

**BHARATHIAR UNIVERSITY, COIMBATORE-641 046**

**M. Sc. PHYSICS DEGREE COURSE**

**(AFFILIATED COLLEGES – CBCS PATTERN)**

**(For Candidates Admitted During the Academic Year 2016-2017 Batch & Onwards)**

**SCHEME OF EXAMINATIONS**

Semester	Study Components	Ins. Hrs	Exam				Credits
			Dur. Hrs.	CIA	Univ. exam	Total Marks	
I	Paper – I Classical Mechanics	5	3	25	75	100	4
	Paper – II Mathematical Physics	5	3	25	75	100	4
	Paper – III Quantum Mechanics-I	5	3	25	75	100	4
	Paper – IV Advanced Computational Physics	5	3	25	75	100	4
	Practical – I General Physics	3	-	-	-	-	-
	Practical – II Electronics	3	-	-	-	-	-
	Elective I	4	3	25	75	100	4
II	Paper – V Quantum Mechanics-II	5	3	25	75	100	4
	Paper – VI Electromagnetic Theory	5	3	25	75	100	4
	Paper –VII Electronic Devices	5	3	25	75	100	4
	Practical- I General Physics	5	4	40	60	100	4
	Practical- II Electronics	5	4	40	60	100	4
	Elective II	5	3	25	75	100	4
III	Paper – VIII Experimental Techniques & Data Analysis	5	3	25	75	100	4
	Paper – IX Nuclear & Particle Physics	5	3	25	75	100	4
	Paper – X Spectroscopy	5	3	25	75	100	4
	Paper – XI Communication Electronics	5	3	25	75	100	4
	Practical- III Advanced Practicals	3	-	-	-	-	-
	Practical- IV Special Electronics	3	-	-	-	-	-
	Elective III	4	3	25	75	100	4
IV	Paper –XII Condensed Matter Physics	5	3	25	75	100	4
	Paper –XIII Thermodynamics & Statistical Physics	5	3	25	75	100	4
	Paper –XIV Introductory Astronomy, Astrophysics & Cosmology	5	3	25	75	100	4
	Practical- III Advanced Practicals	5	6	40	60	100	4
	Practical- IV Special Electronics	5	6	40	60	100	4
	Project	5	-	-	-	150*	6
Total						2250	90

\* Project report – 120 marks (80%); Viva-voce – 30 marks (20% )

**List of Group Elective papers (Colleges can choose any one of the Grouppapers as electives)**

	GROUP A	GROUP B
Paper I/ Semester I	Physics of Non-conventional Energy Resources	Elements Of Nanoscience and Nanotechnology
Paper II/Semester II	Atmospheric Physics	Plasma Physics
Paper III/Semester III	Laser Physics & Nonlinear Optics	Thin Film Physics

## FIRST SEMESTER

### PAPER I – CLASSICAL MECHANICS

#### **UNIT 1: Lagrangian Formalism:**

Constraints and Degrees of Freedom- Generalized Coordinates: Generalized Displacement, Acceleration, Momentum, force & Potential- Variation techniques and Euler's Lagrange Differential equation- Hamilton's Variational principle- Lagrange's equation of motion from Hamilton's principle- Deduction of Newton's Second law of Motion from Hamilton's principle- Application of Lagrange's equation of motion: Linear Harmonic Oscillator- Simple Pendulum- Isotropic Oscillator.

#### **UNIT II: Hamiltonian Formalism:**

Phase space- Hamiltonian- Hamilton's Canonical Equation of Motion- Significance of H- Deduction of Canonical Equation from Variation principle- Application of Hamilton's equation of motion: Simple Pendulum, Isotropic Oscillator - Principle of Least Action and Proof- Canonical Transformations- Generating Function and different forms

#### **UNIT III: Hamilton –Jacobi Method:**

Hamilton Jacobi Method, Solution of Harmonic Oscillator by HJ method- Particle falling freely- Kepler Problem- Damped Harmonic Oscillator- Poisson's Brackets- Definition- Equation of motion in Poisson's Bracket form- Poisson Theorem(Jacobi Identity)- Angular Momentum and Poisson's Brackets.

