems **(03 Lectures)**.

**M.Sc. (Physics) Semester II**

**PHYC-202**

**STATISTICAL MECHANICS (4 Credits)**

**UNIT I (12 Lectures)**

Quantum statistical mechanics of identical particles, Condition for statistical equilibrium **(03 Lectures)**
Symmetry of wave function, Postulate of equal a prior probability, Random walk **(02 Lectures)**
Ensemble in quantum statistics, Grand Canonical Ensemble **(02 Lectures)**
Partition function, Quantum distribution functions (Bose-Einstein and Fermi-Dirac), Derivation of distribution laws using grand partition function **(05 Lectures)**

**UNIT II (13 Lectures)**

Derivation of energy and pressure of Boson gas, Degeneracy of Boson gas **(03 Lectures)**
Applications of Bose-Einstein statistics, Bose-Einstein condensation, Planck's Radiation law **(03 Lectures)**
Properties of liquid He II, Super fluidity in liquid He II, Tisza's two fluid model **(03 Lectures)**
Energy and pressure of Fermi gas at absolute zero, Fermi energy as a function of temperature, Thermodynamic properties of an electron gas **(04 Lectures)**

**UNIT III (13 Lectures)**

Application of statistical mechanics, Rotating bodies **(02 Lectures)**
The probability distribution for angular momentum and angular velocities of rotation of molecules **(03 Lectures)**
Statistical interpretation of thermo dynamic functions in terms of the grand partition function **(03 Lectures)**
Gibbs Paradox **(02 Lectures)**
White Dwarf and Chandra Shekhar limit **(03 Lectures)**

**UNIT IV (14 Lectures)**

Phase transition: First and second kind of phase transition, Gibb's phase rule, One dimensional Ising model **(04 Lectures)**

Fluctuations, Mean value of fluctuations, Energy fluctuations in canonical ensemble and concentration fluctuations in grand canonical ensemble **(04 Lectures)**

Nyquist theorem (derivation and its applications) **(02 Lectures)**

Thermodynamics of irreversible processes, Onsager reciprocal relations Phenomenological coefficient, Principle of minimum entropy production **(04 Lectures)**

**M.Sc. (Physics) Semester II**

**PHYC-203**

**CLASSICAL ELECTRODYNAMICS (4 Credits)**

**UNIT I (12 Lectures)**

Homogeneous and inhomogeneous (Poincare) Lorentz groups, Pseudo-Euclidean spacetime, Spacetime rotations, rapidity, Proper, improper, orthochronous, antichronous Lorentz groups, Light cone and Matrix representation of Lorentz transformations. **(06 Lectures)**

Spacelike, timelike and lightlike Four-vectors, orthogonality, Four-tensors, Jacobians, Contravariant and Covariant tensors, Trace of a tensor, Contraction, Symmetric and Antisymmetric tensors, Inner and outer products, Quotient Law, Metric tensor, Pseudotensors, completely antisymmetric unit tensor of rank four, four-velocity, four-momentum, four-acceleration, Minkowski force. **(06 Lectures)**

**UNIT II (12 Lectures)**

Covariant form of continuity equation, 2-Form electromagnetic field-strength tensor, dual field-strength tensor, Covariant formulation of Maxwell's field equations with gauge invariance, Lorentz force equation in covariant form, Transformation of electromagnetic fields as tensor components, Invariants of the field. **(06 Lectures)**

Canonical approach to electrodynamics, Lagrangian and Hamiltonian formulation for a relativistic charged particle in external electromagnetic field, Proca Lagrangian, Canonical and Symmetric Stress Tensors, Conservation laws, Solution of the wave equation in covariant form, Invariant Green function. **(06 Lectures)**

**UNIT III (12 Lectures)**

Retarded and advanced potentials, Lienard-Wiechert potentials for a moving point charge, Fields produced by a charge in uniform and accelerated motion, Radiation from an accelerated charge, Radiated power, Larmor's formula and its relativistic generalization, Angular distribution of radiation due to an accelerated charge. **(06 Lectures)**

Bremsstrahlung, Synchrotron radiation, Thomson scattering of radiation, Thomson cross section, Multipole expansion of electromagnetic fields, Properties of multipole fields, Energy and Angular momentum of multipole radiation. **(06 Lectures)**

## UNIT IV (12 Lectures)

Radiation damping, Radiative reaction force and its derivation, Difficulties with classical Abraham-Lorentz model, Integro-differential equation of motion, Pre-acceleration, Line breadth and Level shift of an oscillator. **(06 Lectures)**

Scattering by free and bound electrons, Rayleigh Scattering, Frequency dependence of total cross section, Resonance fluorescence, State of polarization of scattered radiation, Coherence and incoherence in scattered light **(06 Lectures)**

**M.Sc. (Physics) Semester II**

**PHYC-204**

**ATOMIC AND MOLECULAR SPECTRA (4 Credits)**

**UNIT I (14 Lectures)**

Introduction to Quantum theory, Spin-Orbit interaction energy, Doublet separation, Spectroscopic Description of Atomic Electronic States – Term Symbols, Intensity rules for fine structure doublet, Fine structure of Hydrogen lines **(06 Lectures)**

Optical spectra of alkali metals, Non-penetrating and penetrating orbits, Rydberg-Schruster law, Runge's Law, The Ritz Combination Principle, Optical spectra of alkaline earth elements, Singlet and triplet terms **(05 Lectures)**

Normal and Anomalous Zeeman Effect, Paschen-Back effect of one electron system **(03 Lectures)**

**UNIT II (12 Lectures)**

Coupling scheme for two electron systems – non-equivalent and equivalent electron cases, Hund's rule, Lande's interval rule **(06 Lectures)**

Hyperfine structure, Isotope effect in atomic spectra, distinction between Isotope effect and hyperfine structure, Normal and inverted terms, Applications of Hyperfine structure, Lamb Rutherford Shift **(06 Lectures)**

