PHYSICS

M. Sc. Examination Choice Based Credit System (CBCS)
&
Syllabus

The duration of the M.Sc. (Physics) course will be two years: Previous and Final. Each year shall be of two semesters and thus there will be four semesters in all.

Programme Specific Outcomes:

- To develop understanding of basic concepts of Physics and appreciate how simple fundamental laws govern diverse natural phenomenon.
- To advance knowledge of the latest progress and applications in Physical Science.
- To inculcate logical thinking and skills for deductive analysis.
- To learn experimental skills and analysis tools.
- To encourage for research and higher studies in Physics and related fields.
- To prepare for Physics competitive exams e.g. CSIR-NET, GATE, JEST etc.
- To prepare foundations that can make good Physics teachers.
- To become lifelong learners and contribute to society in any career.

System of Examination

(Effective from the session 2019-2020)

Each semester will consist of **four** theory papers, laboratory training and seminar/project work. Each semester will be of **25** credits. Each theory paper shall be of **04 credits**, practical training of **08 credits** and seminar/project work of **01 credit**. One credit implies **15** contact hours. The examination of each theory paper shall be of 100 marks. The practical examination shall be of 200 marks. The candidate needs to pass in theory and practical examination separately. For each course written examination will carry 70% marks and rest 30% will be based on internal assessment by teachers. The details of the courses are given below.

M.Sc. I
THEORY

Semester I

Paper I	PHY-101	Mathematical Physics
Paper II	PHY-102	Classical Mechanics
Paper III	PHY-103	Quantum Mechanics – I
Paper IV	PHY-104	Electronics

Semester II

Paper I	PHY-201	Thermodynamics and Statistical Physics
Paper II	PHY-202	Electromagnetic Theory and Plasma Physics
Paper III	PHY-203	Group Theory and Molecular Spectra
Paper IV	PHY-204	Solid State Physics

PRACTICALS

A candidate will be required to perform at least eight experiments in each Semester from courses **A** and **B** detailed at the end of the M. Sc. I course. The student is also required to prepare and present a seminar on a topic allotted that will be graded out of 25 marks. In the examination the candidate has to do two experiments. Time allotted for performing the experiments shall be three hours for each experiment. The distribution of marks shall be as follows:

Experiment –	100 marks		
Viva –	40 marks		
Total –	**140 marks**	Internal Assessment –	**60 marks**

Grand Total practical – **200 marks**

Seminar/Project work – **25 marks**

M. Sc. II

In each semester the first three papers shall be compulsory and the fourth one will be optional; selected from the same group. A particular optional group will run depending on the availability of staff and requisite number of students. The number of seats available in any group for any year will be decided depending on various logistics at the local level. There shall be a practical course for each optional group. The candidate needs to pass in theory and practical examination separately. The details of the courses are given below.

THEORY

Semester III

Paper I	PHY-301	Numerical Methods and Programming
Paper II	PHY-302	Electrodynamics
Paper III	PHY-303	Quantum Mechanics – II
Paper IV	PHY-304	Optional Papers – I (a/b/c/d/e/f)

Semester IV

Paper I	PHY-401	Nuclear and Particle Physics
Paper II	PHY-402	Lasers and Modern Optics
Paper III	PHY-403	Condensed Matter Physics
Paper IV	PHY-404	Optional Papers – II (a/b/c/d/e/f)

Optional Theory Papers :

Group (a)	Astrophysics I & II
Group (b)	Biophysics I & II
Group (c)	Electronics I & II
Group (d)	Solid State Physics I & II
Group (e)	Spectroscopy and Lasers I & II
Group (f)	X-rays I & II

PRACTICALS

A candidate will be required to perform at least eight experiments in each Semester from courses **C** and **D** detailed at the end of the M. Sc. II course. The student is also required to prepare and present a seminar on a topic allotted that will be graded out of 25 marks. In the examination the candidate has to do two experiments. Time allotted for performing the experiments shall be three hours for each experiment. The distribution of marks shall be as follows:

Experiment –	100 marks		
Viva –	40 marks		
Total –	**140 marks**	Internal Assessment –	**60 marks**

Grand Total practical – **200 marks**

Seminar/Project work – **25 marks**

Course wise Syllabus
M.Sc. I
Semester I

Paper I: Mathematical Physics

Course Objectives: Understanding mathematical functions and solution methods useful in various branches of Physics.

Unit – I

Special Functions: Second order linear differential equations; Solution by series expansion; Legendre, Bessel, Hermite and Laguerre differential equations, their solutions and properties, Spherical Harmonics**.**

Unit – II

Fourier Transform: Dirac Delta function, Fourier Transform, Sine and Cosine transform, Linearity, Change of Scale, Translation, Modulation, simple applications.
Green Function: Green's function as a technique to solve linear ordinary differential equations, Homogeneous and Inhomogeneous boundary conditions, Solution of Poisson equation using Green's function technique, Symmetry property.

Unit – III

Complex Variables I: General function of complex variable, Cauchy-Riemann differential equation and analyticity, conformal mapping (translation, rotation, inversion), Cauchy's integral formula, Taylor's and Laurent's series, singularity poles.

Unit – IV

Complex Variables II: Residue theorem. Evaluation of definite integrals, around (i) unit circle and (ii) infinite semi-circle; using Jordan's lemma with poles lying on real axis, and of integrals involving multiple valued function-branch point.

References:

1. Mathematical Methods for Physicists by G. Arfken, H. Weber and F.E. Harris (Elsevier)
2. Mathematics for Physicist by P. Dennery and A. Krzynicki (Dover Publication)
3. Special Functions and their Applications by N.N. Lebedev (Dover Publication)
4. Mathematical Methods for Physics and Engineering by K.F. Riley, M.P. Hobson and S.J.Bence (Cambridge University Press)
5. Mathematical Physics by B. S. Rajput (Pagati Prakashan)
6. Complex Variables and Applications by J.W. Brown and R. V. Churchill (McGraw-Hill)

Course Outcomes:

- The students will understand various functions and solutions to differential equations.
- The foundation for understanding of Classical and Quantum Mechanics will be laid.
- The techniques learnt will be useful in different branches of Physics.

Paper-II: Classical Mechanics

Course Objectives: Understanding basic methods of mechanics and use of Lagrangian and Hamiltonian approach.

Unit - I

Vectors: Curvilinear Coordinates, Gradient, Divergence and Curl, Laplace equation in spherical polar and cylindrical polar coordinates and their solution, Green's theorem, Gauss and Stokes Theorems.
Tensors: Covariant and Contravariant vectors, Tensors – Addition, Multiplication, Contraction, Symmetry properties; Tensor density, Pseudo-tensors.

Unit-II

Mechanics of a system of particles: Generalized coordinates and Constraints, Generalised coordinates, D' Alembert's principle, Lagrange's Equation. Hamilton's principle, Least action principle, Langrange's equations, symmetry properties and Noether's theorem, Lagrangian formulation for elementary mechanical systems - free particle, simple and double pendulum.

Unit-III

Two Body Problem: Reduction to one-body problem, reduced mass, Virial Theorem, planetary orbits.
Scattering: Collision between particles, disintegration of particles, elastic collisions, scattering, Rutherford's formula.
Small oscillations: Damped and Forced oscillations, coupled vibrations.

