NATIONAL INSTITUTE OF TECHNOLOGY, DURGAPUR
DEPARTMENT OF PHYSICS

Curricula and Syllabi for M. Sc. Course in Physics

FIRST SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	PH1101	MATHEMATICAL METHODS OF PHYSICS	3-1-0	4
2	PH1102	CLASSICAL MECHANICS	3-1-0	4
3	PH1103	CONDENSED MATTER PHYSICS-I	3-1-0	4
4	PH1104	ANALOG AND DIGITAL ELECTRONICS	3-1-0	4
5	PH1105	QUANTUM MECHANICS- I	3-1-0	4
6	PH1151	GENERAL PHYSICS LAB	0-0-6	3
7	PH1152	SOLID STATE PHYSICS LAB	0-0-4	2
TOTAL				**25**

SECOND SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	PH2101	QUANTUM MECHANICS- II	3-1-0	4
2	PH2102	OPTOELECTRONICS-I	3-1-0	4
3	PH2103	NUCLEAR PHYSICS AND PARTICLE PHYSICS	3-1-0	4
4	PH2104	ELECTRODYNAMICS	3-1-0	4
5	PH2105	PHYSICS OF CRYSTALLINE AND NON-CRYSTALLINE SOLIDS	3-1-0	4
6	PH2151	ELECTRONICS LAB	0-0-6	3
7	PH2152	NUCLEAR PHYSICS LAB	0-0-4	2
TOTAL				**25**

THIRD SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	PH3101	STATISTICAL MECHANICS	3-1-0	4
2	PH3102	NUMERICAL AND NONLINEAR ANALYSIS	2-0-2	3
3	PH3103	GENERAL THEORY OF RELATIVITY AND COSMOLOGY	3-0-0	3
4	PH91XX	ELECTIVE - I	3-1-0	4
5	PH91XX	ELECTIVE - II	3-1-0	4
6	PH3151	SEMINAR		1
7	PH3152	OPTOELECTRONICS LAB / ADVANCED CONDENSED MATER PHYSICS LAB	0-0-12	6
TOTAL				**25**

FOURTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	PH4101	Advanced Quantum Mechanics and Field Theory	3-1-0	4
2	PH4102	Atomic and Molecular Spectroscopy	3-1-0	4
3	PH91xx	Elective - III	3-1-0	4
4	PH91xx	Elective - IV	3-1-0	4
5	PH4151	Project	14	7
6	PH4152	Presentation and Viva Voce		2
TOTAL				**25**

Electives	**Group-I: Condensed Matter Physics Specialization**		**Group-II: Opto-Electronics Specialization**	
	Paper code	Name of the Paper	Paper code	Name of the Paper
Elective-I	PH9111	Condensed Matter Physics-II	PH9121	Optoelectronics-II
Elective-II	PH9112	Materials for Engineering Applications	PH9122	Circuit Analysis and Integrated Circuits
Elective-III	PH9113	Nanomaterials	PH9123	Nonlinear Optics
Elective-IV	PH9114	X-Rays and Structural Studies	PH9124	Communication Technologies

SUMMARY OF COURSES

Sub Discipline: DEPARTMENTAL CORE

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
PH1101	MATHEMATICAL METHODS OF PHYSICS	3-1-0	4	Dr. S. Basu
PH1102	CLASSICAL MECHANICS	3-1-0	4	Prof. A. K. Meikap
PH1103	CONDENSED MATTER PHYSICS-I	3-1-0	4	Prof. P. Kumbhakar & Dr. A. Mondal
PH1104	ANALOG AND DIGITAL ELECTRONICS	3-1-0	4	Dr. M. K. Mandal & Dr. H. Chaudhuri
PH1105	QUANTUM MECHANICS- I	3-1-0	4	Dr. S. Sahoo
PH2101	QUANTUM MECHANICS- II	3-1-0	4	Dr. S. Sahoo
PH2102	OPTOELECTRONICS-I	3-1-0	4	Prof. P. Kumbhakar & Dr. A. Mondal
PH2103	NUCLEAR PHYSICS AND PARTICLE PHYSICS	3-1-0	4	Dr. A. K. Chakraborty
PH2104	ELECTRODYNAMICS	3-1-0	4	Dr. S. Basu
PH2105	PHYSICS OF CRYSTALLINE AND NON-CRYSTALLINE SOLIDS	3-1-0	4	Prof. A. K. Meikap
PH3101	STATISTICAL MECHANICS	3-1-0	4	Dr. S. Basu
PH3102	NUMERICAL AND NONLINEAR ANALYSIS	2-0-2	3	Dr. M. K. Mandal & Dr. H. Chaudhuri
PH3103	GENERAL THEORY OF RELATIVITY AND COSMOLOGY	3-0-0	3	Dr. S. Sahoo
PH4101	Advanced Quantum Mechanics and Field Theory	3-1-0	4	Dr. S. Sahoo
PH4102	Atomic and Molecular Spectroscopy	3-1-0	4	Dr. S. Basu

Sub Discipline: DEPARTMENTAL ELECTIVES

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
PH9111	Condensed Matter Physics-II	3-1-0	4	Dr. S. Basu
PH9112	Materials for Engineering Applications	3-1-0	4	Dr. A. K. Chakraborty
PH9113	Nanomaterials	3-1-0	4	Dr. A. Mondal
PH9114	X-Rays and Structural Studies	3-1-0	4	Dr. H. Chaudhuri
PH9121	Optoelectronics-II	3-1-0	4	Prof. P. Kumbhakar
PH9122	Circuit Analysis and Integrated Circuits	3-1-0	4	Dr. M. K. Mandal
PH9123	Nonlinear Optics	3-1-0	4	Prof. P. Kumbhakar
PH9124	Communication Technologies	3-1-0	4	Dr. M. K. Mandal

Sub Discipline: LABORATORY & SESSIONAL COURSES

SUBJECT CODE	SUBJECT	L-T-P	CREDIT
PH1151	GENERAL PHYSICS LAB	0-0-6	3
PH1152	SOLID STATE PHYSICS LAB	0-0-4	2
PH2151	ELECTRONICS LAB	0-0-6	3
PH2152	NUCLEAR PHYSICS LAB	0-0-4	2

Sub Discipline: PROJECT, SEMINAR etc.