**UNIT III (13 Lectures)**

Microwave Spectroscopy – Rotational spectra, Diatomic and polyatomic molecules, Infrared Spectroscopy – Vibrating diatomic molecule, the diatomic vibrating rotator, Rotation- Vibration spectra of diatomic molecules, Breakdown of Born Oppenheimer Approximation **(06 Lectures)**

Raman Spectroscopy- Pure rotational Raman spectra, Vibrational Raman spectra, Structural determination from Raman Spectroscopy, Selection rules, P.Q and R branches, Isotopic shift **(05 Lectures)**

Determination of heat of dissociation, Effect of anharmonicity, Coriolis force

**(02 Lectures)**

## UNIT IV (14 Lectures)

Vibronic-transition and Frank-Condon rule **(02 Lectures)**

Coherence-spatial and temporal, He-Ne gas laser, ruby laser, Raman spectroscopy, uses of lasers in Raman spectroscopy **(06 Lectures),**

Principle of Electron Spin Resonance (E.S.R), Nuclear Magnetic Resonance (N.M.R), and Nuclear Quadrupole Resonance (N.Q.R.) spectroscopy and their applications **(06 Lectures)**

**M.Sc. (Physics) Semester I/II**

**PHYC-205**

**OPTICS EXPERIMENTS (4 Credits)**

**LAB II**

| ***S.No.*** | ***EXPERIMENT*** |
|---|---|
| **1** | MICHELSON INTERFEROMETER |
| **2** | ETALON |
| **3** | GRATING |
| **4** | RAYLEIGH REFRACTOMETER |
| **5** | POLARIZATION |
| **6** | EDSER-BUTLER |
| **7** | BABINET COMPENSATOR |
| **8** | ULTRASONIC INTERFEROMETER |
| **9** | HYSTERESIS LOOP TRACER |

**DEPARTMENT OF PHYSICS (Semester II)**

**ELECTIVE PAPER**

**PHYE-201**

**INSTRUMENTS AND DEVICES -2 (3 credits)**

**UNIT I (10 Lectures)**

**Modern communication techniques:Cellular Telephony-Definition of a cellphone, History of cellphone, How cellphones work, Analog and Digital signals, Cell Access technology, parts of a cellphone, Advantages and disadvantages of cellphones, MTSO, Direct Sequence Spread Spectrum, Special features of DS/SS, frequency hopping spread spectrum.**
Global Positioning System - What is GPS? How it works, Use of spread spectrum in GPS. GPS and curvature of spacetime, How GPS utilizes time dilatation.

**UNIT II (10 Lectures)**

Satellite Communications - Kepler's Laws, Geostationary orbit, Power systems, Attitude control, Multiple access methods, Antenna look angles (boresight), limits of visibility, transponders, satellite wideband receivers.

Introduction to optical communication systems.

Optical sources--incandescent, luminescent ( photoluminescence, cathadoluminescence, electroluminescence). LED--structure, parameters and characteristics. Application of LEDs. Semiconductor lasers.

**UNIT III (10 Lectures)**

Optical detectors--figure of merit, thermal detectors, general characteristics of photodetectors, photomultiplier tube, PIN diode, Avalanche photodiode, phototransistors, charge coupled device.

**UNIT IV (11 Lectures)**

Spectroscopic techniques: X-ray spectrographs and spectrometers: Single crystal, Double crystal and Bent crystal spectrographic and their resolving powers, Instrumentation and Experimental procedures of **:**X-ray photoelectron

and Auger electron Spectrometers ( XPS/AES), X-ray fluorescence Spectrometer.

Diffraction Techniques: Diffractometer Geometry : Reciprocal lattice construction, Parafocusing, Goniometry, Powder Diffractometer, Buerger single crystal diffractometer, Semiautomatic instruments, Fully automatic instruments. Instrumentation and Experimental procedures of XRD.

## M.Sc. (Physics) Semester III

## PHYC- 301

## QUANTUM MECHANICS -1 (4 Credits)

### UNIT I (14 Lectures)

Matrix formulation of Quantum Mechanics - Bra, Ket and matrix representation, Ket-Bra and matrix algebra, Linear vector spaces and transformations, Special Matrices **(03 Lectures)**

Transformation and Diagonalization of matrices, Transformation Theory, Unitary matrix W, transformation of hamiltonian with W, Transformation matrices U and V. Representation of operators and quantum states, Hilbert space and Projection operators. **(04 Lectures)**

Equations of motion: Schrödinger, Heisenberg and Interaction pictures.Quantization of Classical system, motion of a particle in electromagnetic field **(04 Lectures)**

Matrix theory of Harmonic oscillator, coordinate representation, raising and lowering operators, matrices for a, x and p. **(03 Lectures)**

### UNIT II (15 Lectures)

Symmetry in Quantum Mechanics- Symmetry transformation, Generators for symmetry transformations, Translation in space, Conservation of linear momentum, translation in time, Conservation of energy, Rotation in Space, Conservation of angular momentum **(03 Lectures)**

Rotational, angular momentum , and Unitary Groups: Proper rotation group, infinitesimal rotations, spin of a vector particle, commutation relations for the generators, Choice of representation, Unitary and special unitary groups in two dimensions and their generators [U(n), SU(n) and SU(3)]Angular and spin momentum matrices **(05 Lectures)**

Combination of angular momenta. Clebsh-Gordon coefficients, Selection rules, Recursion relations and computation, Irreducible Tensor operators.Product and combination of tensor operators, Wigner-Eckart theorem **(04 Lectures)**

Space inversion and time Reversal. Dynamical Symmetry: QM hydrogen atom problem and Classical isotropic oscillator **(03 Lectures)**

## UNIT III (14 Lectures)

Variational Method, derivation of ground state energy of Hydrogen and Helium atoms; Basic idea of evaluation of energy of excited states. **(04 Lectures)**

Time dependent perturbation theory, transition probability, Fermi's Golden Rule No.2 **(03 Lectures)**

Semi-Classical theory of radiation, probabilities of stimulated emission and absorption; probability of spontaneous emission using Einstein's coefficients. **(04 Lectures)**

Identical particles with spin. Symmetry and Antisymmetry of wave functions, Slater's determinantal wave functions. Excited states of Helium atom. **(03 Lectures)**

