Department of Physics

M. Sc. Physics Semester Examination Ordinance and Syllabus

ORDINANCE FOR MASTER'S DEGREE COURSE WITH SEMESTER SYSTEM IN THE FACULTY OF SCIENCE

*(The date of implementation will be decided by the executive council of the University.)**

Introduction: This is a 2- year post-graduate degree course, consisting of four semesters, divided into two parts, Previous and Final. In each Semester there will be available 13 weeks teaching and there will be thirty clock hours/ periods per week teaching. The courses will be as proposed by Board of Studies of the subject concerned and approved by the statutory bodies of the University. The teaching session will be divided into two terms:

Term I: July to November and Term II: December to April.

Admission: Candidates possessing 3- year Bachelor's degree with the subject concerned from Siddharth University or any University/ Institute recognized by this University will be eligible for the admission. Admission to the course will be done through an Entrance test conducted by the University with reservations as per State Government rules. The students who have passed previous year will be eligible, subject to University admission rules, for admission to the final year.

Examination: The students with attendance less than seventy five percent in Theory and Practical courses separately will not be allowed to appear in the Examination. However, any relaxation in the attendance will be as per University rules.

The minimum pass mark in each Semester in the aggregate of Theory and Practical courses will be 36% of the maximum marks, separately. However the minimum pass mark required in any theory paper will be 20% of the maximum mark. The students will provisionally be promoted to II/ IV Semester, without waiting for the result of I / III Semester, respectively.

*** Effective from academic session 2011 - 2012***

The candidates who fail to secure minimum prescribed pass marks in one theory paper but succeed in securing the minimum pass mark of the Semester will be promoted to the next Semester provisionally. Similarly, the candidates who fail to secure minimum prescribed pass marks in the aggregate of theory papers in a Semester but succeed in securing the minimum pass mark in each theory paper will also be promoted to the next Semester provisionally. Such students will have to opt a paper to clear the Semester. In the case of promotion from II semester to III Semester their admission to the Final Year will be completely provisional subject to his passing the Previous Year examination. The students so promoted shall have to take examination in the paper concerned along with the regular examination of the concerned Semester. In case they are unable to clear both the Semesters of a year they will be declared failed in that Part of the Examination. In that situation the promotion given to them will be null and void and similarly their admission done in the final year will also automatically stand cancelled. They will have to reappear at the next regular examination for whole examination of the concerned Part as Ex-student.

In the panel of Practical examiners, there will be a coordinator from the concerned University Department.

The result of the candidates who have passed the Previous and Final Year, will be declared-
First Division: 60% or above of the aggregate,
Second Division: 45% or above but less than 60%, of the aggregate
Third Division: 36% or above but less than 45%, of the aggregate.

M. SC. EXAMINATION SEMESTER SYSTEM PHYSICS

(SESSION 2013 – 2014)

The course will be divided in two parts. Each part shall be of two Semesters; each consisting of four theory papers and each paper of forty periods teaching load. The examination of each theory paper shall be of 50 marks. In each Semester there will be 240 period of Practical course and the examination of practical shall be of 100 marks. The pass marks in theory and practical examination will be 36% of the aggregate separately. The details of the courses are given below.

M.Sc. I
THEORY

Semester I

Paper I	Course I	Vector & Tensor Analysis and Group Theory	50 marks
Paper II	Course II	Quantum Mechanics – I	50 marks
Paper III	Course III	Special Theory of Relativity and Electromagnetic Theory	50 marks
Paper IV	Course IV	Electronics	50 marks

Semester II

Paper I :	Course V	Mathematical Physics	50 marks
Paper II	Course VI	Solid State Physics	50 marks
Paper III	Course VII	Thermodynamics and Statistical Physics	50 marks
Paper IV	Course VIII	Molecular Spectroscopy	50 marks

PRACTICALS

A candidate will be required to perform at least five experiments in each Semester from either of the courses A and B detailed at the end of the M. Sc. I course and have to present a seminar on a topic related to experiments done in respective Lab courses. In the examination the candidate has to do one experiment from the chosen group. Time allotted for performing the experiment shall be four hours. The distribution of marks shall be as follows:

	Regular Candidate	Ex- Candidate
Experiment	40	40
Seminar	15	15
Record	25	---
Viva	20	45
Total	100	100

M. Sc. II
In each semester the first three papers shall be compulsory and the fourth one i.e. Courses XII and XVI 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 pass marks in theory and practical examination will be 36% of the aggregate separately. The details of the courses are given below.