PH3151	SEMINAR		1
PH3152	OPTOELECTRONICS LAB / ADVANCED CONDENSED MATER PHYSICS LAB	0-0-12	6

PH1101 Mathematical Methods of Physics 4 credits [3-1-0]

Complex variables: Analytic functions, Cauchy Riemann equations, integration in the complex plane, Cauchy's theorem, Cauchy's integral formula. Taylor and Laurent expansion, singular points and their classifications. Branch point and branch cut. Riemann's sheets. Application of residue theorem to the evaluation of definite integrals and the summation of infinite series. Integrals involving branch point singularity. [13]

Fourier and Laplace transforms: Fourier and Laplace transforms, Inverse transform, convolution theorem, solution of ordinary and partial differential equation by transform method. [6]

Theory of ordinary and partial differential equations: ordinary and partial differential equations of mathematical Physics. Hermite Lagurre, Bessel and associated Legendre function and their recurrence relations. Integral representation and orthogonality. [13]

Integral equations: Fredholm and Volterra equations of first and second kinds. [5]

Vector space: Linear vector space, Subspaces, Linear independence, Basis and dimension. Linear transformation, Linear operators, Matrix representation. The algebra of matrices, special matrices, Rank of matrix, equivalent matrices, eigen values and eigenvectors of matrices. The Caylen-Hamilton theorem. Function of matrices, diagonalisation of matrices, quadratic form, principal axis transformation. [8]

TEXT BOOKS:

1. G. Arfken (Academic Press), *Mathematical Methods for Physicists*
2. P. Dennery and A. Krzywicki (Harper and Row), *Mathematics for Physicists*

REFERENCE BOOKS:

1. J. Mathews and R. I. Walker (Benjamin), *Mathematical Methods of Physics*
2. A. W. Joshi (Wiley Eastern), *Matrices and Tensors*

PH1102 Classical Mechanics 4 credits [3-1-0]

Review: Hamilton's Principle and Lagrange's equation of motion, Legendre transformation and Hamilton's equations of motion. Physical significance. [5]

Canonical Transformations: The equations of canonical transformations. Integral invariant of Poincare. Lagrange and Poisson brackets as canonical invariants. The equations of motion in the poisson bracket formulation. Infinitesimal conctact transformations and conservation theorems. [10]

Hamilton–Jacobi Theory: Hamilton-Jacobi equation and application to harmonic oscillator. Action-angle variables. The Kepler problem. H-J theory. Geometrical optics and wave mechanics. [6]

Lagrangian and Hamiltonian formulations for continuous systems: Transition from a discrete to a continuous system. Lagrangian formulation for continuous system. The stress – energy tensor and conservation theorems. Hamiltonian formulation. [6]

Rigid body motion: The independent co-ordinates of a rigid body. Euler angles, Cayley-Klein parameters. Euler's theorem. Infinitesimal rotations, coriolis force.
Angular momentum and kinetic energy of motion of a rotating body. The inertia tensor and moment of inertia. Principal axis transformation, Euler equation, torque free motion of rigid body. [10]

Special Theory of Relativity in Classical Mechanics: Covariant four dimensional formulations. Minkowski's space. Force and energy equations in relativistic mechanics. Lagrangian formulation of relativistic mechanics. Hamiltonian formulation of relativistic mechanics. Covariant Lagrangian and Hamiltonian formulation. [8]

TEXT BOOKS:

1. H. Goldstein, *Classical Mechanics*
2. Rana & Jog, *Classical Mechanics*

REFERENCE BOOKS:

1. Corben & Stehle, *Classical Mechanics*
2. Landau and Lifshitz, *Mechanics*

PH1103 Condensed Matter Physics-I 4 credits [3-1-0]

Free electron model: Heat capacity; Transport properties; Electron-electron interaction, electron-phonon interactions, Polarons, Hall Effect; Elementary concepts of quantum Hall effect. [5]

Structure and Scattering: Crystalline solids, liquids and liquid crystals, Nanostructures, Bucky balls. [8]

Electrons in a periodic potential: Bloch's theorem; Nearly free electron Model, Tight-binding model; Motion of an electron in a dc electric field, Effective Mass, Concept of holes, Energy band structure of solids, Energy band properties of semiconductors. [10]

Crystal Binding: Types of solids, Van der Waals solids, Ionic and Covalent solids, Metallic bonding, calculation of cohesive energy. [6]

Lattice Vibrations: Lattice vibrations, Adiabatic & harmonic approximations. Vibrations of mono and diatomic lattices, Lattice Heat Capacity, Einstein and Debye models. [6]

Superconductivity: Properties of Superconductors, Experimental Survey, Meissner effect, London's equation, Thermodynamics of superconductors, Cooper pair, BCS theory, Ginzburg-Landau theory, Flux quantization, Magnetism; Exchange interaction. [6]

Magnetism: Diamagnetism, paramagnetism, Ferromagnetism, anti-ferromagnetism & Ferimagnetism, Hund's rules, Pauli paramagnetism, Heisenberg model, Mean field theory, spin waves, Giant and Colossal magnetoresistance. [4]

TEXT BOOKS:

1. M. Ali Omar, *Elementary Solid State Physics (Addision-Wesley)*
2. C. Kittel, *Solid State Physics (Wiley Eastern)*
3. F. C. Phillips, *An introduction to crystallography (Wiley)*

REFERENCE BOOKS:

1. Christman, *Solid State Physics (Academic press)*

PH1104 Analog and Digital Electronics 4 credits [3-1-0]

Semiconductor Devices: Bipolar devices- Junction diode, bipolar junction transistor, Heterojunction devices. Unipolar devices- Metal-semiconductor contacts, JFET, MOSFET [10]

Active Circuits: Amplifiers- Discrete component transistor amplifier design technique. Video amplifiers, RF amplifiers, Power amplifier design consideration. Oscillators- Feedback principle, OP-Amp based R-C phase shift, Wien bridge oscillators. OP-Amp circuits- Active filters, Butter worth filter. [10]

Passive Networks and Transmission Line: Prototype LC frequency selective networks HF transmission lines Primary and secondary line constants, lnput impedance, VSWR, Distortion of e. m. wave in practical lines, Fault location in practical line. [5]

Digital Electronic Circuits: Logic Circuits- Classification, Logic simplification, SOP and POS design of combinational circuits. Sequential Circuit- Flip-f1ops, Counters and Registers. Arithmetic Circuit- RCA, CLA, BCD adders, multipliers. [10]

Communication: Classification of modulation- AM, FM, and PM and Comparative merits in the context of transmission bandwidth, Power utilization. AM and FM modulators and demodulators. Effect of Noise on Communication System- Characteristics of additive noise, Performance of AM, FM receivers in the face of noise. [10]

TEXT BOOKS:

1. S. M. Sze, *Physics of semiconductor devices.*
2. J. Millman & Grable, *Microelectronics.*
3. Fraser, *Telecommunications.*
4. Malvino and Leach, Digital Principles & Applications
5. V.C. Hamacher et. al. *Computer organisation*.