## UNIT IV (14 Lectures)

Non-relativistic scattering theory, differential and total scattering cross section, Born approximation method with examples of scattering by Coulomb, Gaussian, Square well and Yukawa potentials. **(05 Lectures)**

Partial wave analysis, optical theorem, phase shift, example of scattering by square well potential. **(06 Lectures)**

Scattering by identical particles (expression for scattering cross-section only). Atomic scattering of fast electrons, significance of atomic scattering factor. **(03 Lectures)**

**M. Sc. (Physics) Semester III**

**PHYC-302**

**NUCLEAR PHYSICS - 1 (4 Credits)**

**UNIT I (14 Lectures)**

Basic facts about nuclei, Mass and binding energy, Semi-empirical mass formula **(06 Lectures)**
Nuclear size determination using mu-mesic X-rays and scattering of fast electrons **(04 Lectures)**
Nuclear spin and magnetic moment of nuclei, Molecular beam resonance method, Nuclear resonance absorption and induction method, Electric quadrupole moment **(04 Lectures)**

**UNIT II (15 Lectures)**

Alpha decay, Experimental results on alpha decay-Alpha spectra and Geiger-Nuttall relation, Theory of alpha decay **(05 Lectures)**
Beta-spectra, Fermi's theory of beta decay, Sergeant's law, Kurie Plot, Allowed and forbidden transitions, Fermi and Gamow Teller Transition, Extraction of Fermi constant, Parity violation in beta-decay, Detection of neutrino **(10 Lectures)**

**UNIT III (14 Lectures)**

Gamma emission, Multi-polarity of gamma rays, Selection rules **(04 Lectures)**
Theoretical prediction of decay constants, Estimation of Transition probabilities, estimation of single particle unit **(05 Lectures)**
Internal conversion, Angular correlation, Nuclear isomerism, Mossbauer Effect. **(05 Lectures)**

**UNIT IV (15 Lectures)**

Nuclear reactions, Conservation laws, The Q-equation and deduction of nuclear energy levels **(03 Lectures)**
Compound nucleus, Bohr hypothesis, Resonance phenomenon, Breit- Wigner one level formula, Optical model, Simple discussion of direct reactions **(06 Lectures)**
Nuclear fission, Bohr-Wheeler theory of nuclear fission, Controlled chain reaction, Nuclear reactors **(04 Lectures)**
Nuclear Fusion **(02 Lectures)**

## M.Sc. (Physics) Semester III

## PHYC-303

## SOLID STATE PHYSICS -1 (4 Credits)

### UNIT I (13 Lectures)

Lattice Dynamics :Phonon dispersion spectra for three dimensional monatomic solids, Density of states, Phonon branches in 3-d solid with a polyatomic basis **(04 Lectures)**

Local phonon modes, Inelastic scattering by phonons, Experimental measurements of phonons **(02 Lectures)**

Phonon heat capacity, Debye model and Born cut-off procedure, Thermal conduction: lattice thermal conduction and phonon free path, anharmonic effects **(04 Lectures)**

Normal and umklapp process, defect controlled phonon scattering, Heat capacity of amorphous material **(03 Lectures)**

### UNIT II (12 Lectures)

Free Electron Theory: Electrical conductivity, Sommerfeld's; Wiedmann-Franz law **(02 Lectures)**

Lorentz number, Motion in magnetic fields, Plasmons **(02 Lectures)**

Plasma optics, Dispersion relation for electromagnetic waves, Transverse and longitudinal modes **(03 Lectures)**

Transparency of alkali halide crystals in ultraviolet light, Screening effect, Mott metal-insulator transistor **(02 Lectures)**

Polaritons, Electron-electron interaction, Electron-phonon interaction, Polarons **(03 Lectures)**

### UNIT III (12 Lectures)

Semi-conductors: Lattice properties of $4^{th}$ group elements: Structure, physical constants, influence of impurities, diffusion of impurities, Influence of lattice defects **(03 Lectures)**

Fermi level and electron-hole distribution in energy bands, Models of an impurity semi-conductor **(03 Lectures)**

Temperature dependence of Fermi level in an extrinsic semi-conductor, Conductivity and Hall effect in semi-conductors, Constant energy surfaces and effective mass in Si and Ge, Effect of temperature and impurities in semi-conductors **(04 Lecture)**

Rectification, Schottky barrier, Heterostructures. N-N heterojunction. semiconductor, Introduction to amorphous semi-conductors **(02 Lectures)**

**UNIT IV (13 Lectures)**

Superconductivity:Concept of superconductivity, Meissner effect, Type I and type II superconductors **(02 Lectures)**

Energy gap, Isotope Effect, Microwave and infrared properties,London equations, Penetration depth **(02 Lectures)**

Coherence length, Super-conductivity ground state, BCS theory **(03 Lectures)**

Flux quantization in a ring, Electron tunneling, DC & AC Josephson Effect **(02 Lectures)**

Macroscopic quantum interference, SQUID, Introduction to high Tc super-conductors **(02 Lectures)**

Dislocation in Solids: Dislocation stress and strain, Fields of dislocations, Dislocation multiplication **(02 Lectures)**

**M.Sc. (Physics) Semester III**

**PHYC-304A**

**ELECTRONICS - I (4 Credits)**

**UNIT I (15 Lectures)**

Linear Wave Shaping**:** High Pass and Low Pass RC Networks: Detailed Analysis **(08 Lectures)**
Response to Sinusoidal, Step, Pulse, Square wave, Exponential and Ramp Inputs.