#### **UNIT IV: Two Body Problem:**

Equivalent One body problem- General Features of central force, motion- Stability of orbits and Conditions for closure- Motion under InverseSquare Law- Shapes of orbits- Inertial/Non inertial frames- Rotatory Coordinatory system- Effects of Coriolis force on the moving bodies.

#### **UNIT V: Rigid body dynamics:**

Euler theorem- Euler's angle- Angular velocity of a rigid body-Angular momentum of Rigid Body- Moments and Products of Inertia- Principle Axis of Transformation- Torque Free Motion of a Rigid Body- Poinso Solutions- The motion of a Symmetric Top under action of Gravity- Stable and Unstable Equilibrium.

#### **Books for Study**

1. Classical Mechanics- S.L.Gupta, V. Kumar & H.V.Sharma-Pragati Prakashan- Meerut, 2003
2. Classical Mechanics- H. Goldstein-Addison Wesley, London,1996

#### **References:**

1. Elements of Statistical Mechanics-Kamal Singh & S.P. Singh- S. Chand & Company, New Delhi, 1999.
2. Elements of Statistical Mechanics-Gupta & Kumar- Pragati Prakashan- Meerut
3. **Classical Mechanics – J.C.Ubadhyaya-Himalaya Publishing House (2012)**

## FIRST SEMESTER

### PAPER II- MATHEMATICAL PHYSICS

#### **Unit I: Special Functions**

Legendre's Polynomials and Functions- Differential Equations and Solutions-Generating Functions- Orthogonality-Relation between Legendre Polynomial and their Derivatives- Recurrence Relations- Bessel's Function-Differential Equation and Solution-Generating Functions-Recurrence Relations- Hermite function.

#### **Unit II: Complex Variable Theory**

Functions of a Complex Variable-Single and Multivalued Functions-Cauchy-Reimann Differential Equation-Analytical Line Integrals of Complex Function-Cauchy's Integral Theorem and Integral Formula-Derivatives of an Analytic Function-Taylor's Variables-Residue and Cauchy's Residue Theorem.

#### **Unit III: Linear Space**

Definition of Vector Space-Linear Dependence-Linear Independence-Basis-Dimension of a Vector Space-Representation of Vectors and Linear Operators with respect to Basis-Schmidt Orthogonalization Process-Inner Product.

#### **Unit IV: Fourier Series & Laplace Transforms**

Fourier Series-Dirichlet's Theorem-Change of Interval-Complex Form-Fourier Series in the Interval  $(0, \infty)$  - Uses of Fourier Series.-Laplace Transform-Definition-Properties-Translation Property-Inverse Laplace Transform-Properties, example problems.

#### **Unit V: Group Theory**

Definition of Groups-Groups of Transformation-Multiplication Table ( $C_{4v}$ )-Subgroups and Conjugate Classes-Cyclic Groups-Symmetry Elements-Transformation & Matrix Representation-Point & Space Groups-Reducible & Irreducible Representation of a Group-Schur's Lemmas-Orthogonality Theorem- Character of a Representation & Character Table-  $C_{2v}$  &  $C_{3v}$  Groups in Molecular Physics-Application for Classification of Elementary Particles

#### **BOOKS FOR STUDY**

1. Mathematical Physics- Sathya Prakash-Sultan Chand & Sons
2. **Mathematical methods for Physicists**-Arfken,weber &Harris – Academic Press- 7<sup>th</sup> edition
3. **Elements of group theory for Physicists** – A.W. Joshi, -Wiley Eastern, 2002

#### **References:**

1. Mathematical Physics-B.D. Gupta-Vikas Publishing House, 3rd Edition, 2006
2. Mathematical Physics-B.S. Rajput- Pragati Prakashan- Meerut 17th Edition 2004
3. Mathematical physics by P.K. Chattopadhyay-New Age International-New Delhi.
4. Mathematical Physics-P.P. Gupta, Yadav & Malik-Kedarnath Ramnath-Meerut
5. Numerical Methods in Science & Engineering-M.K. Venkataraman-National Publishing- Chennai,1986
6. Numerical Methods-A. Singaravelu-Meenakshi Publishing

## FIRST SEMESTER

### PAPER III- QUANTUM MECHANICS - I

#### **Unit I: Introduction & General Formalism:**

Inadequacy of classical Physics, wave packets and Uncertainty relations-Schrodinger wave equation and probabilistic interpretation, Simple one dimensional problems –Wells and Barriers

State Vectors-Hilbert Space-Dirac Notation-Dynamical Variables as Operators-Change of Basis-Unitary Transformation-Equation of Motion in Schroedinger Picture, Heisenberg Picture & Dirac Picture.