REFERENCE BOOKS:

1. J. D. Ryder, *Electronic fundamental and applications.*
2. S. Soclof, *Applications of analog integrated circuits.*
3. J.D. Ryder, *Networks lines and fields.*
4. R. Roddy and J. Coolen, *Electronic communication*.

PH1105 Quantum Mechanics –I 4 credits [3-1-0]

Introduction to Quantum Mechanics: Old quantum theory and its limitations, wave packets, Uncertainty principle, Schroedinger's wave equation, postulates of wave mechanics, expectation value, expansion of a state function, Orthogonality, completeness and closure, Dirac delta function, stationary states, probability and current densities, Ehrenfest's theorem. Application of wave mechanics to simple problems: Reflection and transmission through potential barriers, particle in a box, linear harmonic oscillator etc. **[8]**

General Principles of Quantum Mechanics: Linear vector space, ket and bra vectors. Scalar product of vectors and their properties. Linear operators, Adjoint operarors, Unitary operators, Hermitian operators, Eigen values and eigenvectors. Degeneracy. Schmidt method of orthogonalization. Expansion theorem. Completeness and Closure property of the basis set. Representation of ket and bra vectors and operators in the matrix form. Unitary transformations of basis vectors and operators. **[8]**

Quantum Dynamics: Time evolution of quantum states. Time evolution operator and its properties. Schroedinger picture, Heisenberg picture, Interaction picture. Equations of motion. Operator method solution of Harmonic oscillator, Matrix representation and time evaluation of creation and annihilation operators. Density matrix. **[8]**

Rotation and Orbital Angular Momentum: Angular momentum operators as the generators of rotation**,** rotation matrix. L_x, L_y, L_z, and L^2 and their commutator relations. Raising and lowering operators. L_x, L_y, L_z, and L^2 in spherical polar co-ordinates. **[8]**

Spin Angular Momentum: Spin – ½ particles, Pauli spin matrices and their properties. Eigen values and Eigen functions. Spinor transformation under rotation. **[2]**

Addition of Angular Momentum: Total angular momentum J. Addition of angular momenta and C. G. co-efficients. Angular momentum states for composite systems in the angular momenta (½, ½) and (1, ½). **[3]**

Motion in a Spherically Symmetric Field: Hydrogen atom. Reduction to equivalent one body problem. Radial equation. Energy eigenvalues and eigen functions, degeneracy, radial probability distribution. Free particle problem incoming and outgoing spherical waves, expansion of plane waves in terms of spherical waves. Bound states of a 3-D square well, particle in a sphere. **[8]**

TEXT BOOKS:

1. S Gasiorowicz, *Quantum Physics*
2. David J. Griffiths, Introduction to Quantum Mechanics, Pearson Education, New Delhi.

REFERENCE BOOKS:

1. J L Powell and B. Craseman, *Quantum Mechanics*
2. L I Shiff, *Quantum Mechanics (3 rd ed.)*
3. P Roman, *Advanced Quantum Mechanics*
4. M E Rose, *Elementary Theory of Angular Momentum*

PH2101 Quantum Mechanics –II 4 credits [3-1-0]

WKB Approximation and Variational Method: The WKB approximation, Connection formulae, Bohr Sommerfeld quantization rule, Harmonic oscillator and cold emmision. **[7]**
The varitional method and its application to simple problems (Ground state of the Hydrogen atom, He-atom, Harmonic oscillator, Hydrogen molecule etc.). **[5]**
Perturbation Theory: Time-independent perturbation theory for non-degenerate and degenerate states. First and second order perturbation, Applications to anharmonic oscillator, He atom, Linear and quadratic Stark effect, Normal and anomalous Zeeman effect. **[10]**
Time-dependent perturbation theory, transition probability, constant and harmonic perturbation, Fermi golden rule, Electric dipole radiation and selection rules. **[8]**
Scattering: Scattering amplitude and cross section. Born approximation. Application to Coulomb and Screened Coulomb potentials. Partial wave analysis for elastic and inelastic scattering, optical theorem, Black disc scattering, scattering from a hard sphere, Resonance scattering from a square-well potential. **[15]**

TEXT BOOKS:

1. S Gasiorowicz, *Quantum Physics*
2. David J. Griffiths, Introduction to Quantum Mechanics, Pearson Education, New Delhi.

REFERENCE BOOKS:

1. J L Powell and B. Craseman, *Quantum Mechanics*
2. L I Shiff, *Quantum Mechanics (3 rd ed.)*

PH2102 Optoelectronics-I 4 credits [3-1-0]

Basic principles of Laser:
Properties of Laser Radiation, Basic components of Laser, Classifications of Lasers, Spontaneous and stimulated emission. [2]
Einstein's coefficients and their relations, conditions of population inversion, [2]
Absorption and amplification of light in a medium, population inversion and threshold condition for a laser, gain coefficient. [4]
Laser Rate Equations, 2-level laser, 3-level and 4-level lasers. [3]
Line broadening mechanisms—(spontaneous transition, collision broadening and Doppler broadening) [3]
Modulation Techniques:
Propagation of EM waves in anisotropic dielectric medium, dielectric Tensor, Index ellipsoid. [2]
Electro-optic effect, electro-optic phase retardation, electro-optic amplitude modulation, phase-modulation of light. [4]
Acousto-optic effect (introduction), Application of EO effect. [2]
Photonic devices: Light Emitting Diode (LED), quantum efficiencies (internal and external), responsivities, Characteristics and applications of various kinds of LEDs, dome type LED, homojunction LED, heterojunction LED, guided wave LED, edge-emitting LED, quantum cascaded LED, quantum dot LED, operational circuit and modulation of LEDs. Different types of coupling procedure of LED with optical fiber. Coupling coefficients and coupling loss. [5]
Photo diode, quantum efficiencies (internal and external), responsivities, Characteristics and applications of various kinds of photodetectors, P-I-N photodiode, Avalanche photodiode, Metal–Semiconductor-Metal (M-S-M) photodiode, quantum well photodetector, multiquantum well photodetector, infrared photodetector etc. Photomultipliers tubes. [6]
Charge coupled devices (CCD), solar cell [4]
Fiber Optics: Rectangular and cylindrical waveguides, propagation of radiation in dielectric waveguides. [4]
Step index and graded index fiber, modes in fiber, dispersion in multimode & single mode fiber, attenuation mechanisms in fibers, signal distortion, mode coupling, power launching and coupling, fiber parameter specifications. [3]
Applications: Holography, and communication (introductory) [1]

TEXT BOOKS:

1. S. M. Sze, *Physics of semiconductor devices.*
2. O. Svelto, *Principles of Lasers*
3. Franz and Jain, *Optical communication systems*