RC circuits applications **(02 Lectures)**
High pass RC circuit as a differentiator, Low Pass RC circuit as an Integrator. Criterion for good differentiation and integration. Laplace Transforms and their application to circuit elements **(05 Lectures)**

**UNIT II (15 Lectures)**

Amplifiers: Difference Amplifiers **(05 Lectures)**
Broadband Amplifiers, Methods for achieving broadbanding **(04 Lectures)**
Emitter Follower at High Frequencies **(01 Lecture)**
Operational Amplifiers and its Applications **(05 Lectures)**

**UNIT III (15 Lectures)**

Power Supplies:Electronically Regulated Power Supplies **(02 lectures)**

Converters and Inverters **(01Lectures)**
High and Low Voltage Supplies, Application of SCR as Regulator **(02 Lectures)**
SMPS **(02 Lectures)**
Elements of Digital Circuit Technology:Transistor as a Switch - Switching times: Definition and Derivation - Rise Time, Fall Time, Storage Time, Delay Time, Turn On Time, Turn Off Time Charge Control Analysis **(03 Lectures)**.

Multivibrators: Astable, Monostable and Bistable **(03 Lectures)**.
Schmitt Trigger **(02 Lectures)** .

## UNIT IV (15 Lectures)

Flip Flops: RS, RST, JK, T, D, JK M/S Flip flops, Race problem, Preset and Clear functions **(02 Lectures)**

Number Systems: Binary, Octal and Hexadecimal Number Systems. Binary Arithmetic **(02 Lectures)**

Arithmetic Circuits. Binary Codes: Gray, 8421, 2421, 5211. Boolean Variables and Operators, Simplification of Boolean Expressions. Karnaugh Maps **(05 Lectures)**

Counters and Registers : Binary Counters: Up, Down, Parallel. Modulus Counters: Counter Reset Method, Logic Gating Method. Ring Counter, Shift Registers

**(04 Lectures)**

D/A converter and A/D converter. Simultaneous and Counter method of A/D converter, Successive Approximation method **(02 Lectures)**

**M.Sc. (Physics) Semester III**

**PHYC-304B**

**LASERS AND OPTO-ELECTRONICS - 1 (4 Credits)**

**UNIT I (15 Lectures)**

Laser theory, Light Amplification, threshold condition - **(03 Lectures)**
Laser Rate Equations-two, three and four level systems -**(03 Lectures)**
Laser power around threshold, optimum output coupling – **(02 Lectures)**
Line Broadening Mechanisms–Natural,Collision and Doppler–**(03 Lectures)**
Optical Resonators – Modes of a rectangular cavity and open planar resonator, Modes of a Confocal resonator system, General Spherical resonator, Higher order modes- **(04 Lectures)**

**UNIT II (15 Lectures)**

Essential criterion to observe non linear optical effects. First experimental demonstration of non-linear phenomena – **(03 Lectures)**
Classical theory of non-linear response in one dimension, Generalization to three dimensions - **(03 Lectures)**
General properties of the polarizability tensor – Reality condition, Intrinsic symmetry, general form and frequency dependence, overall symmetry - **(05 Lectures)**
Second harmonic generation and phase matching techniques -**(03 Lectures)**
Basic idea of self-focusing -**(01 Lecture)**

**UNIT III (15 Lectures)**

Non-linear coupling of three waves to produce sum and difference frequencies - **(04 Lectures)**
Manley Rowe relations and their significance – **(03 Lectures)**
Sum and difference frequency generation when both input frequencies are lasers **-(02 Lectures)**
Parametric conversion and amplification – **(03 Lectures)**
Basic idea of optical phase conjugation - **(03 Lectures)**

**UNIT IV (15 Lectures)**

Fiber as a guiding medium, Total Internal reflection Acceptance angle Numerical aperture – **(02 Lectures)**
Types of fiber, Refractive index profiles – **(02 Lectures)**
Concept of modes, Electromagnetic analysis of guided modes in symmetric step index planar wave guide and step index fiber - **(03 Lectures)**

Concept of Normalized Frequency, V Parameter - **(01 Lecture)**
Pulse dispersion in step index fibers. Concept of Dispersion shifted and Dispersion flattened Fibers - **(04 Lectures)**
Fiber attenuation, Misalignment losses, Fiber material, Fiber fabrication, Splices and Connectors -**(03 Lectures)**

**M.Sc. (Physics) Semester III**

**PHYC-304C**

## X-RAY CRYSTALLOGRAPHY (4 Credits)

### UNIT I (12 Lectures)

Scattering of X-rays, Compton scattering and Thompson's theory scattering by a pair of electrons and electron cloud in an atom, Atomic structure factors **(06 Lectures).**

Scattering by diatomic and simple polyatomic molecules, Scattering by liquids and determination of atomic distribution in monatomic liquids, Zernicks Prins Formula **(06 Lectures).**

### UNIT II (12 Lectures)

Derived charge distribution and a comparison with Hartee-Fock and Thomas-Fermi models, Intensity of scattering from free electrons. Klein Nisima formula (no derivation), Comparison with experiments **(05 Lectures).**

Dispersion theory applied to x-rays, Anomalous dispersion, The forced, Damped oscillations of an electron and dielectric constant of the medium. Significance of complex dielectric constant. The index of refraction, experimental methods for measuring the refractive index **(07 Lectures).**

### UNIT III (12 lectures)

Direct and Reciprocal lattice, point groups and Space groups, Diffraction of x-rays by Crystals, Laue's and Bragg's equations for X-ray diffraction and their equivalency, Neutron and electron diffraction, relative merits and demerits of electron, neutron and X-ray diffraction **(06 Lectures).**

Various methods of X-ray diffraction; Collimation and recording of X-ray beam, Laue, Powder, Rotating/oscillating and moving film methods in details. Interpretation of diffraction pattern with the help of various tools, factors affecting X-ray intensities **(06 Lectures).**

## UNIT IV (12 Lectures)

Crystal structure factor calculation for fcc, bcc, hcp lattice, Space lattice extinction, Relative merits of crystal structure determination. The phase problem and various methods of its solution, trial and error methods, optical method, Fourier and Patterson methods **(06 Lectures).**

Small angle X-ray scattering (SAXS) from crystalline and non-crystalline materials; General theory; scattering by a single particle, group of particles. Experimental consideration for construction of SAXS apparatus, method of interpretation and comparison of experimental SAXS results and its application to the study of metals, alloys, polymers, finally dispersed solid, large molecules etc **(06 Lectures).**