#### **Unit II: Approximate Methods:**

Time Independent Perturbation Theory in Non-Degenerate Case-Ground State of Helium Atom- Degenerate Case-Stark Effect in Hydrogen-Variation Method & its Application to Hydrogen Molecule- WKB Approximation.

#### **Unit III: Time Dependent Perturbation Theory:**

Time Dependent Perturbation Theory-First and Second Order Transitions-Transition to Continuum of States-Fermi Golden Rule-Constant and Harmonic Perturbation-Transition Probabilities-Selection Rules for Dipole Radiation-Collision-Adiabatic Approximation

#### **Unit IV: Angular Momentum**

Orbital Angular Momentum-Spin Angular Momentum-Total Angular Momentum Operators-Commutation Relations of Total Angular Momentum with Components-Ladder Operators-Commutation Relation of  $J_z$  with  $J_+$  and  $J_-$  Eigen Values of  $J^2$ ,  $J_z$  -Matrix Representation of  $J^2$ ,  $J_z$ ,  $J_+$  and  $J_-$  Addition of Angular Momenta- Clebsch Gordon Coefficients-Properties.

#### **Unit V: Relativistic Wave Equation:**

Klein Gordon Equation-Plane Wave Equation-Charge and Current Density-Application to the study of Hydrogen Like Atoms-Dirac Relativistic Equation for a Free Particle-Dirac Matrices-Dirac Equation in Electromagnetic Field-Negative Energy States.

#### **Books for Study :**

1. Quantum Mechanics-Gupta, Kumar & Sharma 23rd Edition, 2003-2004
2. **Quantum Mechanics – Aruldas-2002**

#### **References:**

1. Quantum Mechanics-Satyaprakash
2. Quantum Mechanics-L.I. Schiff- McGraw Hill, 3rd Edition, 1968
3. Quantum Mechanics-E. Merzbacher-Wiley and Sons, 3rd Edition, 2004
4. Quantum Mechanics-A. Devanathan-Narosa Publishing-New Delhi, 2005
5. A Text Book of Quantum Mechanics-P.M. Mathews & K. Venkatesan-Tata McGraw Hill.
6. Principles of Quantum Mechanics-Shankar, Springer, 2005

## FIRST SEMESTER

### PAPER IV-ADVANCED COMPUTATIONAL PHYSICS

#### **Unit I: Numerical Differentiation**

Finding Roots of a Polynomial-Bisection Method-Newton Raphson Method-Solution of Simultaneous Linear Equation by Gauss Elimination Method-Solution of Ordinary Differential Equation by Euler, Runge-Kutta Fourth Order Method for solving first order Ordinary Differential Equations

#### **Unit II: Numerical integration**

Newton's cotes formula-Trapezoidal rule-Simpson's 1/3 rule- Simpson's 3/8 rule-Boole's rule-Gaussian quadrature method-(2 point and 3 point formulae)-Giraffe's root square method for solving algebraic equation.

#### **Unit III: Matlab Fundamentals**

Introduction-Matlab Features-Desktop Windows: Command, Workspace, Command History, Array Editor and Current Directory -Matlab Help and Demos- Matlab Functions, Operators and Commands. Basic Arithmetic in Matlab-Basic Operations with Scalars, Vectors and Arrays-Matrices and Matrix Operations-Complex Numbers- Matlab Built-In Functions-Illustrative Examples

#### **Unit IV: Matlab Programming**

Control Flow Statements: *if, else, else if, switch* Statements-*for, while* Loop Structures-*break* Statement-Input/Output Commands-Script 'm' Files -Function 'm' Files-Controlling Output

#### **Unit V: Matlab Graphics:**

2D Plots-Planar Plots, Log Plots, Scatter Plots, Contour Plots-Multiple Figures, Graph of a Function-Titles, Labels, Text in a Graph- Line Types, Marker types, Colors-3D Graphics-Curve Plots-Mesh and Surface Plots-Illustrative Examples