REFERENCE BOOKS:

1. P. Bhattacharya, *Semiconductor opto-electronic devices*.
2. W. Koechner, *Solid State Laser Engineering*
3. J. M. Senior, *Optical fiber communications principles and practice*
4. *S.O. Kasap, Optoelectronics and Photonics principles and practices*
5. *Martin A Green, Solar Cells: Operating Principles, Technology, and System Applications*

PH2103 Nuclear Physics & Particle Physics 4 credits [3-1-0]

General properties of Nucleus: Evidence of existence of nucleus, Rutherford's gold-leaf experiment, basic nuclear properties such as size, shape, density, mass, mass defects, binding energy, charge distribution, spin, parity, nuclear moments, etc. Nuclear forces, forms of nucleon-nucleon potential, charge independence and charge symmetry of nuclear forces. **[8]**
Nuclear models: Liquid drop model, semi-empirical mass formula, Single particle shell model and its validity and limitation, explanation of magic nuclei. **[8]**
Nuclear radiations: Theories of alpha, beta and gamma decays, selections rules, neutrino hypothesis, nuclear isomers, energy loss by charged particles and gamma rays. **[8]**
Nuclear reactions: General review of nuclear reactions, types of nuclear reactions, nuclear fission and fusion, reactions cross-section and yield, conservation rules, energy and mass distribution in nuclear reactions, threshold energy of nuclear reaction, reaction mechanism, Compound nucleus hypothesis and direct reactions. **[10]**
Elementary particle Physics: Classification of fundamental forces, elementary particles and their quantum numbers (charge, spin, parity, isospin, strangeness, etc.), Gellmann-Nishijima formula, Quark model, baryons and mesons. CPT invariance, Symmetry arguments in particle reactions, Parity violation in weak interaction, Relativistic kinematics. **[10]**

Text Books:
1. S.N. Ghoshal, Atomic & Nuclear Physics
2. D. C. Tayal, Nuclear Physics
3. V. K. Mittal, R. C. Verma, S. C. Gupta, Introduction to Nuclear and Particle Physics

Reference Books:
1. David Griffiths, Introduction to Elementary Particles
2. Irving Kaplan, Nuclear Physics
3. B. L. Cohen, Concepts of Nuclear Physics

PH2104 Electrodynamics 4 credits [3-1-0]

Electrostatic and magnetostatic field Problems: Uniqueness theorem, Green's reciprocation theorem, solution by Green's function, solution by inversion, Solution of Laplaces' equation. Magnetic circuits. Magnetic scalar potential and vector potential, use of vector potential in solution of field problems. [8]

Propagation of Plane Electromagnetic Waves: Maxwell's equations, Plane electromagnetic waves in free space. Poynting vector for free space. Plane electromagnetic waves in matter. Plane electromagnetic wave propagation in non-conducting media and conducting media. Poynting vector in conducting media, Reflection and refraction at a plane boundary. [6]

Greens function. Solution of Maxwell's equations. Lorentz and Coulomb gauge. Gauge invariance. Linear and Circular polarizations. Stoke's parameters. Frequency dispersion characteristics of dielectrics and conductors. Waves in dispersive medium. Kramer–Kronig relations. [6]

Wave Guides and Resonant Cavities: Cylindrical cavities and wave guides. Modes in a rectangular wave guide. Resonant cavities. [5]

Radiation, Scattering and Diffraction: Fields and radiation of a localised oscillating source. Electric dipole fields and Radiation. Scattering by a small dielectric sphere in long wavelength limit. Rayleigh scattering. Kirchoffs formulation of diffraction by a circular aperture. [6]

Radiation by Moving Charges: Lienard–Wiechert potentials and fields for a point charge. Total power radiated by an accelerated charge. Larmor's formula. Thomson Scattering. [6]

Electrodynamics & Relativity: Special theory of Relativity an Introduction, Lorenz Transformation, The structure of Spacetime ,Magnetism as relativistic phenomena, How the field transform, The field tensor, electrodynamics in tensor notation, relativistic potentials. [8]

TEXT BOOKS:

1. J. D. Jackson, *Classical Electrodynamics*
2. D. J. Griffiths, *Electrodynamics*

REFERENCE BOOKS:

1. M. Born and E. Wolf, *Principles of Optics*
2. J. R. Reitz, F. J. Milford & R. W. Christy, *Foundations of Electromagnetic Theory*
3. Panofsky & Phillips, Classical *Electricity & Magnetism*

PH2105 Physics of Crystalline and Non-Crystalline Solids 4 credits [3-1-0]

Topic-1: Symmetry operations and their classifications, Macroscopic Symmetry, Mirror plane, Rotation axis, Centre of symmetry, Roto Inversion symmetries and their examples, 32 Point Groups, Seven Crystal classes and their unit cells. [8]
Topic-2: Bravais Lattices, density of packing, Microscopic Symmetry Elements, Screw axis and Glide plane of symmetries, Hermann- Mauguin Symbols, Space Groups. Basic introduction to the crystal structure analysis. Derivation of Laue and Bragg's reflection. Reciprocal lattice, the relation with direct lattice. Importance of reciprocal lattice, Ewald's sphere. [10]
Topic-3: Deviation from perfect crystallinity, Defects in crystals and their classifications. Poly Crystals and their characteristics, Long range and short range order. Differences between polycrystals and single crystalline states of matter. Mechanical properties and deformation characteristics in polycrystals. Crystal defects and introduction to their analysis. Deviation from perfect poly crystallinity, Preferred orientations and their analysis. [12]
Topic-4: Phase transformations, Diffusion mechanism, Diffusion less transformations, Time - temperature transformation for some important alloys [5]
Topic-5: Non-crystalline solids. Localized states, Kubo-Greenwood formula, hoping mechanism, short range and long range order, structure of amorphous state-Mott transition. [5]
Topic-6: Quasi Crystalline state of matter. Liquid crystals, the delicate state of matter. Different classification of Liquid crystals and their properties. Applications of liquid crystals in display devices. Plastic crystals. [5]

TEXT BOOKS:
1. L. V. Azaroff, *Introduction to solids*
2. F. C. Phillips, *An introduction to crystallography*
3. S. K. Chatterjee, *X-ray diffraction its theory and applications*

REFERENCE BOOKS:
1. M. J. Burger, *Crystal structure analysis*
2. B. D. Cullity, *X-ray diffraction*
3. B. E. Warren, *X-ray diffraction*

PH2151 Electronics Lab 3 credits [0-0-6]

1. To study the current mirror circuit
2. To study the frequency response of BJT amplifier in CE configuration and to investigate different related properties with and without feedback.
3. To study the frequency response of two-port Network.
4. To study amplitude modulation and demodulation circuit.
5. Generation of square wave-form using IC555.
6. Design and study of 4-bits BCD adder/subtractor

PH2152 Nuclear Physics Lab 2 credits [0-0-4]

1. Determination of the operating plateau of a GM tube.
2. Study on random nature of radioactive decay.
3. Determination of half-life of a radioactive isotope.
4. Verification of inverse square law of radioactivity.
5. Determination of linear absorption coefficient of a radioactive isotope.