**M.Sc. (Physics) Semester III/IV**

**PHYC-305**

**GENERAL EXPERIMENTS**

**LAB III (4 Credits)**

| ***S.No.*** | ***EXPERIMENT*** |
|---|---|
| **1.** | HALL EFFECT |
| **2.** | E.S.R. |
| **3.** | FOUR PROBE |
| **4.** | FORBIDDEN ENERGY GAP |
| **5.** | GM COUNTER |
| **6.** | β- ENERGY |
| **7.** | KLYSTRON |
| **8.** | PHASE SHIFTER |

**M.Sc. (Physics) Semester IV/III**

**PHYC-405A**

**LAB IVA- ELECTRONICS (4 Credits)**

| S.No. | EXPERIMENT |
|---|---|
| 1. | STUDY OF DIGITAL CIRCUITS |
| 2. | STUDY OF EMITTER FOLLOWER |
| 3. | STUDY OF DIFFERENCE AMPLIFIER |
| 4. | STUDY OF SCHMITT TRIGGER |
| 5. | STUDY OF PAM, PWM, PPM |
| 6. | STUDY OF PCM RECEIVER AND TRANSMITTER |
| 7. | STUDY OF OPAMP CHARACTERISTICS. |
| 8. | STUDY OF OPAMP APPLICATIONS |
| 9. | STUDY OF ANALOG TO DIGITAL CONVERTERS |
| 10. | STUDY OF DIGITAL TO ANALOG CONVERTERS |
| 11. | STUDY OF MULTIVIBRATORS |
| 12. | STUDY OF 555 TIMER |
| 13. | STUDY OF ALU IC 74181 |
| 14. | STUDY OF MICROPROCESSOR IC 8085 |

**M.Sc. (Physics) Semester IV/III**

**PHYC-405B**

**LAB IVB – OPTO-ELECTRONICS (4 Credits)**

| S.No. | EXPERIMENT (ANY 7 WOULD BE PERFORMED IN A SEMESTER) |
|---|---|
| 1. | STUDY OF CHARACTERISTICS OF LED AND PIN PHOTO DETECTOR |
| 2. | STUDY OF FREQUENCY RESPONSE OF OPTICAL RECEIVER |
| 3. | TO STUDY ATTENUATION IN OPTICAL FIBERS |
| 4. | TO FIND NUMERICAL APERTURE OF OPTICAL FIBERS |
| 5. | STUDY OF NOISE IN AN OPTICAL RECEIVER |
| 6. | TO STUDY ABBE'S THEORY OF IMAGE FORMATION AND SPATIAL FILTERING |
| 7. | TO STUDY DIFFRACTION PATTERN USING A SOFTWARE CONTROLLED SET-UP SELF-IMAGING |
| 8. | SELF-IMAGING |
| 9. | TO STUDY MICROBENDING LOSSES IN AN OPTICAL FIBER |
| 10. | STUDY OF PULSE AMPLITUDE MODULATION AND TIME DIVISION MULTIPLEXING |
| 11. | STUDY OF DIGITAL DATA COMMUNICATION |
| 12. | STUDY OF NRZ AND ITS DETECTION |
| 13. | STUDY OF RZ AND ITS DETECTION |
| 14. | STUDY OF MANCHESTER CODING AND ITS DETECTION |
| 15. | STUDY OF ASK MODULATION AND DEMODULATION |

**M.Sc. (Physics) Semester IV/III**

**PHYC-405C**

**LAB IVC – X-RAYS (4 Credits)**

| S.No. | EXPERIMENT |
|---|---|
| 1. | TO TAKE THE POWDER PHOTOGRAPH OF Cu & W AND INDEX IT |
| 2. | TO TAKE THE LAUE PHOTOGRAPH OF KCl AND INDEX IT |
| 3. | TO DETERMINE THE WAVELENGTH OF $K_\alpha$ & $K_\beta$ LINES OF Mo BY MEANS OF MULLER SPECTROGRAPH |
| 4. | TO TAKE THE 15° OSCILLATION PHOTOGRAPH OF KDP CRYSTAL AND HENCE INDEX THE REFLECTION SPOT |
| 5. | TO TAKE ABSORPTION SPECTRA USING BENT CRYSTAL CAUCHOIS TYPE SPECTROGRAPHY |

**DEPARTMENT OF PHYSICS (Semester III)**

**PHYE-301**

# MATERIALS SYNTHESIS AND CHARACTERIZATION TECHNIQUES

**(3 Credits)**

## UNIT I (11 Lectures)

Thin Film Deposition:Physical vapour deposition methods, vacuum condition during evaporation, Design and characteristics of vacuum systems**.**Pulsed Laser deposition, Bulk sample preparation, Quartz crystal monitor ,Optical and Electrical methods of monitoring.

## UNIT II (11 Lectures)

Structural ( Microstructural/Nanostructural ) Characterization: Diffraction Methods- electron and neutron scattering and diffraction.Conventional and Intense X-ray Sources (Synchrotron Radiation).
Various x-ray diffraction methods for crystal structure determination of inorganic, organic to macro biomolecules. Basic concepts of small angle X-ray scattering and its application in evaluation of shape and size of surface particles.

## UNIT III (11 Lectures)

Microscopic Methods-Basics and applications of Optical microscope including Nanoscope, Basic working principles and applications of Electron microscope-Scanning electron (SEM) & Transmission electron microscopy (TEM). Elementary Concepts and their Physical, chemical and Biological applications of scanning probe microscopy (AFM, MFM, EFM, STM etc), Confocal microscopy, Focussed ion beam system.

## UNIT IV (12 Lectures)

Electronic and Chemical Characterization: PES (Photo electron spectroscopy), EELS (Electron energy loss spectroscopy),LEED (Low Energy Electron Diffraction) for Surface Structure, Surface Topography. RBS (Rutherford Back Scattering) and SIMS (Secondary Ion Mass Spectroscopy) PIXE (Particle induced x-ray emission) for chemical analysis. Defect related electronic states characterization by C-V characteristics of electronic junction devices.