Unit-IV

Hamiltonian Formulation: Hamilton equations, canonical transformations, Poisson's bracket, Symplectic approach to canonical transformations; Hamilton Principle function, Hamilton-Jacobi equation, Harmonic Oscillator Problem, Hamilton characteristic Function, separation of variables, Central Force problem.

References:

1. Vector Analysis and Introductory Tensor Analysis by M.R. Spiegel (Schaum Series)
2. Matrices and Tensors in Physics by A.W. Joshi (New Age)
3. Classical Mechanics by H. Goldstein (Narosa, New Delhi)
4. Classical Mechanics by K.C. Gupta (Wiley Eastern)
5. Classical Mechanics by L.D. Landau (Elsevier)
6. Classical Mechanics by N.C. Rana and P.S. Joag (Tata-McGraw-Hill)

Course Outcomes:

- The students will understand dynamics of particles and conservation laws.
- The understanding of different mechanical problems and their solutions will be developed.

Paper-III: Quantum Mechanics - I

Course Objectives: Understanding concepts of quantum mechanics and solving operator equations for different quantum problems.

Unit-I

Wave Mechanical formulation: Schrodinger wave equation, Hermetian operators and observables, Discreet and continuous spectrum, Dirac delta function, Commuting observables and related algebra, Pure and mixture states; Simple applications: potential well, barrier potential, tunnel effect, unbound states: reflection and transmission of waves.

Unit - II

Identity of Particles: Distinguishability of identical particles, exchange degeneracy and operator, construction of symmetric and antisymmetric wave functions, Pauli's exclusion principle and Slater's determinant, Electron spin hypothesis, spin matrices and eigen value equations, symmetric and antisymmetric wave functions for hydrogen molecule.

Unit - III

Matrix formulation: Concept of Hilbert Space, Dirac's bra and ket notations, Orthonormality and completeness relations (discrete and continuous), linear and real operators, eigenvalue equations and related theorems, projection operators and measurement, application to Harmonic Oscillator, Equivalence of wave and matrix mechanics.

Unit - IV

Theory of Angular momentum: Orbital, spin and total angular momentum operators: eigen value equations and matrix representations, Ladder operators, commutation relations, Addition of angular momenta, Clebsch-Gordon coefficients.

References:

1. Quantum Mechanics, Vol. I & II by Albert Messiah (Dover Publication)
2. The Principles of Quantum Mechanics by P.A.M. Dirac (Oxford University Press)
3. Quantum Mechanics by L.I. Schiff (Tata-McGraw-Hill)
4. Modern Quantum Mechanics by J.J. Sakurai (Addison Wesley)
5. Introduction to Quantum Mechanics by D.J. Griffths (Pearson Education)
6. Quantum Mechanics by C. Cohen-Tannoudji, B. Diu and F. Laloe (Wiley VCH)
7. Quantum Mechanics by B. K. Agarwal and Hari Prakash (Prentice-Hall, India)

Course Outcomes:

- The students will understand wave mechanical formulation of quantum particles and various rules arising out of it.
- The understanding of different formulations of quantum mechanics laying foundations for the study of molecules, atoms and fundamental particles.

Paper-IV: Electronics

Course Objectives: Understanding functions of electronic devices and circuit logic.

Unit - I

Power Electronics: SCR: Basic structure, I-V characteristics and two- transistor model of SCR, SCR controlled half and full wave rectifier circuit and their analysis. UJT, equivalent circuit, I-V characteristics, Saw tooth wave generation. Elements of SMPS.

Unit - II

Operational Amplifier: IC-741 - Block diagram, operation, Characteristics of op-amp; inverting and non-inverting inputs: Input offset current and Input offset voltage, differential amplifier, CMRR, Slew rate and power band width, op-amp as an amplifier. Application of Op-amp: summer, integrator and differentiator. Timer: IC-555 - Block diagram, Astable and Monostable operations, application of IC-555 - VCO.

Unit - III

Boolean Algebra and Gates: Boolean algebra, composite function and their algebraic simplification, De-Morgan's theorem ,duality in Boolean algebra, Universality of NAND and NOR gates. SOP and POS forms, karnaugh map, design of logic circuits, X-OR gate and its applications, half adder and full adder, parallel adder, look ahead carry.

Unit - IV

Elements of Logic Families: Transistor as a switch, FAN IN , FAN OUT, Noise Immunity, propagation delay, RTL, DTL, TTL logic, Sourcing and Sinking logic, TTL loading and Fan out, ECL logic.

References:

1. Switch Mode Power Conversion by K. Kit Sum (Marcel Dekker).
2. Power Electronics by P.C. Sen (Tata Mc Graw-Hill)
3. Pulse, Digital and Switching Wave Forms by J. Milman and H. Taub (McGraw-Hill)
4. Op-amp and Linear Integrated Circuits by R.A. Gayakwad (Prentice-Hall India)
5. Integrated Circuits by J. Millman and C.C. Halkias (Tata-McGraw-Hill)
6. Digital Principle and Application by A.P. Malvino and D.P. Leach (McGraw-Hill)
7. Modern Digital Electronics by R.P. Jain (Tata McGraw-Hill)

Course Outcomes:

- The students will understand electronic circuits and control using various devices.
- The students will understand simple logic and control via logic circuits.

Semester-II

Paper-I: Thermodynamics and Statistical Physics

Course Objectives: Understanding laws of thermodynamics and microscopic statistical description.

Unit – I

Second law of thermodynamics, Entropy and Probability, Thermodynamic Potentials, Thermodynamic Equilibrium, Third law of thermodynamics, First and Second order phase transistions: Clausius - Clapeyron and Ehrenfest's equations; Chemical potential and phase equilibria, Gibb's phase rule.

Unit – II

Thermodynamic properties of liquid Helium II, The lambda - transition, London's explanation, Quantum liquid, Tisza two fluid model, Landau spectrum, concept of second sound.
Conditions for Equilibrium, Entropy of an Ideal Boltzmann gas, Gibb's paradox, Sackur - Tetrode equation.

Unit – III

Canonical and Grand Canonical Ensembles, Entropy of a system in contact with heat reservoir, Ideal gas in canonical ensemble, Maxwell velocity distribution, Grand canonical ensemble, Thermodynamics of photons, Translational, Rotational and Vibrational partition functions of a molecule and their applications.

Unit – IV

Thermodynamical properties, Black body radiation, Bose - Einstein Condensation, Ideal Fermi - Diarc gas, Fermi temperature, applications of degeneracy to free electrons in metals, Magnetic susceptibility, White dwarfs and Chandrashekhar limit.

References:

1. A Treatise on Heat by M.N. Saha and B.N. Srivastava (Indian Press Limited, Allahabad)
2. Heat and Thermodynamics by M.W. Zemansky and R.H. Dittman (McGraw Hill)
3. Fundamentals of Statistical and Thermal Physics by F. Reif (McGraw-Hill)
4. Statistical Mechanics by K. Huang (John Wiley & Sons)
5. Statistical Mechanics by R.K. Pathria (Elsevier)
6. Statistical Mechanics and Properties of Matter by E.S.R. Gopal (Macmillan Ltd., Delhi)
7. Statistical Mechanics by B. K. Agarwal and M. Eisner (Wiley Eastern)

Course Outcomes:

- The students will understand laws of thermodynamics and relation between macroscopic and microscopic properties.
- The students will be able to apply the concepts in different states of matter.