PH3101 Statistical Mechanics 4 credits [3-1-0]

Scope and aim of Statistical Mechanics: Phase Space, Phase Points, Ensemble. Density of Phase Point and Liouville's Equation, Stationary ensembles: Micro - Canonical, Canonical and Grand Canonical. Partition functions. Equilibrium Properties of Ideal System: Ideal gas, Harmonic Oscillators, Rigid rotators. Bose – Einstein and Fermi – Direct distribution functions, general equations of states for ideal quantum systems, Properties of ideal Bose - gas, Bose – Einstein condensation. [14]

Density Matrix: Statistical and Quantum mechanics approaches, Properties of mixed and Pure states, density matrix for stationary ensembles, Application of a free particle in a box, an electron in a magnetic field, Density matrix for a beam of spin ½ Particles, construction of density matrix for different spin states and calculation of the polarization vector. [10]

Statistical mechanics of interacting systems: Cluster expansion for a classical gas, Virial expension of equation of state, Evaluation of the Virial coefficients, Exert treatment of the second Virial coefficients, Quantum cluster expansion. [8]

Strong Interacting system: Ising Model, Ideas of exchange interaction and the Heisenberg Hamiltonian, Ising Hamiltonian as a truncated Heisenberg Hamiltonian, [5]

Phase Transitions: General remarks, Phase transition and critical phenomena, critical indices, Landau's order parameter theory of phase transition. [5]

Fluctuations: Fluctuations of fundamental thermodynamic quantities. Correlations of fluctuations in space and time. [3]

TEXT BOOKS:

1. R. K. Pathria, *Statistical Mechanics*
2. K. Huang, *Statistical Mechanics*

REFERENCE BOOKS:

1. L. D. Landen, E. M. Lifshitz and P. Pilaevskii, *Statistical Physics (Pt.-I)*
2. R. P. Feynaman, *Statistical Mechanics, A set of lectures*
3. S. K. Ma, *Statistical Physics*
4. A Ishihara, *Statistical Physics*
5. M. Teda, R. Kubo, and N. Satto, *Statistical Mechanics*

PH3102 Numerical and Nonlinear Analysis 3 credits [2-0-2]

Numerical analysis: Numerical analysis and C++ programming to solve the problems in the following topics: (i) Solutions of nonlinear equations, (ii) Interpolation, (iii) Numerical integration and differentiation, (iv) Numerical solution of first and second order differential equations, (v) Systems of linear equations, (vi) Methods of least squares, etc. **[15]**

Introduction to nonlinear system: Introduction to dynamical systems; basic concepts of nonlinear dynamics using the simple pendulum, examples of linearity and nonlinearity in physics and other sciences – electronics, LASER, geophysics, biology, finance & economics; One and two dimensional nonlinear systems; Systems of differential equations with examples; control parameters; fixed points and their stability; phase space; periodic orbits; nonlinear oscillators and their applications; bifurcation and physical examples. **[4]**

Fractals and Chaos: Dynamical systems and fractals; Examples of fractals in nature; Fractal dimension - a non-integer dimension; Multifractal detrended fluctuation analysis (MFDFA) technique, hurst exponent. Basic concept of chaotic system; Strange attractors; Evolution of phase space volume in chaotic and non-chaotic system; Chaotic time series [**4]**

Time series analysis: Concept of frequency domain and time domain for analysis of time series data, Continuous and discrete time series; Stationary and non-stationary data; Periodic and non-periodic signals; Frequency analysis of time series; Fourier series and Fourier Transform; Discrete Fourier Transform (DFT), Fast Fourier Transform (FFT), Power law; Noises in signals – white noise, pink noise etc.; Signal Filtering process – concept of RMS analysis, SVD technique, Surrogate data. **[6]**

Software packages for the study of nonlinear system (Computation Lab): Introduction to software packages which are widely used in the study of nonlinear systems – Mathematica; Matlab. Methods and Applications of DFT & FFT algorithms; estimation of hurst exponent using power law slope, R/S method. Methods and Applications of MFDFA algorithms. Analysis of Chaotic time series, estimation of lyapunov exponent. **[6]**

TEXT BOOKS:

1. J H Mathews & K D Fink, Numerical Methods Using Matlab (ISBN 81-203-2765-9).
2. S. H. Strogatz, Nonlinear Dynamics and Chaos with Applications to Physics, Biology, Chemistry and Engineering, Perseus Books Publishing, 2000.

REFERENCE BOOKS:

1. A Stevens & Clayton Walnum, C++ Programming Bible (ISBN 81-265-0005-0)
2. H. Kantz and T. Schreiber, Nonlinear Time Series Analysis, CUP 1998, 2nd edition

PH3103 General Theory of Relativity and Cosmology 3 credits [3-0-0]

Tensor analysis: Scalars, contravariant vectors, covariant vectors, tensors of higher rank, Tensor algebra, Christoffel symbols, covariant differentiation of vectors, higher rank tensors & fundamental tensors, Tensor form of gradient, divergence and curl, Riemann-Christoffel curvature tensor, Ricci tensor, scalar curvature, Bianchi identities. **[11]**

Gravitaion: Statement of the Principle of Equivalence, Gravitational forces, Relation between $g_{\mu\nu}$ and $\Gamma^{\lambda}_{\mu\nu}$, Newtonian limit, Principle of general covariance, Derivation of Einstein field equations, Brans-Dicke theory, coordinate conditions, Cauchy problem, energy, momentum and angular momentum of gravitation, Experimental tests of the general theory of relativity. **[12]**

Cosmology: The cosmological principle, Newtonian cosmology, Einstein universe, Expanding universe, Hubble's law, Robertson-Walker metric, red shift, measures of distance, red-shift versus distance relation. Density and pressure of the present universe, matter dominated era, observation of cosmic microwave radiation background, Elementary idea about dark matter and dark energy. **[12]**

TEXT BOOKS:

1. Gravitation and Cosmology – S. Weinberg
2. An Introduction to Relativity – J. V. Narlikar

REFERENCE BOOKS:

1. An Introduction to Cosmology – J. V. Narlikar
2. Gravity: An Introduction to Einstein's General Relativity – J. B. Hartle
3. Relativity, Gravitation and Cosmology: A Basic Introduction – Ta-Pei Cheng

PH3151 Seminar 1 credit

PH3152 Optoelectronics Lab/Advanced Condensed Mater Physics Lab 6 credits [0-0-12]

Group- I

1. Synthesis of a semiconductor ZnS nanoparticles by chemical method
2. Determination of optical absorption characteristics of Nanoparticles
3. Electrical transport properties of compacted assembly of nanoparticles
4. Analysis of electron micrograph of the materials
5. Structural characterization of nanomaterials by XRD technique

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Group- II

1. Design and study the ECL OR NOR gate.
2. Design of PLL and study of its properties.
3. Design and study of active band pass filter.
4. Microprocessor programming.
5. Determination of Si Solar Cell efficiency
6. Output spectrum of Si and Ge detector
7. Determination of wavelength of He-Ne laser using a diffraction grating.
8. Measurement of coherence properties of laser light.
9. Measurement of beam size, beam divergence and Gaussian shape characteristics of laser radiation.