**M.Sc. (Physics) Semester IV**

**PHYC-401**

## QUANTUM MECHANICS - 2 (4 Credits)

### UNIT I (14 Lectures)

Fundamentals of Electronic Structure Theory **(03 Lectures)**
Thomas-Fermi model. Self-consistent fields, Hartee-Fock Theory**(03 Lectures)**
Heitler-London Theory of hydrogen molecule. Bonding and Anti-bonding orbitals. Valence bond theory **(04 Lectures)**
Molecular orbitals. LCAO method. **(04 Lectures)**

### UNIT II (15 Lectures)

Relativistic Wave Equations – Klein-Gordon equation **(03 Lectures)**
Dirac equation: negative energy solutions, antiparticles, Dirac hole theory **(03 Lectures)**
Feynman interpretation of antiparticles, Gama-matrices and their properties **(02 Lectures)**
Covariant form, proof of covariance, Free particle solution and non-relativistic reduction **(2 Lectures)**
Charge conjugation, Parity & Time reversal invariance,
Two component theory of neutrino, Spin & Helicity **(02 Lectures**)
Central force problems: Hydrogen atom, spin orbit energy, magnetic moment **(03 Lectures)**

### UNIT III (15 Lectures)

Definition of fields and coordinates of the field, Euler-Lagrange equations in field theory, Action Functional and Lagrangian, Functional derivatives and Lagrangian equations for fields.**(02 Lectures**)
Classical and quantum Hamiltonian Field Equations, Noether's theorem, Space time translations, Lorentz transformations, Fields with more than one component and Complex scalar field **(03 Lectures**)
Second quantization of non relativistic Schrodinger equation ( Schrodinger Field) , The N-representation, creation and annihilation operators, Fock Space, Bosonic and Fermionic Fields **(05 Lectures**)
Relativistic fields: Natural Units, Klein-Gordon field, Creation and annihilation operators, Propagator, Quantization of Dirac field,positive and negative energy

spinors, projection operators for positive and negative energy states,Helicity and Chirality projection operators **(05 lectures**)

**UNIT IV (14 Lectures)**

Quantum Theory of radiation field: Transversality Condition, radiation gauge, covariance of quantization procedure, momentum expansion, spin of the photon, The Feynman propagator for transverse photons **(05 Lectures)**

Fourier decomposition and radiation oscillators,Quantization of radiation oscillators (Photon states), Quantized Radiation field (Photons as quantum mechanical excitations of radiation field) **(05 Lectures)**

Interaction of field with charge particles, Absorption, induced and spontaneous emission, Transition probabilities, Time dependent dirac perturbation, Planck's formula. **(04 Lectures)**

**M. Sc. (Physics) Semester IV**

**PHYC-402**

**NUCLEAR PHYSICS –2**

**UNIT I (15 Lectures)**

Nuclear two-body problem, Simple theory of deuteron **(04 Lectures)**
Spin dependence and non-central feature of nuclear forces **(03 Lectures).**
Partial wave analysis, Low energy n-p scattering, Scattering length and effective range theory, Low energy p-p scattering **(06 Lectures).**
Charge symmetry and charge independence of nuclear forces, Meson theory of nuclear forces (2 Lectures)

**UNIT II (12 Lectures)**

Nuclear models, Evidence of shell structure, magic numbers and spin-orbit coupling, extreme single particle model, Predictions of spin, parity and electromagnetic moments **(06 Lectures).**
Collective model, Rotational and Vibrational Hamiltonian, Vibrational and rotational spectra of different nuclei **(06 Lectures)**

**UNIT III (13 Lectures)**

Classification of elementary particles **(03 Lectures)**
Exact conservation laws, Approximate conservation laws: Isospin and Isospin wave functions for pion-nucleon system, strangeness, parity, time reversal and charge conjugation, CP violation **(10 Lectures)**

**UNIT IV (14 Lectures)**

Eight fold way, Quarks, Quark-Quark interaction, SU (3) quark model, Magnetic dipole moment of baryons, Masses of hadrons **(07 Lectures)**
Basic ideas about the standard model **(04 Lectures)**

**M.Sc. (Physics) Semester IV**

**PHYC-403**

## SOLID STATE PHYSICS - 2 (4 Credits)

### UNIT I (12 Lectures)

Dielectric and Ferroelectric Properties- Macroscopic electric field, Local field at an atom, Clausius-Mosotti equation **(03 Lectures)**
Dielectric constant and polarisability, Electronic Polarisability, Classical theory of electronic polarisability **(04 Lectures)**
Structural phase transition, Soft modes **(02 Lectures)**
Antiferroelectricity, Ferroelectric domains, Piezoelectricity **(3 Lectures)**

### UNIT II (12 Lectures)

Magnetic properties-Quantum theory of diamagnetism and paramagnetism **(02 Lectures)**
Susceptibility behaviour of paramagnetic systems, super paramagnetism, Behaviour of Fe and rare earth groups, Quenching of oribital magnetic moments, paramagnetic moment of metallic solids. Van Vleck paramagnetism **(03 Lectures)**
Heisenberg theory, Spin wave theory for ferromagnetic and antiferromagnetic systems, $T^{3/2}$ law. Acoustic and optical magnons **(03 Lectures)**
Phase transformation in antiferromagnetic systems, Susceptibility behaviour of ordered systems, Anisotropy **(02 Lectures)**
Domain theory, Bloch wall, Coercivity and Hysteresis, Amorphous ferromagnets **(02 Lectures)**

### UNIT III (12 Lectures)

Band Theory- Bloch theorem, Tight binding approximation, LCAO method and its application, derivation of dispersion relation, concepts of effective mass and holes **(03 Lectures)**
Brillouin zones, reduced zone scheme, Shape of bands and their overlapping, Behaviour of ionic-covalent and metallic solids **(03 Lectures)**
Construction of Fermi-surfaces, Methods for the study of Fermisurfaces, Anomalous Skin Effect **(03 Lectures)**
Cyclotron resonance, Extremal orbits, Landau energy levels, Magnetic subbands, Landau diamagnetism, de Hass-van Alphen Effect, Shubnikov-de Hass effect, Quantum Hall Effect **(03 Lectures)**