#### **Reference :**

1. Engineering and Scientific Computations Using Matlab- Sergey E. Lyshevski-JohnWiley & Sons
2. A Guide to Matlab for Beginners & Experienced Users-Brian Hunt, Ronald Lipsman, Jonathan Rosenberg-Cambridge University Press
3. Matlab Primer-Timothy A. Davis & Kermit Sigmon-Chapman & Hall CRC Press-London
4. Matlab Programming-David Kuncicky-Prentice Hall
5. An Introduction to Programming and Numerical Methods in MATLAB- S.R. Otto and J.P.Denier- Springer-Verlag-London
6. Numerical Methods Using Matlab-John Mathews & Kurtis Fink-Prentice Hall-New Jersey, 2006
7. Introductory Methods of Numerical Analysis- S.S. Sastry-Prentice Hall, 2005

#### **Books for Study:**

1. Numerical methods in Science and Engineering- M.K. Venkataraman-National Publishing Co. Madras, 1996
2. Getting Started With Matlab-Rudra Pratap-Oxford University Press-New Delhi

## SECOND SEMESTER

### PAPER V – QUANTUM MECHANICS - II

#### **Unit I: Scattering Theory**

Scattering Amplitude-Expression in terms of Green's Function-Born Approximation and its Validity- Partial Wave Analysis-Phase Shifts-Scattering by Coulomb and Yukawa Potential

#### **Unit II: Application to Atomic Structure**

Central Field Approximation-Thomas Fermi Model-Hartree's Self Consistent Model-Hartree Fock Equation-Alkali Atoms-Doublet Separation-Intensities-Complex Atoms-Coupling Schemes

#### **Unit III: Application to Molecular Structure**

Hydrogen Molecule Ion-Hydrogen Molecule-Heitler London Method-Covalent Bond-Spin Orbit Interaction as Correction to Central Field Approximation- Hartree Fock Self Consistent Field Method for Molecules-Hybridization.

#### **Unit IV: Theory of Radiation (Semi Classical Treatment)**

Einstein's Coefficients-Spontaneous and Induced Emission of Radiation from Semi Classical Theory- Radiation Field as an Assembly of Oscillators-Interaction with Atoms-Emission and Absorption Rates- Density Matrix and its Applications

#### **Unit V: Quantum Field Theory**

Quantization of Wave Fields- Classical Lagrangian Equation-Classical Hamiltonian Equation-Field Quantization of the Non-Relativistic Schroedinger Equation-Creation, Destruction and Number Operators-Anti Commutation Relations-Quantization of Electromagnetic Field Energy and Momentum.

#### **Books for Study:**

1. A Text Book of Quantum Mechanics-P.M. Mathews & K. Venkatesan-Tata McGraw Hill 29<sup>th</sup> Reprint 2002
2. Quantum Mechanics-Gupta, Kumar & Sharma, 23rd Edition, 2003-2004

#### **References:**

1. Quantum Mechanics-Satyaprakash
2. Introduction to Quantum Mechanics-A.K. Chandra-Tata McGraw Hill
3. Quantum Mechanics-Merzbacher-John Wiley & Sons 3rd Edition, 2004
4. Quantum Mechanics-Devanathan-Narosa Publishing-New Delhi, 2005
5. Quantum Mechanics-Aruldas, 2002
6. Quantum Mechanics-A.K. Ghatak and S. Loganathan-McMillan India 4th Edition, 1999
7. Quantum Mechanics-Messiah(North Holland)1970
8. Quantum Mechanics-L.I. Schiff- McGraw Hill 3rd Edition, 1968
9. Principles of Quantum Mechanics-R.Shankar, Springer, 2005
10. Introduction to Quantum Mechanics – David J Griffiths- Addison Wesley – 2<sup>nd</sup> edition



## SECOND SEMESTER

### PAPER VI – ELECTROMAGNETIC THEORY

#### **Unit I: Electrostatics**

Coulomb's law- Gauss law-differential and integral representation- Electric field- Electric potential-energy density-Method of images-Multipole expansions.