Paper II: Electromagnetic Theory and Plasma Physics

Course Objectives: Understanding Physics of Electromagnetic waves and plasma state.

Unit – I

Maxwell Equations: Microscopic and Macroscopic fields, Macroscopic Maxwell equations, Fields **D** and **H**, Dielectric tensor, Principal dielectric axes.
Potential and Gauges: Scalar and vector potentials, Gauge transformation, Lorentz guage and Transverse gauge, Maxwell equations in terms of electromagnetic potentials.

Unit - II

Propagation of Electromagnetic Waves: Propagation of electromagnetic waves in free space, conducting and non-conducting medium, skin depth, Boundary conditions on EM Fields, Reflection and refraction at a plane interface between dielectrics.
Polarisation of EM Waves: Fresnel's Formula, Normal- and anomalous- Dispersion, metallic reflection. EM Wave in bound media: rectangular and circular wave guides, TE, TM and TEM Modes, Cut-off frequency and Wavelength.

Unit – III

Plasma State: Plasma state of matter, Motion of charge particles in uniform E & B fields, non-uniform fields, drifting motion, electrostatic and magnetostatic lenses; Time varying E & B fields, Adiabatic invariants, Plasma confinements (Pinch effect, Mirror confinement, Van Allen Belts), Elementary idea of fusion technology.

Unit – IV

Hydrodynamics of Plasma: Hydrodynamical description, Equation of magneto hydrodynamics, High frequency plasma oscillations, Short wavelength limit and Debye-screening distance.
Wave Phenomenon in Magneto-Plasma: Electromagnetic waves perpendicular to B_0, phase velocity, Polarization, Cut-off and resonances, Electromagnetic waves parallel to B_0, Alfven waves.

References:

1. Introduction to Electrodynamics by D.J. Griffiths (Prentice - Hall, New Delhi)
2. The Classical theory of Fields by L.D. Landau and E.M. Lifshitz (Elsevier)
3. Classical Electrodynamics by J.D. Jackson (Wiley Eastern)
4. Introduction to Plasma Physics by F.F. Chen (Plenum Press, New York)
5. Plasma Physics by S.N. Sen (Pragati Prakashan)

Course Outcomes:

- The students will understand nature of Electric and Magnetic fields, Electromagnetic waves and plasma state.
- The students will be able to apply the concepts in various branches of Physics.

Paper-III: Group Theory and Molecular Spectra

Course Objectives: Understanding radiations due to transitions in molecules and symmetry considerations for them.

Unit – I

Rotation and Vibration Spectra: IR and Raman spectra of rigid rotator and harmonic oscillator, IR and Raman spectra of non-rigid rotator, anharmonic oscillator and vibrating rotator, Intensities in rotation - vibration spectra, Isotope effects in rotation and vibration spectra.

Unit – II

Electronic Spectra: Electronic energy and total energy, vibration structure of electronic transitions, progressions and sequences, rotational structure of electronic bands, band head formation and band origin. Intensity distribution in vibrational structure, Frank-Condon principle and its quantum mechanical formulation, intensity alternation in rotational lines.

Units – III

Group Theory: Symmetry elements and symmetry operations, Point group and their representation, Mathematical group, Matrix representation, Orthogonality theorem (statements and interpretation only), Reducible and irreducible representations, Direct product group.

Unit – IV

Vibrational and Raman Spectra: Normal modes, symmetry characterization of electronic states and vibrational modes of polyatomic molecules, character tables (C_{2v}, D_{3h} and D_{6h}) and their applications to selection rules of IR and Raman spectra, application to H_2O and CO_2 molecules.

References:

1. Molecular Spectra and Molecular Structure by G. Herzberg (Dover Publication).
2. Fundamentals of Spectroscopy by C.N. Banwell and E.M. McCash (Tata-McGraw-Hill)
3. Introduction to Molecular Spectroscopy by G.M. Barrow (McGraw-Hill)
4. Modern Spectroscopy by M.J. Hollas (Wiley Inter Science)
5. Elements of Group theory for Physicists by A.W. Joshi (Wiley Eastern)
6. Chemical Applications of Group Theory by F.A. Cotton (Wiley Eastern)

Course Outcomes:

- The students will understand various electromagnetic transitions in molecules.
- Finding selection rules using symmetry and group considerations.
- The students will be able to apply the concepts in various branches of Physics.

Paper IV: Solid State Physics

Course Objectives: Understanding the physics related to matter in solid state.

Unit - I

Crystal Structure: Ionic, covalent, metallic and hydrogen bonding, space lattice and basis ; Types of lattice, Miller indices, crystal structures of NaCl, CsCl, ZnS, graphite and diamond; Reciprocal lattice and Brillouin Zones; Basic idea of crystal defects and dislocations.

Unit – II

Band Theory of Solids: Sommerfield model, Density of states, Fermi and mean energies at zero and finite temperatures; Origin of energy bands; Bloch Theorem; Kronig Penny model, Electron dynamics in crystalline lattice; Tight binding approximation.

Unit - III

Thermal Properties: Lattice vibrations of mono and diatomic chains, Quantization of lattice vibration, Phonon; Infrared absorption; Einstein and Debye theories of specific heat; Thermal conductivity; Anharmonicity and Thermal expansion.

Unit - IV

Optical Properties: Optical reflectance, Kramers-Kronig relations; Conductivity and dielectric function of electron gas; Basic theory of luminescence, phosphorescence, thermoluminescence, electroluminescence and photo-conductivity; Excitons in ionic and molecular crystals, Electron-hole drops (EHD) and colour centres.

References:

1. Solid state Physics by A.J. Dekkar (McMillan Publishers)
2. Introduction to Solid State Physics by C. Kittel (Wiley Eastern)
3. Elementary Solid State Physics by M. Ali Omar (Pearson Education)
4. Solid State Physics, N.W. Ashcroft and N.D. Mermin, (Harcourt Asia Limited)
5. Principles of the Theory of Solids by J.M. Ziman (Cambridge University Press)
6. Solid State Physics by S.O. Pillai (New Age Publishers)

Course Outcomes:

- The students will understand crystal structure and energy concepts.
- Learn different properties of solids and their relation to crystal structure and defects.

PRACTICAL

Students will be required to perform at least five experiments from each course. They will have to maintain record books of experiments done for each course separately.

LIST OF EXPERIMENTS

COURSE A: Electronics

1. Study of regulator circuits
2. Study of switch mode power supply (SMPS)
3. Study of characteristic of SCR and controlled rectification by SCR.
4. Study of RC coupled amplifier
5. Study of emitter follower
6. Study of phase shift oscillator
7. Study of multivibrator: Use of 555
8. Study of saw tooth wave generation by UJT
9. Study of characteristics of operational amplifier
10. Study of TTL gates
11. Study of combinational logic circuits
12. Study of super heterodyne receiver
13. Study of linear and square wave detector
14. Microwave measurement: Mode analysis and standing wave ratio

COURSE B: Optical and General

1. Use of constant deviation spectrograph
2. Use of Fabry-Perot interferometer
3. Use of concave grating
4. He-Ne Laser
5. e/m by Zeeman effect
6. EPR of free radicals
7. Programming on PC
8. Velocity of ultrasonic wave
9. Hall effect
10. Magnetic Susceptibility
11. Measurement of dipole moment
12. Use of scintillation counter
13. Determination of Dielectric Constant

Course Outcomes:

- Learning circuit fundamentals and making connections to study properties of electronic devices.
- Hands on experience with optical instruments and understanding concepts of physical optics.
- Learn to present observations, results and analysis in suitable and presentable form.