**UNIT IV (12 Lectures)**

Electronic and optical properties- The upper filled band and the conduction band in ionic crystals **(02 Lectures)**

Excitons, Qualitative discussion of lattice defects and their influence on electronic levels **(02 Lectures)**

Colour centers, Luminescence, thallium activated alkali halides **(03 Lecture)**

General – Alloys, Substitutional solid solution **(02 Lectures)**

Order disorder transformation, Phase diagrams **(02 Lectures)**

Elementary theory of order, Transition metal alloys and KONDO effects **(01 Lecture)**

**M.Sc. (Physics) Semester IV**

**PHYC-404A**

**ELECTRONICS - 2 (4 Credits)**

UNIT I (15 Lectures)

Amplitude and Frequency Modulation: Introduction, Amplitude Modulation **(01 Lectures)**
Spectrum of the modulated signal **(01 Lecture)**
Square law Modulator, Balanced Modulator, DSBSC, SSB and vestigial sideband modulation **(04Lectures)**
Limitations of Amplitude Modulation **(01 Lecture)**
Analysis and frequency Spectrum **(01 Lecture)**
Generation and Detection of FM **(02 Lecture)**
Comparison of AM and FM **(01 Lecture)**
Pre-emphasis and De-emphasis, Reactance Modulator. Capture Effect. Varactor Modulator **(02 Lectures)**
FM Receiver, Foster Seely Discriminator. Ratio Detector **(02 Lectures)**

UNIT II (15 Lectures)

Television: Electronic image capture, Conventional Camera tubes & Modern Devices **(03Lectures)**
Interlaced Scanning **(01 Lecture)**
Synchronization, Resolution **(02 Lectures)**
Composite Video Signal. Vestigial Sideband Modulation **(03 Lectures)** Transmitter/Receiver- B/W TV & Colour TV, Receiver Block Diagram. Sync. Separator. Vertical and Horizontal deflection circuits **(04 Lectures)**
Modern Display Technology: Flat Panel Displays(LCD, Plasmas etc.) and their addressing techniques. Smart Windows **(02 Lectures)**

UNIT III (15 Lectures)

Digital Communication: Basics of Digital Communications, Advantages of Digital Communication, Typical communication system (02 Lectures)

Mathematical Theory of Digital Communication: Classification of signals, unit impulse function, Sampling property of the unit impulse function, unit step function, Analysis and transmission of signals, expression of an aperiodic signal as a continuous sum of exponential functions, unit gate function, Fourier spectrum of the gate pulse, The ‘mathematics’ of modulation, Impulse train and its Fourier response, ideal and practical filters, Sampling Theorem, Nyquist rate

and Nyquist interval, Signal reconstruction: The Interpolation Formula, The Interpolation Function, Practical difficulties in signal reconstruction, Aliasing, Pulse Code Modulation, Basic stages of Generation and Reception of PCM, Quantizing, Compandor, Encoder **(10 Lectures)**
Differential Pulse Code Modulation, Delta Modulation **(01 Lecture)**
Principles of Digital data transmission: Amplitude Shift Keying, Frequency Shift Keying. Phase Shift Keying. Differential Phase Shift Keying. Digital Multiplexing **(02 Lectures)**

**UNIT IV (15 Lectures)**

Microprocessors-Architecture and Programming: Volatile and non volatile memories, magnetic memories, DRO, NDRO system Semiconductor memories RAM, ROM, EPROM Addressing of memories: MAR, MAD & NDR hexadecimal addressing **(02 Lectures)**
Buffer register, Shift register, Ring Counter shift counter, Controlled shift registers, Tristage switches Tristate register Reduction of Connecting wires, Bus organization Arithmatic unit , Binary addition Half and Full subtractor **(03 Lectures)**
Intel Microprocessors: Historical Perspective. Organization of Microprocessor based system. 8085: Programming model. Registers, Accumulator, Flags, Program Counter, Stack Pointer. 8085 Instruction Set: Data Transfer Operation, Arithmetic Operations, Logic Operations, Branching Operations, One, Two and Three Byte Instructions, Opcode Format **(08 Lectures)**
Microprocessor 8086, its organization & instructions **(02 Lectures)**

## M.Sc. (Physics) Semester IV

## PHYC-404B

## LASERS AND OPTO-ELECTRONICS - 2 (4 Credits)

### UNIT I (15 Lectures)

Conventional versus holographic photography, Hologram of a point source, hologram of an extended object, Off-axis technique in the recording of holograms **(02 Lectures)**

Three dimensional holograms – Reflection holograms **(01 Lectures)**

Basic idea of holographic data storage, Holographic interferometry – double exposure, real time, time average holographic interferometry **(02 Lectures)**

Optical correlation. Fourier Transform holograms and their use in character recognition **(02 Lectures)**

Optical data processing (basic idea). Abbe's theory. Spatial filters – low pass, high pass, band pass filters **(02 Lectures)**

Fraunhofer Diffraction and the Fourier Transform – mathematical concept **(02 Lectures)**.

Young's experiment. Michelson Stellar interferometer and its limitation. Hanbury Brown and Twiss interferometer **(02 Lectures)**

Classical and quantum coherence functions, first and second order coherence, coherent states. Discussion of Young's experiment in quantum mechanical terms **(02 Lectures)**

### UNIT II ( 15 Lectures)

Losses in the cavity – quality factor, line width of the laser **(02 Lectures)**

Mode selection **–** Transverse and longitudinal, free spectral range and finesse of etalon **(02 Lectures),**

Q **–** Switching **–** Peak Power, Total Energy, Pulse duration, Techniques for Q-Switching- Mechanical, electro-optic and acousto-optic **(03 Lectures)**

Mode locking in lasers – Theory, Techniques for mode locking **–** Acousto-optic and electro-optic **(03 Lectures)**

Laser Systems –Nd:YAG, Nd: Glass, $CO_2$ Laser, Excimer Laser **(02 Lectures)**

Free Electron Lasers – Introduction, Single particle dynamics, wiggler, electron trajectory, FEL Gain, Spontaneous Emission, effect of input wave polarization on FEL gain **(02 Lectures)**