PH4101 Advanced Quantum Mechanics and Field Theory 4 credits [3-1-0]

Relativistic Quantum Mechanics: Klein-Gordon equation and its drawbacks, Dirac equation, properties of Dirac matrices, Non-relativistic reduction of Dirac equation, magnetic moment, Darwin's term, spin-orbit coupling, Covariant form of Dirac equation, bilinear covariants. **[11]**

Free particle solution of Dirac equation, projection operators for energy and spin, physical interpretation of free particle solution, Zitterbewegung and negative-energy solutions, hole theory, charge conjugation, space reflection and time reversal symmetries of Dirac equation. **[11]**

Quantum Field Theory: Transition from discrete to continuous system, Lagrangian formulation for continuous systems, Noether's theorem, second quantization, quantization of scalar field, Dirac field and electromagnetic field. Electromagnetic interaction and gauge invariance. **[12]**

The S-matrix expansion, Wick's theorem, Feynman diagrams, lowest order matrix elements for Compton scattering. Moller scattering and Bhaba scattering from Feynman diagram. Detail calculation of differential cross-section of Compton scattering only. **[11]**

TEXT BOOKS:

1. Advanced Quantum Mechanics – J. J. Sakurai
2. Quantum Field Theory – F. Mandal and G. Shaw

REFERENCE BOOKS:

1. Relativistic Quantum Mechanics – Bjorken and S. D. Drell
2. Classical Mechanics – H. Goldstein
3. Quantum Field Theory – C. Itzykson and J. Zuber
4. The Quantum Theory of Fields, Vol. I & Vol. II – S. Weinberg
5. An Introduction to Quantum Field Theory – M. E. Peskin and D. V. Schroeder

PH4102 Atomic and Molecular Spectroscopy 4 credits [3-1-0]

Atomic Spectroscopy: Introduction to atomic spectroscopy, Introduction to quantum mechanics, One electron Atom problem, Interaction of one-electron atoms with electromagnetic radiations, Fine structure and hyperfine structure, Interaction of one-electron atom s with external electric and magnetic fields. Two electrons atoms. [12]

Introduction to Molecular spectroscopy: Introduction to molecular spectroscopy, spin resonance spectroscopy, spin and applied fields, NMR and ESR spectroscopy. Born-Oppenheimer approximation and separation of electronic and nuclear motion in molecules. Band structure of molecular spectra. [4]

Microwave and infrared spectroscopy: Rotational spectra of diatomic molecules in rigid and nonrigid rotator mode. Selection rules. Determination of bond length. Rotational spectra of polyatomic molecules (spherically symmetric, symmetric top and asymmetric top molecules). Isotope effect. . [5]

Near Infrared spectroscopy: Vibrational spectra of diatomic molecules in harmonic and anharmonic oscillator model. Morse potential and dissociation energy of diatomic molecule. Selection rules. Rotational–Vibrational spectra. Isotope effect. [6]

Electronic spectra of diatomic molecules:
Vibrational band structure of electronic spectra, Deslandre's table. Isotopic shifts of O-O and other bands. Determination of molecular constants. Rotational structure of vibronic bands. P, Q and R branches. Intensity distribution in the vibrational structure of electronic bonds. Frank-Condon Principle. [6]

Raman Spectroscopy: Pure rotational Raman spectra, vibrational Raman spectra, and polarization of light and Raman effect. [6]

Spin Resonance spectroscopy: Nuclecar magnetic resonance spectroscopy, Electron spin resonance spectroscopy [6]

TEXT BOOKS:

1. Bransden and Joachin, Physics of *Atoms and Molecules*
2. Banwell ansd McCash, *Fundamentals of Molecular Spectroscopy*

REFERENCE BOOKS:

1. G. Herzberg, *Spectra of Diatomic molecules, Dores, NY*
2. G. M. Barrow, *Molecular Spectroscopy*
3. G. Herzberg, *Raman and Infrared Spectra van-Norstrand, NY*

PH9111 Condensed Matter Physics-II 4 credits [3-1-0]

Crystal elasticity and lattice dynamics: Generalized Hook's law, elastic stiffness and compliance coefficient, second and third order elastic constants, Cauchy relations, strain-energy function, homogeneous deformation. Theory of lattice vibration in harmonic approximation, Born Karman cyclic condition, phonon frequency distribution, dispersion relations, diffraction of X-rays and neutrons by phonons, Debye Waller factor, Mossbauer effect and its applications. Thermodynamic functions and relations for a crystal. [15]

Electronic energy band theory: Reciprocal lattice and Brillouin Zones, Fermi surfaces, effective mass of electrons. Approximation methods for calculation of energy bands, OPW method, APW method, pseudopotential theory, Many electron theory, Hartree and Hartree-Fock approximations for exchange and correlation energies.
[15]

Electronic properties of solids: Transport equation in presence of magnetic filed, cyclotron resonance, energy levels and density of states in presence of magnetic field. Landau diamagnetism and deHass-van Alphen effect. Hall effect and manetoresistance. Spin paramagnetism. [15]

TEXT BOOKS:

1. Born and Huang, *Dynamical theory of crystal lattice*
2. Rogalski & Palmer, *Solid State Physics*
3. Ashcraft & Mermin, *Solid State Physics*

REFERENCE BOOKS:

1. D. C. Wallace, *Thermodynamics of crystals*
2. Aniwalu, *Intermediate Quantum theory of crystalline solids*
3. Pines, *Elementary excitations in Solids*

PH9121 Optoelectronics -II 4 credits [3-1-0]

Resonator: Optical beam propagation and resonators, paraxial ray analysis, propagation and properties of Gaussian beam, Fundamental Gaussian beam in a lens like medium-ABCD Law, Gaussian beam focussing, stability of resonators, g parameters, various types of resonators. [14]