Semester-III

Paper-I: Numerical Analysis and Programming

Course Objectives: Learn elements of computer programing and understand computational methods applicable in various branches of Physics.

Unit - I

Numerical Analysis I: Interpolation: methods of interpolation, least square curve fitting, Methods of equal intervals, unequal intervals, Central Differences. Inverse interpolation: Iteration of successive approximation, exchange of dependent and independent variables and reversion of series. Numerical differentiation: Method based on interpolation, on finite differences. operator and on undetermined coefficients.

Unit – II

Numerical Analysis II: Numerical integration: Simpson's one-third and one-eighth rule, Euler-Maclaurin formula, Quadrature formulae, Numerical Solution to ordinary differential equation by Euler's and Runge-Kutta methods, Solution of algebraic and transcedental equations: Convergence, Newton-Raphson method, Iterative methods.

Unit - III

Fortran: Flow Charts, Integer and Floating point Arithmetic, Expression, Built in fuctions, Executable and Non- Executable statements, Assignments, Control and Input and Output Statements, Looping, Function and Subroutines, Operation with files.

Unit - IV

Application to Numerical Analysis related to Unit II.

References:

1. Introductory Methods of Numerical Analysis by S.S. Sastry (Prentice-Hall India)
2. Numerical Methods by E. Balguruswamy (Tata McGraw-Hill)
3. Fortran 77 and application to Numerical Analysis by C. Xavier (New Age Publishers)
4. Numerical Recipes for FORTRAN by W. Press et al. (Cambridge University Press)
5. Computer Programming in Fortran by V. Rajaramanna (Prentice-Hall India)

Course Outcomes:

- The students will understand various numerical techniques.
- Will be able to use or write computer programs for solving mathematical equations.

Paper II: Electrodynamics

Course Objectives: Understanding behaviour of electromagnetic fields in relativistic and quantum regimes.

Unit-I

Four Dimensional Formulation: Postulates of special theory of relativity, Minkowski Space, Lorentz transformation, Intervals, Light cone, Proper time, Four Vectors, Doppler Effect (Transverse and Longitudinal) and Aberration, Relativistic Mechanics: Langrangian formulation, Principle of least action, Four-momentum vector of a free particle, Hamiltonian, Equation of motion.

Unit – II

Electromagnetic Field Equations: Four Potential Four dimensional formulation: Action of a charged particle, Generalised Momentum and Hamiltonian, Equation of motion, Electromagnetic field tensor, Transformation properties of electric and magnetic fields, Invariants of Electromagnetic field, Four dimensional formulation of first and second pair of Maxwell equations, Equation of continuity.

Unit – III

The Field of Moving Charges: Retarded potentials, Lienard-Wiechert potentials, Field due to system of charges at large distances, Dipole radiation, Quadrupole and magnetic dipole radiation; Field at near distances, Radiation from a rapidly moving charge, Synchrotron radiation (magnetic bremsstrahlung), Radiation damping.

Unit – IV

Field Quantization: Lagrangian and Hamiltonian formalism for relativistic field, canonical commutation relations and quantization of Klein-Gordon field, Complex scalar field; Normal ordering, EM field as non-interacting harmonic oscillators, Quantization of radiation field, Algebra of annihilation and creation operators and their representations.

References:

1. The Classical theory of Fields by L.D. Landau and E.M. Lifshitz (Elsevier)
2. Classical Electrodynamics by J.D. Jackson (Wiley Eastern)
3. Classical Electricity and Magnetism by W. Panofsky and M. Phillips (Dover Publication)
4. Quantum Electrodynamics by F. Mandl & G. Shaw (John Wiley and Sons)
5. A First Book of Quantum Field Theory by A. Lahiri & P.B. Pal (Narosa, New Delhi)

Course Outcomes:

- The students will understand relativistic electromagnetic field equations and the concept of field quantization.
- The students will get familiar with concepts useful for research in many areas of Physics.

Paper III: Quantum Mechanics – II

Course Objectives: Understanding advanced concepts of quantum mechanics and its application in understanding molecular structure.

Unit – I

Approximate methods: Time independent perturbation theory and anharmonic oscillator, Variational method and Helium atom, Time dependant perturbation theory and transition probability (Fermi-Golden Rule), WKB method and alpha decay.

Unit - II

Molecular Structure: H_2^+ ion, Born-Oppenheimer approximation and its application, H_2 molecule. Heitler-London theory, Valence bond theory of diatomic molecules, exchange energy; Simple valence bond treatment of H_2O and C_6H_6 molecules; LCAO approximation, application to H_2 and other molecules, hybridization, Huckel approximation and its application to butadiene and benzene molecules.

Unit-III

Relativistic quantum mechanics: Klein-Gordon equation, Plane wave solution and Physical interpretation, Inadequacy of Klein-Gordon equation; Dirac equation, α and β matrices and related algebra, Representation and arbitrariness of α and β, Probabilistic interpretation.

Unit – IV

Covariance of Dirac equation: Covariant form of Dirac equation, Dirac(γ) matrices, Representation and algebra, Linearly independent set of composite γ- matrices; Infinitesimal and Finite proper Lorentz transformation, Proof of covariance, Plane wave solution and negative energy states; Two component Pauli spin theory, Non relativistic correspondence.

References:

1. Quantum Mechanics by L.I. Schiff (Tata-McGraw-Hill)
2. Introduction to Quantum Mechanics by D.J. Griffths (Pearson Education)
3. Quantum Mechanics by C. Cohen-Tannoudji, B. Diu and F. Laloe (Wiley VCH)
4. Quantum Chemistry by Ira N. Levine (Pearson Education)
5. Relativistic Quantum Mechanics by James D. Bjorken and Sidney D. Drell (McGraw-Hill)
6. An Introduction to Relativistic Quantum Field Theory by S.S. Schweber (Harper & Row)

Course Outcomes:

- The students will learn approximate methods for solving many body problems.
- Understand molecular electronic configurations and structure.
- Prepare for research in molecular, atomic and particle physics.

Paper - IV: Optional-I

Course Objective: Do deeper study in a specific branch of Physics, to inculcate self-study and get familiar with requirements of research.

(a) Astrophysics- I

Unit – I

Elements of Optical and Radio Astronomy, **Celestial Sphere**: Spherical triangle, Co-ordinate systems; Altazimuth, Equatorial, Ecliptic and Galactic, **Time:** Sidereal time, Ephemeris and Universal time

Unit – II

Properties of Stars: Distance, Luminosity, Temperature, Colour of stars and their determination, Spectral types, H-R diagram, Boltzmann excitation equation, Saha's theory of thermal ionisation and its application, The MKK spectral classification

Unit – III

The Sun: Surface features; Evershed effect, Rotation, Magnetic field, Prominences, Photosphere, Chromosphere, Corona, Solar activity, Radio emission from the sun,
Planets: Periods, Orbits and phases of planets, Physical properties of planets and their satellites, Planetary rings, Asteriods, Comets and Meteors, Origin of the solar system

Unit – IV

Stellar Variability: Binary stars; visual, eclipsing and spectroscopic binaries, Determination of elements of a true orbit. Stellar masses and radii, Mass-luminosity relation, Stellar pulsation,Classical cepheids and R R Lyrae stars, Period-luminosity relation, Novae and supernovae.