#### **Unit II: Electrostatics in macroscopic media**

Potential and Field due to an Electric Dipole-Dielectric Polarization-External Field of a Dielectric Medium-Guass' Theorem in a Dielectric-Electric Displacement Vector **D**-Linear Dielectrics-Relations connecting Electric Susceptibility  $\chi_e$ , Polarization **P**, Displacement **D** and Dielectric Constant-Boundary Conditions of Field Vectors-Molecular Field-Clausius Mosotti Relation for Non-Polar Molecules- Electrostatic Energy and Energy Density

#### **Unit III: Magnetostatics**

Biot-Savart Law- Statement-Lorentz Force Law and Definition of B-Divergence and Curl of B Magnetic Scalar Potential (derivation of expression only)-Equivalence of Small Current Loop and Magnetic Dipole-Magnetic Vector Potential (derivation of expression only).

#### **Unit IV: Electromagnetics**

Equation of Continuity-Displacement Current-Derivation of Maxwell's Equations-Physical Significance-Poynting Vector-Momentum in EM Field-Electro Magnetic Potentials-Maxwell's Equations in terms of EM Potentials-Lorentz Gauge-Coulomb Gauge- Boundary Conditions at Interfaces.

#### **Unit V: Relativistic Electrodynamics**

Four Vectors-Transformation Relation for Charge and Current Densities for Electromagnetic Potentials- Covariant Form of Inhomogeneous Wave Equations-Covariance of Field Equations in terms of Four Vectors-Covariant Form of Electric and Magnetic Field Equations-Covariance of Electromagnetic Field Tensor-Covariant Form of Lorentz Force Law.

#### **Books for Study**

1. Electromagnetic Theory-Chopra & Agarwal-Nath & Co. 1984

##### **References:**

1. Electrodynamics-Gupta, Kumar & Singh-Pragati Prakashan-Meerut 1600
2. Electromagnetic Theory & Electrodynamics-Satyaprakash-Kedarnath Ramnath & Co.Meerut
3. Classical Electrodynamics-J.D. Jackson-Wiley Eastern 3rd Edition, 2004
4. Principles of Electrodynamics-M. Schwartz-McGraw Hill
5. Introduction to EM Fields & Waves-Carson & Lorrain
6. Introduction to Electrodynamics – David J Griffiths – Pearson – 4<sup>th</sup> edition 2012

## SECOND SEMESTER

### PAPER VII- ELECTRONIC DEVICES

#### **Unit I: Semiconductor Devices**

FET as a Voltage Variable Resistor-Common Source Amplifier at High Frequencies-Common Drain Amplifier at High Frequencies-Silicon Controlled Rectifier (SCR) Characteristics-SCR Power Control- Tunnel Diode -Optoelectronics: Photo Resistor-Photo Diode-Photo Transistor-LED-Photo Voltaic Effect-Solar Cells

#### **Unit II: Operational Amplifier**

Frequency Response of an Op-Amp-Parameters of an Op-Amp-Sign Changer-Scale Changer-Adder-Subtractor-Phase Shifter-Differential Amplifier-Integrator-Differentiator-Analog Computer Setup to Solve Linear Simultaneous Equations-Differential Equations in Physics-Logarithmic & Exponential Amplifiers-Active Filters.

#### **Unit III: Digital Circuits & Devices I**

Logic Families-Combinational Logic-Function of Combinational Logic-Flip Flops and other Multivibrators-Counters

#### **Unit IV: Digital Circuits & Devices II**

Shift Registers-Memories RAM, ROM, PROM, EPROM-Charge Coupled Devices (CCD)

#### **Unit V: Signal Processing & Data Acquisition**

Wave Form Generators and Wave Shaping Circuits-Sinusoidal Oscillators-Phase Shift Oscillator-Wein Bridge Oscillator-Crystal Oscillator- Multivibrators, Comparators-Schmitt Trigger-Square Wave & Triangular Wave Generators-Pulse Generators-IC 555 Timer and its Application-Signal and Signal Processing-Analog Multiplexer and Demultiplexer- D/A Converters-A/D Converters.