THEORY

Semester III

Paper I	Course IX	Computational Techniques	50 marks
Paper II	Course X	Nuclear & Particle Physics	50 marks
Paper III	Course XI	Quantum Mechanics II	50 marks
Paper IV	Course XII	OPTIONAL (a/b/c/d/e/f)	50 marks

Semester IV

Paper I	Course XIII	Electrodynamics and Plasma Physics	50 marks
Paper II	Course XIV	Modern Optics	50 marks
Paper III	Course XV	Condensed Matter Physics	50 marks
Paper IV	Course XVI	OPTIONAL (a/b/c/d/e/f)	50 marks

OPTIONAL THEORY PAPERS : (Two papers, each of 50 marks)

Group (a)	Astrophysics:	Course XII (a) & XVI (a)
Group (b)	Biophysics:	Course XII (b) & XVI (b)
Group (c)	Electronics:	Course XII (c) & XVI (c)

Group (d)	Solid State Physics:	Course XII (d) & XVI (d)
Group (e)	Spectroscopy and Lasers:	Course XII (e) & XVI (e)
Group (f)	X-rays:	Course XII (f) & XVI (f)

PRACTICALS

A candidate will be required to perform at least five experiments in each Semester from either of the courses C and D detailed at the end of the M. Sc. II course and has to present a seminar on a topic related to experiments done in respective Lab courses. In the examination the candidate has to do one experiment from the chosen group. Time allotted for performing the experiment shall be four hours. The distribution of marks shall be as follows:

	Regular Candidate	Ex- Candidate
Experiment	40	40
Seminar	15	15
Record	25	---
Viva	20	45
Total	100	100

In the fourth Semester provision for project work instead of performing the experiments is being introduced for regular students only. However, before implementing this system details will be prepared and approved by the respective statutory authorities. In that case it has to be made clear at the beginning of III semester with due information to Board of Studies. The candidate will have to do in the Semester III any five experiments from both the groups taken together; to be chosen judiciously at the local level. The candidate will submit a dissertation at the end of the IV semester. The dissertation has to be defended and will be evaluated during the examination by a board appointed for the purpose. The distribution of marks shall be as follows:

Project Dissertation	
Internal Evaluation	30
External Evaluation	30
Defense	40
Total	100

M.Sc. I
Semester I

Paper-I: Course I: Vector & Tensor Analysis and Group theory

Units I & II-Vector and Tensor Analysis: Curvilinear Coordinates, Gradient, Divergence and Curl, Green's theorem, Gauss and Stokes Theorems, Covariant and Contravariant Vectors and Tensors, Addition, Multiplication, Contraction, Symmetry properties, Tensor density, Levi-Cevita tensor density, Pseudo-tensors, Axial and Polar Vectors, Tensorial expressions of Gradient, Divergence and Curl, Continuity equations. Differentiation, Affine Connection and Covariant Differentiations, Metric tensor, Christoffel Symbols.
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 - 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. Vector Analysis and an Introduction to Tensor Analysis by Murray R. Spiegel (Schaum Out line Series)
2. Lectures on General Relativity by A. Papapetrou (D. Reidel Publishing Company)
3. Matrices and Tensors in Physics by A.W. Joshi (Wiley Eastern Ltd., New Delhi).
4. Elements of Group theory for Physicists by A. W. Joshi (Wiley Eastern. Ltd. New Delhi).
5. Group Theory and Quantum Mechanics by M Tinkham (Tata Mc-Graw Hill, New Delhi).
6. Chemical Applications of Group Theory by F. A. Cotton (Wiley Eastern. Ltd. New Delhi).
7. Valence by C. A. Coulson

Paper-II: Course II: Quantum Mechanics - I

Unit I: Mathematical Preliminaries:
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 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: 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.