References:

1. An Introduction to the Study of Stellar Structure by S. Chandrashekhar (Dover Publications)
2. Text book on Spherical Astronomy by W. M. Smart (Cambridge University Press)
3. Principles of Astronomy by S. P. Wyatt (Allen and bacyon, Inc.)
4. An Introduction to Astrophysics by B. N. Basu , T. Chattopadhyay, S. N. Biswas (Prientice Hall of India)
5. Astrophysics and Stellar Astronomy by T. L. Swihart (John wiley and Sons, NewYork)
6. Stars, Galaxies by K. D. Abhyankar (University press)
7. Essentials of Astronomy by Lloyd Motz (Columbia University Press)
8. The Physical Universe by F. Shu (University Science Books, California, U.S.A.)

(b) Biophysics-I

Unit – I

Nucleic Acids: Nucleosides and nucleotides, primary, secondary and tertiary structure of DNA, Watson - Crick model, backbone conformation, sugar puckering, different forms of DNA, Z-DNA, structure of RNA, different forms of RNA and their biological functions. The central dogma, DNA replication, RNA transcription and protein biosynthesis, reverse transcription, mutation and regulation of genes.

Unit – II

Proteins: Amino acids, peptide bond, disulphide bridge, Primary, secondary, (α- helix and β- sheet), tertiary and quaternary structure of proteins. Protein conformation, torsion and dihedral angles, Ramachandran map, structure of heamoglobin and myoglobin.

Unit – III

Membranes: Micelle. bilayer and liposome; structure of cell membrane, conformational properties of membranes, passive membrane transport; Donnan equilibrium, Hodgkin - Katz formula, Active membrane transport and transport of charged particles through membranes. Simple idea of molecular reception - smell reception and taste reception.

Unit – IV

Nerve Impulse: The Neuron, Axon and Action potential, recording of action potential, Chronaxie and rheobase; depolarization and reporalization of axon membrane, mechanism of propagation of nerve impluse; Ionic channels, Elementary idea of synaptic transmission.

References:

1. Molecular Biology of the Genes by J. D. Watson (Benjamin Inc, California)
2. Principles of Nucleic Acid Structure by W. Saenger (Springer Verlag, New York)
3. Biophysics; Ed. W. Hoppe et. al. , (Springer Verlag, New York)
4. Introduction to Biophysics by P.S. Narayanan
5. Biophysics by M. V. Volkenstein (MIR publishers)
6. Biophysics by V. Pattabhi & N. Gauttam
7. Intermolecular Interactions: From Diatomics to Biopolymers, Ed. B. Pullman (John Wiley, N. Y.)
8. Physical Biochemistry by K. E. van Holde, (Prentice Hall, N, J.)

(c) Electronics - I

Unit – I

Analog and Combinational Logic Circuits: Analog computation, time and amplitude scaling, Analog to digital and digital to analog converter. Comparator, parity generator and checking, code conversion, Binary to gray and gray to binary. Logic design with MSI coder and decoder, multiplexer and demultiplexer circuits.

Unit – II

Sequential Circuits: Basic definition,finite state model SR,JK,T,D,Edge triggered flip flop,race condition and master slave flip flop,characteristic table and characteristic equation, sequential logic design state table, state diagram,state equation.

Unit – III

Registers and Counters: Register, shift register, universal shift register, Ring counter, twisted or Johnson counter, synchronous and asynchronours counters, UP/DOWN and scale of 2n counter

Unit – IV

Microprocessor: Basic idea of magnetic memory, Ferrite core memory, semiconductor memory viz . RAM, ROM, PROM, EPROM, EEPROM. Introduction to intel 8085 microprocessor architecture, instruction and timings assembly language programming, stack and subroutine, code conversion.

References:

1. Digital Systems by J. Ronald Tocci
2. Digital Principles and applications by Malvino and Leach
3. Microprocessor by Goenkar

(d) Solid State Physics - I

Unit – I

Symmetry Properties of Crystal Lattice : Mathematical group representation, Double valued representation, The crystalline structure; Transformation of crystal lattice; Symmetries in Bravis lattice; Point groups; Space group; Classes, Transformation and construction.

Unit – II

Crystalline Solids: Free electron theory; Fermi gas at finite temperature, Mean energy, Methods of Energy Band Calculation; Electron dynamics in periodic lattice, Wigner-Seitz method and cohesive energy of metals, Orthogonalized plane wave(OPW), Pseudo potential, Augmented plane wave(APW) and Green function methods, Transition metal bands.

Unit - III

Fermi Surface: Construction of Fermi surface, Cyclotron resonance, Electron, hole and open orbits, Anomalous skin effect, De Haas Van Alphen effect.
Lattice Vibration and Thermal Properties: Quantization of lattice vibration, Phonon momentum Inelastic scattering of photon by photon and neutron by photon, Local phonon modes, phonon dispersion relation, Debye model of lattice heat capacity, Anharmonicity and thermal expansion.

Unit – IV

Disordered Materials: Structure, Short range order and dangling bond; Random network model; Amorphous semiconductor; Density of states and mobility gap; Electrical transport, Optical and switching properties.

References:

1. Principle of theory of solid by J.M. Ziman (Cambridge University Press, London)
2. Theoretical Solid State Physics Vol.1 and Vol.11 by W. Jones and N.H. March (John Wiley and Sons, London)
3. Quantum Theory of Solid by C. Kittel (John Wiley and Sons, London)
4. Quantum Theory of Solids by R.E. Peirls (Oxfbrd University Press, London)

(e) Spectroscopy and Lasers-I

Unit – I

Vector model for two and three valence electrons, Lande interval rule, Inverted terms and Hund's rule, Lande 'g' factor, spectral terms by magnetic quantum numbers.

Breadth of spectral lines, Intensity of spectral lines, Nuclear spin, Isotope effect and Hyperfine structure, Lamb shift.

Unit – II

Normal coordinate analysis: classical and quantum mechanical treatment of normal modes of vibration, vibrational selection rules, Fermi resonance, Vibrational and electronic spectra of benzene.

Unit – III

Rotational spectra of linear molecules like CO_2 and HCN, Rotational Raman spectra, Microwave spectra of ammonia.

Rotational structure of vibrational bands, Parallel and perpendicular bands of linear molecules like CO_2 and HCN and symmetric top molecules like NH_3, Coriolis interaction.

Unit – IV

Classification of electronic states, interaction of vibration and electronic motion, Renner-Teller effect, Coupling of rotation with vibration and electronic motion for linear molecules.
Allowed and forbidden electronic transitions, Isotope effect, Teller and Redlich product rule.

References:

1. Atomic spectra: H.E. White
2. Molecular spectra and Molecular structure Vol. I, II, III: G. Herzberg

(f) X-Rays-I

Unit - I

Production of X-Rays, types of X-Ray tubes and auxiliary equipments. General features of continuous and characeristic spectra. Theories of the continuous spectrum : Stoke-Thompson pulse theory and Kramer's Wentzel theory of production of X-Rays by thin and thick targets.

Unit - II

Polarisation of X-Rays, Scattering of X-Rays by atoms and simple molecules. Atomic scattering factors and test of various theories. Scattering by gases and liquids. Compton scattering-Wave mechanical treatment. Klein-Nishina formula (no-dervation). Dispersion theory and reflection of X-Rays. Experimental methods of measuring refractive index. Anomalous scattering. Photoelectrons and their spatial distribution. Fluovescence yield.