Different types of lasers: Gas Lasers, He-Ne, CO_2 lasers. Solid-state laser, Ruby laser, Nd lasers, Ti:sapphire lasers. Liquid laser, Dye laser. Semiconductor lasers etc. [10]

Characteristics of laser radiation: Radiometry and measurement of electromagnetic radiation, spatial energy distributions at the laser output, laser beam divergence and focussing capability. Pulsed radiation, special mechanisms for creating pulses, "Q-switching & mode-locking, different methods of Q-switching, mechanisms and their comparison, methods of mode-locking. [11]

Electromagnetic wave propagation in anisotropic media: The dielectric tensor of an anisotropic medium, plane-wave propagation, the index ellipsoid, phase-velocity, group velocity, and energy velocity. Classification of anisotropic media (crystals), light propagation in uniaxial and biaxial crystals, double refraction. [10]

TEXT BOOKS:

1. O. Svelto, *Principles of Lasers*

2. A Ghatak and K. Thyagarajan, *Optical Electronics, Cambridge University Press (2003)*

3. A Yariv, Quantum Electronics

REFERENCE BOOKS:

1. W. Koechner, Solid State Laser Engineering

2. J. Wilson and J. F. B. Hawkes, Optoelectronics: An introduction,Prentice Hall of India Pvt. Ltd., 2nd ed.-2004

3. Claude Rulliere (Ed.), Femtosecond Laser Pulse, Principles and Experiments, Springer- Verlag, 1998

PH9112 Materials for Engineering Applications 4 credits [3-1-0]

Introduction to Materials: The material world, types of materials, Introduction to metals, ceramics, polymers, composites, semiconductors, their physical properties, and selection. **[4]**

Structural Materials: Metals and alloys, Ferrous alloys, Steel, the Phase rule and phase diagrams of Fe-C system and common non-ferrous alloys, Eutectic, Eutectoid, Peritectic diagrams, the Liver rule. **[8]**

Polymers: Types of polymers, polymerizations processes, step polymerizations and addition polymerization, degradation and stabilization of polymers, conducting polymers, common polymers, their properties and applications. **[6]**

Ceramics & glasses: Types of ceramics, phase diagrams of common ceramic alloys, properties of common ceramics & glasses, their common applications. **[6]**

Composites: Types of composites, conventional composites, fiber reinforced composites, nanocomposites, property averaging by Rule of Mixture, isostress & isostrain loading, Interfacial strength, mechanism of reinforcement. [**6]**

Electrical Materials: Conductors, Conductivity and its temperature dependency, semiconductors, Superconductors. **[4]**

Magnetic Materials: Dia-, Para-, Ferro-, Antiferro- and Ferimagnetic materials and their characteristics, Curie Temperature, Hysteresis, Common magnetic materials and their applications. **[4]**

Optical Materials: Optical properties, color, luminescence, reflectivity, transparency, opacity, etc., optical systems and devices, Laser materials, optical fibers, liquid crystal displays, photoconductors. [**6]**

TEXT BOOKS:

1. J. F. Shackelford, M. K. Muralidhara, *Introduction to Materials Science for Engineers*
2. R. Balasubramaniam, *Callister's Materials Science & Engineering*
3. W.F. Smith, J. Hashemi, R. Prakash, *Materials Science & Engineering*
4. A. K. Bhargava, *Engineering Materials*

REFERENCE BOOKS:

1. Rolf E. Hummel, *Understanding Materials Science : History, Properties, Applications*
2. John Martin, *Materials for Engineering*
3. J. Simmons, K Potter, *Optical Materials*
4. Fuxi Gan, *Laser Materials*

PH9122 Circuit Analysis and Integrated Circuits 4 credits [3-1-0]

Analysis of networks and systems: Sample data system z-transforms and Laplace transforms. **[10]**

IC Technology: Semiconductor material, Crystal growing technology- Czochralski, Epitaxial. **[8]**

Analog Integrated Circuits: Voltage regulators. DAC and ADC circuits. Differential amplifier, PLL **[7]**

Digital Integrated Circuits: Logic families -TTL, ECL, MOS; design of combinational and sequential circuits, registers, counters, gate arrays; programmable logic devices, Programmable gate arrays. Memories Sequential and Random access memories; RAM bipolar and MOS static and dynamic memories; programmable memories PROM, EPROM, EEPROM. **[10]**

Microprocessor and their applications: Architecture of 8 bit (8085) and 16 bit (8086) microprocessors; addressing modes and assembly language programming of 8085 and 8086. 8086 machine cycles and their timing diagrams, and Interfacing. **[10]**

TEXT BOOKS:

1. S. M. Sze, Physics of semiconductor devices.
2. A Papoulis, Signal analysis.
3. Gray and Meyer, Analysis and design of analog integrated circuits.
4. R. S. Gaonkar, Microprocessor architecture, programming and applications with 8085/8085A(2^{nd} Ed.)

REFERENCE BOOKS:

1. J. D. Ryder, Networks lines and fields.
2. F. E. Terman, Electronic and radio engineering.
3. Geiger, Allen and Strader, VLSI design techniques for analog and digital circuits.
4. S. Soclof, Applications of analog integrated circuits.
5. A P. Mathur, Microprocessor.
6. D. V. Hall, Microprocessor and interfacing.
7. Liu and Gibson, Microprocessor.

PH9113 Nanomaterials 4 credits [3-1-0]

Introduction: Types of materials and variety of material properties and effect of size on them. history of nanostructured materials. Evolution of nanotechnology. [4]
Synthesis of nanomaterials: Classification of different methods of synthesis. Mechanical method, planetary ball-mill. Melt mixing. Evaporation methods, physical vapour deposition, laser ablation, laser pyrolysis. Sputter deposition, D.C. sputtering, R.F. sputtering, magnetron sputtering. Chemical vapour deposition (CVD), different types of CVD. Electric Arc deposition, ion-beam technique, molecular beam epitaxy. Synthesis of nanoparticles by chemical methods - colloidal methods, Sol-gel method, etc. [14]
Special nanomaterials: fullerenes, carbon nanotubes, and graphene [4]
Characterization of nanomaterials: Microscopes, confocal microscope, SEM, TEM, STM, AFM, SNOM. X-ray diffractometry. Spectroscopy, UV-Vis, IR, Raman, FTIR, PL, XPS.[14]
Properties of nanoparticles: Mechanical properties, tensile strength, hardness, stiffness etc. Eectrical properties, conductivity, semiconductor nanoparticles. Optical properties, photoluminescence, electroluminescence. Magnetic properties, magnetic nanoparticles, magnetoresistance. [5]
Applications of nanomaterials: Nanolithography, sensors, medical, electronics, and nanocomposites. [4]