Properties of Lasers – Directionality, Coherence etc **(01 Lecture)**

## UNIT III (15 Lectures)

Quantization of Analog signal, A/D and D/A conversion, Bit Rate, Pulse Code Modulation, NRZ, RZ and Manchester Coding, Base Line Wander Effect **(04 Lectures)**

Advantages of Optical Communication, Eye pattern Technique **(02 Lectures)**

Time Division Multiplexing, Wave length Division Multiplexing, Multiplexers and De-Multiplexers **(03 Lectures)**

Direct Detection and Coherent Heterodyne Detection **(02 Lectures)**

Concept of Optical Frequency Division Multiplexing, NEP Heterodyne **(02 Lectures)**

Erbium Doped Fiber Amplifier, Fiber Bragg Grating, System Design, Power Budget, Band width Budget and Rise Time Budget Calculations **(02 Lectures)**

## UNIT IV (15 Lectures)

Electromagnetic analysis of guided modes in symmetric step index planar waveguide **(02 Lectures)**

Basic idea of asymmetric planar waveguides **(01 Lectures)**

Basic idea of slab guide geometries: strip, raised strip, embedded strip, ridge, strip coated guides **(01 Lectures)**

Fabrication of Integrated optical Devices: Substrate, cleaning of the substrate, Methods used to produce wave guiding layers, Sputtering and Dipping, Ion migration **(02 Lectures)**

Beam and waveguide couplers: Transverse couplers, prism-coupler, Grating coupler, thin-film tapered coupler, wave guide-to-fiber couplers **(03 Lectures)**

Electro-optic Effects, Acousto-optic Effect, Raman-Nath acousto-optic modulator **(02 Lectures)**

Bragg modulator, Acousto-optic deflectors, Acousto-optic spectrum analyzer **(02 Lectures)** .

Fiber optic sensors: Phase and polarization fiber sensors, Intrinsic sensors, Extrinsic fiber sensors, Sagnac Effect, Gyroscope **(02 Lectures)** .

## PHYC-404C

## X-RAYS:EMISSION AND ABSORPTION SPECTROSCOPY (4 Credits)

### UNIT I (13 Lectures)

X-ray emission from thin and thick targets, Theories of continuous X-ray spectra: Sommerfeld's theory for the spectral distribution, frequency spectrum of continuous X-ray Experimental spectral and spatial distribution, shortcomings of classical theory, Kramers quantum theory **(08 Lectures)**

X-ray emission spectra, X-ray energy level diagram, Diagram and forbidden lines in X-ray spectra, multiple transitions, Selection rules, Relative intensities of emission lines in a Multiplet, Spin and Screening doublets, screening parameters and their determination, Recent dvances in methods of calculation of screening parameter. **(05 Lectures)**

### UNIT II (13 Lectures)

X-ray satellites and their origin, parent line and its determination for a satellite

Wetzel-Druyvesteyn theory of high energy satellites, hypersatellites, theories

for low energy satellites **(06 Lectures)**

Rearrangement of atomic electrons following inner shell ionization, Radiative transitions, Auger effect and its consequences in X-ray spectra, Coster-Kronig transitions, the super Coster-Kronig transitions **(07 Lectures)**

### UNIT III (12 lectures)

X-ray absorption, Absorption coefficients, Characteristic absorption limits and associated fine structure. Absorption jump ratios **(06 Lectures)**

Theory of absorption curve shape, Nature of the main absorption edge and the white line. X-ray absorption near edge structure, X-ray absorption main edge structure, Introduction of Extended X-ray absorption fine structure **(06 Lectures)**

### UNIT IV (12 Lectures)

Long Range Order and Short Range Order theories of X-ray absorption fine structure, Kronig theory of extended X-ray absorption fine structure, modifications of Kronig theory, Single and double potential model of Lytle **(07 Lectures)**.

Soft X-ray spectroscopy, Experimental methods: Source, Vacuum spectrographs: Crystal spectrometer, Grating spectrograph , Detector, Soft X-ray emission Spectroscopy applied in the study of band structure of solids, Soft X-ray absorption Spectra: Recording and interpretation **(05 Lectures**)

**LABORATORY- PHYC –405A,405B,405C as given in Semester III.**

**DEPARTMENT OF PHYSICS (Semester IV)**

**ELECTIVE PAPER**

**PHYE-401**

**PHYSICS AT LHC AND BEYOND (3 Credits)**

**UNIT I** (10 Lectures)

Overview of high energy physics: Fundamental particles and fundamental forces, Klein-Gordon, Dirac and Maxwell fields. Processes involving electromagnetic, strong and weak interactions.
Gauge invariance, Higgs mechanism and electroweak unification, standard model.

**UNIT II** (13 Lectures)

Brief ideas about grand unified theories, supersymmetry and supergravity, extradimension and string theory. Physics at LHC: LHC and experiments at ALICE, CMS, ATLAS, LHCb, LHCf, MOEDAL, TOTEM etc. Discovery of Higgs and B-physics, test of physics beyond standard model, quark-gluon plasma, test of physics involving extra dimension, gravitons and black holes.

**UNIT III** (12 Lectures)

Need of the hour: Plasma-based accelerators. Definition and characteristics of plasma, collective behaviour, plasma oscillations, plasma frequency. Propagation of electromagnetic waves in plasma, plasma electron quiver velocity, current density, linear dispersion relation, phase and group velocity, refractive index. Under dense, critcally dense and over dense plasmas. Interaction of plasma with intense laser radiation fields, nonlinear interaction- relativistic quiver velocity, dispersion. Transverse and longitudinal ponderomotive forces.

**UNIT IV (10 Lectures)**

Wakefield generation in the relativistic and mildly relativistic regimes; Future high energy accelerators -concept of laser wakefield acceleration (LWFA), energy gain of externally injected test electrons.
Electron acceleration in the bubble regime, beat wave acceleration,Elementary idea of electron beam driven plasma wakefield accelerators (PWFA). The Advanced Wakefield Experiment (AWAKE) at CERN.