Unit - III

X-Ray energy level diagrams, spin and screening doublet laws, multiple radiation and transition probabilities. Absorption spectra, Crictical absorption edges. Theory of fine structure of absorption edges and absorption discontinuty.

Unit - IV

Soft X-Ray emission and absorption spectroscopy and its applications to band structure of solids. Effects of chemical combination on emission and absorption spectra. Forbidden lines. Relative intensities of X-Ray lines. Auger effect and satellite lines. X-Ray spectrographs-plane and bent crystal.

Course Outcomes:

- The students will learn specialized concepts of a specific branch of Physics.
- Will learn to independently reference multiple sources for advanced knowledge.
- Be prepared for research in chosen area of interest.

Semester-IV

Paper-I: Nuclear and Particle Physics

Course Objective: Understand nuclear structure, energy and concept of elementary particles.

Unit – I

Nuclear Models: Evidence of Nuclear shell Structure; Nuclear Potential and sequence of energy levels of nucleons, spin orbit potential and explanation of magic numbers, Collective model.

Nuclear Reactions: Cross section; partial wave analysis, optical theorem and shadow scattering, Compound nucleus hypothesis, Breit-Wigner one level formula, Direct Reactions; pickup and stripping reactions.

Unit – II

Nuclear Reactors: *Fission Reactor*: Neutron multiplication factor, Fermi's four factor formula, resonance escape probability and thermal utilization factor, Basic reactor theory and reactor materials, Basic idea of breeding and fast neutron reactors.

Fusion Reactor: Fusion reaction, reaction rate and critical temperature, Lawson's criteria; magnetic confinement techniques, Tokamak and magnetic mirror devices.

Unit – III

Beta Decay: Pauli's neutrino hypothesis, Fermi theory of (β)-decay, Fermi-Kurie Plot and comparative half lives, selection rules and classification of transitions, Parity non-conservation and Wu's experiment.

Nuclear forces: Deuteron problem, low energy (n-p) and (p-p) scattering, scattering length, effective range theory, Spin-dependence of (n-p) interaction

Unit - IV

Elementary Particles: Fundamental interactions, Classification of elementary particles, symmetry and conservation laws, Elementary idea of CP and CPT invariance, Classification of Hadrons, Quantum numbers in strong interaction, Gell-Mann Nishijima formula, Lie algebra, SU(2)-SU(3) multiplets, Quark model of Hadrons.

References:

1. Nuclear Physics by Irvin Kaplan (Addison-Wesley)
2. Concepts of Nuclear Physics by B.L. Choen (Tata McGraw Hill)
3. Atomic and Nuclear Physics Vol II by S.N.Ghoshal (S. Chand and Co. Ltd.)
4. Nuclear Physics (Theory and Experiment) by R.R. Roy and B.P. Nigam (Wiley Eastern)
5. Nuclear Physics Vol I by Y M Shirikov and N P Yudin, (Mir Publisher, Moscow 1982).
6. Nuclear and Particle Physics by E.B. Paul (North Holland Publishing)
7. Facts and Mysteries in Elementary Particle Physics by M. Veltman (World Scientific)

Course Outcomes:

- The students will learn nuclear structure its energy and conservation laws.
- Understand elementary particles and symmetry considerations.
- Be prepared for research in areas related to nuclear and particle physics.

Paper II: Lasers and Modern Optics

Course Objective: Understand advanced concepts of optics and their applications.

Unit - I

Laser: Einstein coefficients, Light amplification; Population inversion; pumping processes; rate equation for three and four level systems; Cavity modes, polarization of cavity media; Quality factor of cavity and ultimate line width, Characteristic properties, Basic principles of Ruby, He-Ne, CO_2.

Unit - II

Holography: Basic principle of holography, Method of hologram Recording and Reconstruction; Basic theory of plane hologram; practical consideration of holography and its application.

Unit - III

Non- Linear: Non-linear polarizability tensors, Coupled amplitude equation; Manely-Rowe relationship; Parametric amplification and oscillation, Phase matching, Second harmonic generation.

Fibre Optics: Types of fibres, Single mode and multi-mode fibres; dispersion and loss in fibre; Principles of optical communication, Optical elements.

Unit – IV

Quantum Optics: Spatial and temporal coherence, classical and quantum coherence function; Glauber's theory of optical coherence, Over completeness of coherent states and its properties; Quasi phase distribution function.

References:

1. Optical Coherence and Quantum Optics, L.Mandel and E.Wolf (Cambridge University Press, Cambridge, 1995)
2. Quantum Optics by M.O. Scully and M. Suhail Zubairy (Cambridge University Press, Cambridge, 1997)
3. Physics of Non-Linear Optics by Guang S. He and Song H. Liu(World Scientific Press, Singapore, 2003)
4. Laser and holographic Data processing by N. G. Bosov (Mir Publisher, Moscow)

Course Outcomes:

- The students will understand LASERs, wave guides and their applications.
- Understand non-linear optical phenomenon.
- Get familiar with coherence and basic concepts of quantum optics.

Paper III: Condensed Matter Physics

Course Objective: Learn various important properties of materials and their applications.

Unit – I

Magnetic Properties: Magnetic ions, ground and excited states and multiplet separation; Paramagnetism of non-interacting magnetism ions and its application to transition and rare-earth ions.

Ferromagnetism: Molecular field theory, Heisenberg explanation of internal magnetic field, Landau theory of domain, Spin-wave theory, Magnon excitation and Bloch $T^{3/2}$ law, Antiferromagnetism, ferrimagnetism: Neel's two sub-lattice model.

Unit – II

Ferroelectricity: Basic features of piezo-, Pyro- and ferrro electric materials; Order-disorder and displacive type ferro electric materials; Occurance of ferroelectricity due to polerisation catastrophe and lattice modes; Devonshire theory of ferroelectric phase transition.

Unit – III

Superconductivity: Basic features (Zero resistance, Meissner effect, Penetration depth, Critical field, Heat capacity and isotopic shift) of superconductors, Soft and hard superconductors; Thermodynamics of superconducting transitions, London equation, Coherent length; Elements of BCS theory, Applications of superconductors: Particle tunneling and Josephson effect.

Unit - IV

Liquid crystals: Definition, Classification, Characteristic features; Thermotropic and Lyotropic Liquid Crystals, FLCs, Basic principle of LCDs.

Polymers: Structure, properties and methods of Polymerization, Degradation of Polymers, Viscoelastic state, Glass transition temperature.

Nano-materials: Definition, Types and characteristic features; Quantum size effect; density of states, Synthesis and characterization; Nanocomposites, Application in devices.

References:

1. Principle of theory of solid by J.M. Ziman (Cambridge University Press, London)
2. Theoretical Solid State Physics Vol.1 and Vol.11 by W. Jones and N.H. March (John Wiley and Sons, London)
3. Quantum Theory of Solid by C. Kittel (John Wiley and Sons, London)
4. Quantum Theory of Solids by R.E. Peirls (Oxfbrd University Press, London)
5. Nanotechnology: Principles and Practices, S.K. Kulkarni, Capital Pub. Co., New Delhi, 2006
6. Liquid Crystals by S. Chandrashekhar, (Cambridge Univ. Press, London)
7. An Introduction to Polymer Physics by I. I. Perepechko (Mir Publishers)

Course Outcomes:

- The students will learn about different and important types of materials.
- Understand various useful applications of materials.
- Be prepared for research in any area of condensed matter science.