TEXT BOOKS:

1. Nanotechnology: Principles and Practices- S. Kulkarni
2. Nanomaterials from Research to Applications- Hoshino & Mishima
3. Introduction to nannoscience and Nanotechnology, K. K. Chattopadhyay & A. N. Banerjee

REFERENCE BOOKS:

1. Nanocrystalline Materials- S. C. Tjong
2. Handbook of Nanomaterials- Vajtai (editor)
3. Materials Characterization Techniques- Sam Zhang, Lin Li, Ashok Kumar

PH9123 Nonlinear Optics 4 credits [3-1-0]

Introduction to Nonlinear optics: Descriptions of nonlinear optical interactions, nonlinear susceptibility, classical anharmonic oscillator, Miller's rule, coupled-wave equation, sum-frequency mixing, difference-frequency generation, and parametric amplification, Manley-Rowe relations. [10]

Phase-matching Techniques: Birefringence phase-matching, noncollinear phase-matching, noncritical phase-matching, tangential phase-matching, and quasi phase-matching techniques etc. [9]

Nonlinear optical interactions with focused Gaussian beams: Second harmonic generation, conversion efficiency and parameters affecting doubling efficiency etc. Up conversion and down conversion: Sum-frequency mixing, limitation to up conversion, introductory theory, infrared detection, effects of phase-matching, image conversion. [8]

Nonlinear optical materials: Organic, inorganic, and chalcopyrite materials and their linear and different nonlinear optical properties. [4]

Ultrafast phenomena (introductory): Short pulsed laser, Ti:sapphire laser etc., different techniques and principles for the generation of ultrafast laser radiation by Non-collinear Optical parametric amplification technique, magic phase-matching condition. [7]

Higher order Nonlinear Optical Effects: Nonlinear optical effects due to the third and higher order nonlinear susceptibility, Self-focusing, Self-defocusing effects, Critical intensity for waveguide like pulse generation, Four-wave mixing, Optical Phase Conjugation, Applications of nonlinear optical effects in designing logic gates etc. [7]

TEXT BOOKS:

1. Y. R. Shen, The principles of Nonlinear Optics, Wiley, New York, 1984.
2. R. W. Boyd, Nonlinear Optics Academic Press Inc.
3. F. Zernike and J. E. Midwinter, Applied Nonlinear Optics, Wiley, New York, 1973.

REFERENCE BOOKS:

1. Edited by C. L. Tang, Methods of Experimental Physics, vol. 15, Quantum Electronics, Part-B
2. A Yariv and P. Yeh, Optical waves in crystals.
3. Femtosecond Laser Pulse, Principles and Experiments, Claude Rulliere (Ed.), Springer-verlag, 1998
4. V. G. Dmitriev, G. G. Gurzadyan, and D. N. Nikogosyan, Handbook of Nonlinear Optical Crystals, 2nd ed. (Springer-Verlag, Berlin, 1997)
5. M. Born and Wolf, Principles of Optics, 6 th ed. (Pergamon press, Oxford 1980).

PH9114 X-Rays and Structural Studies 4 credits [3-1-0]

Topic-1: Discovery and importance of X-ray, comparison between optical, X-ray diffraction, electron diffraction, and neutron diffraction techniques for structural analysis. X-ray production, general and Characteristic spectra, Short Wave length limit, Absorption of X-ray, Absorption edges, Filtering and monochromatization of X-ray radiation. [10]
Topic-2: Kinematical theory of X-ray diffraction. Scattering of X-ray by an independent electron, Electron scattering factor. Thomsom scattering expression, Scattering by an atom and atomic scattering factor. X-ray diffraction by the regular arrangement of atoms in space, diffraction by a small single crystals, crystal structure factor, Systematic diffraction from different Bravais Lattices and their identification. [10]
Topic-3: Crystal structure analysis by X-ray diffraction. Laue, Rotation and Weissenberg techniques and their analysis. Trial and Error method in structure analysis. Electron density, Patterson function, Heavy atom method, Herker-Kasper inequality. Scattering by irregular arrangement of atoms, diffraction pattern from liquids and amorphous solids, radial distribution analysis. Diffraction from irregular arrangements of small crystals, Powder Pattern theorem. Introduction to the study of defect concentrations and their evaluation [10]
Topic-4: Fourier series and Fourier analysis, Rietveld refinement technique for the defect analysis in crystalline materials [8]
Topic-5: Dynamical theory of X-ray diffraction and its application in large perfect crystals
Low angle scattering technique and the application in the study of fibre materials.
Direct observation by X-ray diffraction. Lang camera. [7]

TEXT BOOKS:

1. M. M. Woolfson, *An introduction to X-ray crystallography*
2. L. V. Azaroff, *Elements of X-ray crystallography*
3. S. K. Chatterjee, *X-ray diffraction its theory and applications*

REFERENCE BOOKS:

1. M. J. Burger, *X-ray crystallography*
2. B. D. Cullity, *X-ray diffraction*
3. B. E. Warren, *X-ray diffraction*
4. H. P. Klug and L. E. Alexander, *X-ray diffraction procedure*

PH9124 Communication Technologies 4 credits [3-1-0]

Digital Modulation Techniques: ASK, FSK, PSK, Principle, modulators and demodulators. **[7]**

TV Systems: Color TV standards - NTSC, PAL. Transmission format of intensity and color signal. Transmitter and receiver systems of broadcast TV, Advanced TV, Cable TV. **[8]**

RADAR System: Basic pulsed radar system-modulators, duplexer, CW radar, MTI radar. **[5]**

Mobile Communication: Concepts of cell and frequency reuse description of cellular communication standards, Trans-receiver, Introduction to Satellite Communication, transponders. **[5]**

Computer communication: Types of networks- Circuit message and packet switched networks, Features of network, Design and examples ARPANET, LAN, ISDN, Medium access techniques- TDMA, FDMA, ALOHA, Slotted ALOHA, Basics of protocol. **[10]**

Fiber optic communication systems: Power budget equation, Multiplexing, Quantum limit, Incoherent reception, Signal-to-noise ratio calculation, Basics of coherent techniques in FOC. **[10]**

TEXT BOOKS:

1. R Roddy and J Coolen, *Electronic communication*
2. Gulati, *Monochrome and color TV*
3. Taub and Schilling, *Principle of communication systems*

REFERENCE BOOKS:

1. A B Carlson, *Communication systems*
2. Kennedy and Davis, *Electronic communication systems*
3. A Dhake, *Television and video engineering*
4. J M Senior, *Optical fiber communications principles and practice*