Unit IV: Approximate methods
Time independent perturbation theory and anharmonic oscillator, Variational method and Helium atom, Time dependant perturbation theory and transition probability (Fermi-Golden Rule-2), WKB method and beta decay.

References:
1. Quantum Mechanics, Vol. (I) by Albert Messiah (North Holland Publishing Company, Amsterdam, 1961)
2. Concepts in Quantum Mechanics by V. S. Mathur and Surendra Singh (CRC Press, 2009)
3. The Principles of Quantum Mechanics by P. A. M. Dirac(Oxford Univ. Press, London, 1958)
4. Quantum Mechanics by B. K. Agarwal and Hari Prakash (Prentice-Hall of India Pvt Ltd, New Delhi, 2005)

Paper III - Course III: Special Theory of Relativity and Electromagnetic Theory

Special Theory of Relativity:
Unit I- Four Dimensional Formulation: Minkowski Space, 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.

Electromagnetic theory:
Unit II- (a) Maxwell Equations: Microscopic and Macroscopic fields, Macroscopic Maxwell equations, Fields **D** and **H**, Dielectric tensor, Principal dielectric axes.
(b) Potential and Gauges: Scalar and vector potentials, Gauge transformation, Lorentz guage and Transverse gauge, Maxwell equations in terms of electromagnetic potentials.
Unit III- Propagation of Electromagnetic Waves: Propagation of electromagnetic waves in free space, conducting and non-conducting medium, Reflection and refraction at a plane interface between dielectrics.
Unit IV- Polarisation by reflection, dispersion: Normal and anomalous, metallic reflection. Electromagnetic wave propagation in bound media-Rectangular and Circular Wave guide, Cut- off frequency and Wavelength, TE, TM and TEM Modes.

References:
1. The Classical Theory of Fields by L.D. Landau and E.M Lifshitz(Pergmon Press,Oxford)
2. Foundations of Electromagnetic Theory by Reitz, Milford & Christy(Narosa,Delhi)
3. Classical Electrodynamics by J.D.Jackson(Wiley East. Ltd.,Delhi)
4. Introduction to Electrodynamics by D.J.Griffiths (Prentice - Hall, New Delhi)
5. Foundations of Electromagnetic Theory by Reitz, Milford & Christy (Narosa, Delhi)

Paper-IV: Course IV: Electronics

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: **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. Astable, Monostable and Bistable Multivibrators.**

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 Basic Theory and Design by Kitsum (Marcel Deknar Inc, New York).
2. Power Electronics by PC Sen (Tata Mc Graw Hill, New Delhi).
3. Pulse, Digital and Switching Wave Forms by J.Milman and H.Tab (Mc graw Hill Kogakusha Ltd .Tokyo)
4. Modern Digital Electronics by R.P.Jain (Tata Mc Graw Hill, New Delhi).
5. Digital Principle and Application by A.P.Malvino and D.P.Leach (Mc Graw Hill, New York).

Semester-II

Paper I: Course V: Mathematical Physics

Unit I- Special Functions: Laplace equation in spherical polar and cylindrical polar coordinates and their solution, Legendre and Bessel differential equations, their solutions and properties, Spherical Harmonics**.**
Unit II- (a) Fourier Transform: Dirac Delta function, Fourier Transform, Sine and Cosine transform, Linearity, Change of Scale, Translation, Modulation, simple applications.
(b) 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.
Complex Variables:
Units III- 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- 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 in the Physical Sciences by M. C. Potter (Prientice Hall)
2. Mathematical Methods for Physicists By Arfken and Weber (Academic Press)
3. Mathematical Methods for Physics and Engineering by Riley, Hobson and Bence (Cambridge University Press)
4. Mathematical Physics by B. S. Rajput (Pagati Prakashan)
5. Mathematics for Physics by P. Dennery and A. Krzynicki (Harper and Row, New York).

Paper II: Course VI: Solid State Physics

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 and Co., London)
2. Introduction to Solid State Physics by C.Kittel (Wiley Eastern, New Delhi)

3. Elementary Solid State Physics: Principle and Application by Omar Ali (Addison Wesley, London).
4. Electrons and Phonons by J.M.Ziman (Oxford University Press, London).