Paper IV: Optional-II

Course Objective: Do deeper study in a specific branch of Physics, to inculcate self-study and get familiar with research requirements.

(a): Astrophysics II

Unit – I

Basic Astrophysics: Hydrostatic equilibrium, Lane - Emden equation, Equation of radiative transfer, Local thermodynamical relation, Radiative equilibrium, Mass-luminosity relation, Stability conditions for convective and radiative equilibrium. Curve of growth.

Unit – II

Stellar Energy: Gravitational contraction, pp cycle, CN cycle and triple alpha –process. Evolutionary sequence of stars, White dwarfs; Structure of envelope and interior, Elementary ideas of neutron stars, Pulsars and Black holes

Unit – III

The Milky Way; Distribution of stars, Interstellar gas and dust, Luminosity function, Star counts, Spiral structure. Galactic rotation, Oort's constant, Mass distribution, 21-cm radiation and Galactic structure

Unit – IV

External Galaxies; Classification, Mass and other physical properties, Radio Galaxies, Active Galaxies, Quasars, Cosmology; Olber's paradox, Newtonian cosmology, Expanding universe, Cosmological postulates, Cosmological red-shift, Big-bang model, Steady state theory.

References:

1. Principles of Astronomy by S. P. Wyatt (Allen and Bacyon, Inc.)
2. An Introduction to Astrophysics by B. N. Basu , T. Chattopadhyay, S. N. Biswas (Prentice Hall of India)
3. Astrophysics and Stellar Astronomy by T. L. Swihart
4. Astrophysics: Stars and Galaxies by K. D. Abhyankar
5. Essentials of Astronomy by Lloyd Motz (Columbia University Press)
6. The Physical Universe by F. Shu (University Science Books, California, U.S.A.)
7. The Structure of Universe by J. V. Narlikar (Oxford University Press)

Course XVI (b): Biophysics -II

Unit - I

Radiation Biophysics: Types of ionizing radiations, interaction between radiation and matter,radiation dose and dose rate, radiation effect on living cell, protein, nucleic acid and membrane. Radiation hazards and radiation protection.

Photobiophysics: Chemical structure and properties of chlorophyll, mechanism of photosynthesis, photochemical systems: PS-I and PS-II, Importance of photosynthesis.

Unit - II

Intermolecular Interactions : Intermolecular potential functions, Rayleigh - Schrodinger perturbation theory of long - range intermolecular interactions, classification of intermolecular forces, concept of short - range forces and inadequacy of Rayleigh - Schrodinger treatment at short range. Representation of short - range forces by classical and semi - empirical methods. Equivalence of classical and quantum - mechanical forces. Multicentred - multipole representation of intermolecular interactions.

Unit - III

X - ray methods: Basic principle of X - ray diffraction, structure factor, Analysis of Laue, Rotation and Powder photographs.

NMR: Basic theory of Nuclear Magnetic Resonance, Chemical shift and spin-spin coupling, relaxation effect, NMR spectrometers and FT spectroscopy, Applications.

Unit - IV

ORD and CD: Basic concept of circular dichoism and optical rotation, Drude equation, Molecular basis of rotatory power, Rotatory behaviour of macromolecules, Moffit plots for helical and random coil structure.

Sedimentation: Sedimentation velocity, apparatus and procedures for sedimentation studies, sedimentation equilibrium, Archibald method; Density gradient sedimentation.

Electrophoresis: Transport in an electric field, isoelectric focussing, orientation of molecules in electric fields.

Chromatography: Basic idea of Molecular - Sieve chromatography; Gel filteration, analysis of the shape of eluting bands; Determination of shape and size of macromolecules.

References:

1. Molecular Biology of the Genes by J. D. Watson (Benjamin Inc, California)
2. Principles of Nucleic Acid Structure by W. Saenger (Springer Verlag, New York)
3. Biophysics; Ed. W. Hoppe et. al. , (Springer Verlag, New York)
4. Introduction to Biophysics by P.S. Narayanan
5. Biophysics by M. V. Volkenstein (MIR publishers)
6. Biophysics by V. Pattabhi & N. Gauttam
7. Intermolecular Interactions: From Diatomics to Biopolymers, Ed. B. Pullman (John Wiley, N. Y.)
8. Physical Biochemistry by K. E. van Holde, (Prentice Hall, N, J.)

Course XVI (c): Electronics – II

Unit - I

Communication Theory: Types of Noise and its Spectrum, S/N ratio in analog communication systems, information content of message, rate of information-transmission in discrete communication channels, channel capacity, Shanon- Hartly Theorem and its applications.

Unit - II

Analog Modulaion: Sampling of analog signals, sampling theorem, Types of modulation and generation: PAM, PPM, and PWM; Quantization of Analog signals: Uniform and Non-uniform.

Unit - III

Digital Modulation: Pule code modulation, Binary coding and PCM bandwidth DPCM, DM and ADM, ASK and FSK system, transmission and detection of binary system.

Unit - IV

Microwaves and Antenna: Microwave generation, Reflex Klystron Oscillator, Transfer Electron Effect :Gun Diode, Tunnel diode, IMPATT. Current and voltage distribution in antenna, Short electric dipole, linear and ground antenna, field -distribution around vertical antenna, antenna arrays.

References:

1. Communication Systems by B. P. Lathi (Oxford University Press)
2. Principles of Communication System by Taub & Schilling (Mc Graw Hill)
3. Microwave by K. C. Gupta (Wiley Eastern Limited)
4. Antennas and Wave Propagation by J.D. Kraus (Tata Mc Graw Hill Publishing Company Limited -2010)

Course XVI (d): Solid State Physics II

Unit – I

Transport Properties: Linearised Boltzmann transport equation, Electrical conductivity, Relaxation time, Impurity scattering, Ideal resistance, Carrier mobility, General transport coefficient; Thermal conductivity, Thermoelectric effects, Lattice conduction, Phonon drag, Hall effect and magnetoresistance.

Unit – II

Superconductivity: Electron-electron interaction and screening, electron-phonon-electron interaction and Cooper pairs, Salient features of BCS theory, Superconducting ground state, Quasi particle and energy gap, High T_c superconductors; Charge transfer model of Cuprates, Defect ordering.

Unit – III

Magnetic Resonance: General theory of magnetic resonance and Bloch equations, Electron paramagnetic resonance (EPR): Method of observation, Structure of resonance lines and their uses; Nuclear magnetic resonance (NMR): Salient theory and method of observation, Structure of resonance lines and their uses.

Unit – IV

Mossbauer Effect: Difficulties in observing resonance flourescence of nuclear system, Recoil energy, Natural and dipole broadenings, Classical and quantum theories of Mossbauer effect, experimental method and principal uses of Mossbauer effect.