Paper-III: Course VII: Thermodynamics and Statistical Physics

Unit I: Thermodynamics: Entropy and Probability, Thermodynamic Potentials, Thermodynamic Equilibrium, Third law of Thermodynamics, Thermodynamics of first and second order phase transistion, Clausius - Clapeyron and Ehrenfest's equations; Chemical potential and phase equilibria. Thermodynamic properties of liquid Helium II, The lambda - transition, London's explanation, Quantum liquid, Tisza two fluid model, Landau spectrum, concept of second sound.
Unit II: 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. Thermodynamics for Chemistis by S. Glasstone (John Wiley, New York)
3. Thermal Physics by C. Kittel (John Wiley, New York 1969)
4. Statistical Mechanics by B. K. Agarwal and Melvin Eisner (Wiley Est. Ltd., Delhi)
5. Statistical Mechanics and Properties of Matter by E.S.R. Gopal (Macmillan Ltd., Delhi)
6. Introduction to Statistical Mechanics by B. B. Laud (Macmillan Ltd., Delhi)

Paper-IV: Course VIII: Molecular Spectroscopy

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.
Unit III - Spectroscopic Techniques: Principle, experimental setup and applications of microwave, infrared, Fourier Transform infrared, Raman, ESR, EPR and NMR spectroscopy.
Unit IV - 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.

References:
1. Molecular Spectra and Molecular Structure by G.Herzberg (Dover Publication, London).
2. Quantum Theory of Molecules and Solids Vol.-I by J.C.Slater (Mc-Graw Hill, New York).
3. Valence by C.A.Coulson.
4. Fundamentals of Spectroscopy : Banwell

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

M. Sc. II

Semester-III

Paper-I: Course IX: Computational techniques

Numerical Analysis:

Unit 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 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.

Elements of Programming Languages-Fortran:

Unit III: 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.
2. Numerical Analysis by Balguruswamy.
3. Numerical Analysis by Harper.
4. Fortran 77 and application to Numerical Analysis by C. Xavier
5. Numerical Recipes for FORTRAN by W. Press et al.

Paper II: Course X: Nuclear & Particle Physics

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 interactions: Deuteron problem, low energy (n-p) and (p-p) scattering, scattering length, effective range theory, Spin-dependence of n-p interaction using deuteron bound, (n-p) and (p-p) scattering data.

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. Atomic and Nuclear Physics Vol II by S.N.Ghoshal (S. Chand and Co. Ltd., New Delhi 1994).
2. Theory of Nuclear structure by M K Pal (Affiliated East West Press, New Delhi 1982).
3. Nuclear Physics (Theory and Experiment) by R.R.Roy and B.P.Nigam (Wiley Eastern Ltd., New Delhi 1993).
4. Nuclear Physics Vol I by Y M Shirikov and N P Yudin, (Mir Publisher, Moscow 1982).
5. Nuclear and Particle Physics by E.B. Paul (North Holland Pub. Co., Amsterdam 1969).
6. Quams and Leptons by F.Halzen and A.D.Martin (John Wiley and sons 1984).
7. The second creations by R.P.Crease and C.C.Mann (Affiliated East West Private Limited, 1986).

Paper III- Course XI: Quantum Mechanics II

Unit I - Formulation of Relativistic quantum theory: **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 II - 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.**

Unit III - Quantization of Klein-Gordon field: ***Lagrangian and Hamiltonian formalism for field, canonical commutation relations and quantization; Hamiltonian and Normal ordering in Fock space, Complex scalar field.***

Unit IV - Quantization of Dirac and Electromagnetic field: ***Projection operators for energy and spin, Lagrangian for Dirac field and quantization, Number representation of Fermions; EM field as non-interacting harmonic oscillators, Quantization of radiation field, Algebra of annihilation and creation operators and their representations.***

References:-

1. Relativistic Quantum Mechanics by James D. Bjorken and Sidney D. Drell (McGraw-Hill Book Company; New York, 1964).
2. An Introduction to Relativistic Quantum Field Theory by S.S. Schweber (Harper & Row, New York, 1961).
3. Quantum Electrodynamics by F. Mandl & G. Shaw (John Wiley and Sons Ltd, 1984)
4. A First Book of Quantum Field Theory by A. Lahiri & P.B. Pal (Narosa Publishing House, New Delhi, 2000)

Paper IV- Course XII: Optional-I

Paper XII (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.)