References :

1. Principle of theory of solid by J.M. Ziman (Cambridge University Press, London)
2. Theoretical Solid State Physics Vol.1 and Vol.11 by W. Jones and N.H. March (John Wiley and Sons, London)
3. Quantum Theory of Solid by C. Kittel (John Wiley and Sons, London)
4. Quantum Theory of Solids by R.E. Peirls (Oxfbrd University Press, London)
5. Mossbauer Effect and its Application by V. G. Bhinde
6. Principles of Magnetic Resonance by C.P. Slichter (Horper and Row, NewYork)

Course XVI (e): Spectroscopy and Lasers-II

Unit - I

Laser Physics: Rate equations for three and four level systems, Resonant modes of optical cavities, Mode size and cavity stability, Q factor and resonance line width, Q switching, Techniques of Q switching, Pockel's effect and mode locking.

Unit - II

Laser Systems: Pulsed crystal lasers, Rare earth ion lasers, Actinide ions and Transition metal ion lasers, Effects of crystal imperfections on laser behaviour, Ga-As injection laser, Tunable dye lasers and colour centre lasers.

Unit - III

Holography: Description of holography, Recording of plane and volume holograms, Holographic interferometry. Applications of holography.
Raman and Brillouin Scattering

Unit - IV

Non Linear Optics: Induced polarization, Parametric amplification, second and third harmonic generation, Parametric light oscillator and Frequency upconversion.
Laser Spectoscopy: Resonance Raman Spectorscopy, Laser investigations in atmospheric pollution monitoring and Picosecond spectroscopy.

References:

1. Atomic and Laser spectroscopy: Alan Corney
2. Lasers vol I and vol II: Edited by A.K.Levine
3. Principles of Holography: Howard M. Smith
4. Laser Applications: Monte Ross
5. Laser Spectroscopy: Edited by J.L.Hall
6. Lasers and Non-linear optics: B.B.Laud

Course XVI (f): X-Rays - II

Unit – I

Crystal systems, Bravais lattices. Symmetries in crystals. Point groups. Space lattices, Unit cells, Lave spots, space groups. Concept of reciprocal space and reciprocal lattice. Theory of diffraction of X-Ray by crystals. Lave equations and their interpration by Bragg.Interpretation of Bragg's law in terms of reciprocal lattice-Ewald's construction. Atomic scattering factors and structure factors. Systematic abstnces and absolute intensity.

Unit - II

Theory of reflection of X-Rays from mosiac and perfect crystals. Effect of thermal agitation. Diffuse reflections. Various types of X-Ray photographs Lave, Debye-Scherrer, rotation. Oscillation, Weissenberg and precession and their interpretation.

Unit - III

Elementary idea of X-Ray diffractometers. Diffraction of X-Rays by fibres and amorphous solids. Effects of grain size in polycrystalline aggregates. Fourier methods for mapping electron densities in crystals. Phase problem in structure analysis. Patterson synthesis. Elementary idea of (i) direct methods for phase determination and (ii) difference Fourier and least-squares methods of refinement.

Unit – IV

Elementry idea of electron and neutron diffractions methods and their comparison with X-Ray diffraction methods. Alloys: order-disorder phenomenon and phase transformations, superlattice.

Course Outcomes:

- The students will learn specialized concepts of a specific branch of Physics.
- Will learn to independently reference multiple sources for advanced knowledge.
- Be prepared for research in chosen area of interest.

PRACTICAL

Candidates will be required to perform at least five experiments from each Course

List of Experiments

Course C

(a): Astrophysics

1. Solar spectrum studies using 2 - m concave grating
2. Solar constant / Solar energy studies
3. Prism spectrograph
4. Orbital elements of Binary / Variable star study
5. Radial velocity determination including correction due to Earth's motion
6. Stellar spectral classification
7. Astronomical Project.

(b): Biophysics

1. Molecular modelling using crystallographic data
2. Electronic properties of biomolecules (CNDO method)
3. Ramchandran plot (ϕ - ψ) of the peptides (PCILO method)
4. Molecular assosisations among nuecleic acid bases
5. Absorption bands of chlorophyll using spectrophotometer
6. Emission spectra of Cu using Fe as standard
7. Rotational spectra of CN molecule
8. Dissosiation energy of iodine molecule
9. Vibrational spectra of benzene

(c): ELECTRONICS

Analog Electronics:

1. Linear characteristics of Operational amplifier
2. Non-linear characteristics of Operational amplifier
3. Active filters using Operational amplifier
4. IC 555 Timer in different modes
5. Phase Locked Loops using IC 565 PLL
6. Sample and Hold circuit
7. Pulse amplitude modulation and demodulation
8. PAM, PPM, PWM modulation and demodulation

(d:) SOLID STATE PHYSICS

1. X-ray powder diffraction
2. Lauve photograph or rotation photograph
3. Experiment on lattice dynamics
4. Energy band gap by four probe technique
5. Dielectric constant of BaTiO3 and Curie temperature
6. Ionic conductivity.

(e): SPECTROSCOPY and LASERS

Spectroscopy:

1. Verification of Cauchy’s and Hartmann dispersion formula
2. Determination of the wavelength of Zn triplets
3. Dissociation energy of Iodine by absorption spectra in visible region
4. Rotational and Vibrational analysis of 3883 Å band system of CN molecule
5. Analysis of 2600 Å vibronic system of benzene
6. Study of the great Ca triads

(f): X-RAYS

1. Determination of wave length of X-ray source using plane crystal spectrograph for Copper target
2. Determination of wave length of X-ray source using plane crystal spectrograph for Molybdenum target
3. X-ray powder photograph of a metal
4. X-ray powder photograph of NaCl (non-metal)
5. Rotation photograph of an organic crystal
6. X-ray fiber photograph

Course D

(a): ASTROPHYSICS

1. Familiarity with the night sky using Celestial globe and star maps
2. Diurnal motion study using telescope
3. Angular separation between stars using telescope
4. Use of Theodolite (Transit measurement; Coordinates of the stars)
5. Rising and Setting time of Planets and stars using Almanac
6. Lunar Photography
7. Stellar Photometry

(b) BIOPHYSICS

1. X - ray powder photograph
2. Fibre photograph
3. Plane crystal photograph
4. Ultrasonic studies of binary liquids
5. Molecular weight of a polymer using Viscometer
6. Optical rotatory dispersion study of dextrose
7. Paper / Thin layer / Column chromatography
8. Study of electrophoresis bands
9. Recording and analysis of ECG

(c) ELECTRONICS

Digital Electronics:

1. Combinational circuits
2. Sequential circuits
3. Characteristics of TTL logic
4. Multiplexer and Demultiplexer circuits
5. Semiconductor memory using IC 7489 RAM
6. D / A and A / D converters
7. Encoder and Decoder
8. Microprocessor 8085 - I
9. Microprocessor 8085 – II

(d) SOLID STATE PHYSICS

1. Thermoelectric power
2. E. P. R.
3. Magnetic susceptibility
4. Electro-Luminescence
5. B.H. curve (Hysteresis loss) by C.R.O
6. Hall effect

(e) SPECTROSCOPY And LASERS

Lasers:

1. Determination of wavelength of laser by grating (transmission / reflection)
2. Power distribution within the laser beam
3. Spatial coherence with Young's double slits
4. Spot size and divergence of a laser beam
5. Raman spectrum of CCl4
6. Study of speckle phenomenon

(f) X- RAYS

1. X-ray emission spectrum using bent-crystal spectrograph for Copper target
2. X-ray emission spectrum using bent-crystal spectrograph for Molybdenum target
3. X-ray absorption spectrum using bent-crystal spectrograph
4. Oscillation photograph of an organic crystal
5. Weissenberg photograph of a crystal
6. Study of absorption edge of Silver