Paper XII (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: Cell membrane, Micelle. bilayer and liposome; structure of 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 and 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.)

Paper XII (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

COURSE XII (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(a) - Fermi Surface: Construction of Fermi surface, Cyclotron resonance, Electron, hole and open orbits, Anomalous skin effect, De Haas Van Alphen effect.
Unit III(b) - 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)

Paper XII (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:
(i) Atomic spectra: H.E. White
(ii) Molecular spectra and Molecular structure Vol. I, II, III: G. Herzberg

Paper XII (f): X-Rays-I

Unit I & II: 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. 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 & IV: X-Ray emission spectra: X-Ray energy level diagrams,spin and creeming doublet laws,multiple radiation and transition probabilities.Absorption spectra,Crictical absorption edges.Theory of fine structure of absorption edges and absorption discontinuty. 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.Augey effect and satellite lines.X-Ray spectrographs-plane and bent crystal.

Semester-IV

Paper I - Course XIII: Electrodynamics & Plasma Physics

Electrodynamics:

Unit I-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 II- 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.

Plasma Physics:

Unit III- Plasma State & its Properties: Elementary ideas of 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,VanAllen Belts), Elementary idea of fusion technology.

Units IV-(a) Hydrodynamics of Plasma: Hydrodynamical description, Equation of magneto hydrodynamics, High frequency plasma oscillations, Short wavelength limit and Debye-screening distance.

(b) 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 wave.

References:

1. The Classical theory of Fields by L. D. Landau and E.M.Lifshitz (Pergmon Press, Oxford)
2. Classical Electrodynamics by J.D. Jackson (Wiley East. Ltd.,Delhi)
4. Introduction to Plasma Physics by F.F. Chen (Plenum Press,New York)
5. Plasma Physics by S.N.Sen (Pragati Prakashan, Meerut)
6. Introduction to Electrodynamics by D .J. Griffiths (Prentice - Hall, New Delhi)
7. Introduction to Plasma Physics by F. F .Chen (Plenum Press, NY)
8. Plasma Physics by S.N.Sen (Pragati Prakashan, Meerut)
9. Light by Ditchborn
10. Geometrical and Physical Optics by R. S. Longhurst

Paper II: - Course XIV: Modern Optics

Unit I & II:

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.

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 and Fibre Optics:

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

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)

Paper III: Course XV: Condensed Matter Physics

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: Materials:
Liquid crystals: Definition, Classification, Characteristic features; Thermotropic and Lyotropic Liquid Crystals, FLCs, Application in Liquid Crystal display devices.
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)

Paper IV: Course XVI: Optional-II

Course XVI (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 Nuelear 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 and techniques: Pule code modulation, Binary coding and PCM bandwidth DPCM, DM and ADM, ASK and FSK system, transmission and detection of binary system.

Unit IV:

Microwave 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:

Some Laser Systems: Pulsed crystal lasers, Rare earth ions, 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: Basic description of holography, Recording of plane and volume holograms, Holographic interferometry.

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 syolumo,Bravais lattices. Symmetries in crystals. Point groups. Space lattices, Unit cells, Lave graphs, 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 & III: 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. Elementry 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. Elementry idea of (i) direct methods for phase determination and (ii) difference Fourier and least-suares methods of refinement.
Unit IV: Elementry idea of electron and neutron diffractions methods and their comparison with X-Ray diffraction methods.Alloys: order-disorder phenomenons and phase transformations superlattice.

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

List of Experiments
<u>Course C</u>
<u>(a): Astrophysics</u>
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.

<u>(b): Biophysics</u>
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

<u>(c): ELECTRONICS</u>
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 $BaTiO_3$ 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 CCl_4
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

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