#### **Books for Study :**

1. Microelectronics-Millman & Grabel-McGraw Hill, 1982
2. Digital Principles and Applications-Malvino & Leach- McGraw Hill

#### **Books for References:**

1. Integrated Electronics-Millman & Halkias-Tata McGraw Hill 17th Reprint 2000
2. Digital Fundamentals-Floyd-UBS 1600
3. Op-amps and linear integrated circuits – Ramakant A Gayakwad – Prentice – Hall, 3<sup>rd</sup> revised edition
4. Physics of Semiconductor Devices-Wiley Eastern

## **PRACTICAL I - GENERAL PHYSICS**

### **(Examination at the end of Second Semester)**

#### **Any Twelve Experiments**

1. Young's Modulus-Elliptical Fringes (Cornu's Method)
2. Young's Modulus-Hyperbolic Fringes (Cornu's Method)
3. Viscosity of a Liquid-Mayer's Oscillating Disc
4. Stefan's Constant
5. Rydberg's Constant-Solar Spectrum
6. Thickness of Wire by Air Wedge and Diffraction
7. Determination of Audio Frequencies-Bridge Method
8. Thermionic Work Function
9. Thermal Conductivity-Forbe's Method
10. Electronic Charge 'e' by Millikan's Oil Drop Method
11. Electronic Specific Charge 'e/m' by Thomson's Method
12. Thermistor-Temperature Coefficient and Band Gap Energy Determination
13. Specific Heat of a Liquid-Ferguson's Method
14. Biprism on Optical Bench-Determination of Wavelength
15. He-Ne Laser –Measurement of Wavelength using reflectance grating.
16. Babinet's Compensator
17. LG Plate-Resolving Power
18. **Thickness of the wire by diffraction**
19. Fabry-Perot Interferometer-Study of Fine Structure
20. Geiger Muller Counter-Determination of Half Life of 'In'
21. Matlab Programming-Roots of a Quadratic Equation & Solution of a System of Linear Equations
22. Matlab Programming -Solution of Ordinary Differential Equations
23. Matlab Programming -Runge-Kutta Method
24. Matlab Programming -Newton-Raphson Method
25. Matlab Programming-Mean, Median & Standard Deviation
26. Matlab Programming-Curve Fitting & Interpolation
27. Matlab Programming-Matrix Summation, Subtraction and Multiplication
28. Matlab Programming-Matrix Inversion and Solution of Simultaneous Equations
29. He-Ne Laser – Measurement of refractive index of liquids.
30. He-Ne Laser – Power distribution measurement.
31. He-Ne Laser- Thickness of wire.

**PRACTICAL II-ELECTRONICS**  
**(Examination at the end of Second Semester)**

**Any Fifteen Experiments**

1. Design of Regulated and Dual Power Supply and Construction using fixed voltage regulator and 723.
2. Basic Logic Gates-Digital IC's
3. Parameters of Op-Amp
4. Design of Wave Form Generators- using Op-Amp and Timer 555.
5. Design of Phase-Shift Oscillator- Op-Amp
6. Design of Wein's Bridge Oscillator- Op-Amp
7. Design of Active Filters- Op-Amp
8. Design of Differential Amplifier- Op-Amp
9. **Sign Changer, Scale Changer, Adder & subtractor**
10. Analog Computer Setup-Solving Simultaneous Equations
11. Design of UJT Relaxation Oscillator
12. CRO-Differentiating, Integrating, Clipping and Clamping Circuits, Square Wave Testing
13. Source Follower
14. SCR-Characteristics and an Application
15. A.C. Amplifier-Inverting, Non-Inverting, Voltage Follower- Op-Amp
16. Function generator using IC 8038
17. Measurement of Hall Coefficient of given Semiconductor-Estimation of Charge Carrier Concentration
18. Digital IC's- Counters, shift register(7476)
19. Schmitt Trigger using discrete components and OP-AMP/ Timer 555
20. Matlab Programming-Charging of an Capacitor in an RC Circuit with three Time Constants
21. Matlab Programming- Full Wave Rectifier-Determination of (a) Peak-to-Peak Value of Ripple Voltage, (b) DC Output Voltage (c) Discharge Time of the Capacitor (d) Period of Ripple Voltage
22. Matlab Programming- Plot of Voltage and Current of an RLC Circuit Under Steady State Conditions
23. Matlab Programming- NPN Transistor-Plotting Input & Output Characteristics
24. Matlab Programming-Frequency Response of a Low Pass Op-Amp Filter Circuit
25. Matlab Programming-Diode-Plot of Forward Characteristics & Load Line Plot-Estimation of Operating Point

## THIRD SEMESTER

### **PAPER VIII-EXPERIMENTAL TECHNIQUES & DATA ANALYSIS**

#### **UNIT – I Introduction:**

Introduction- Measurement of errors: accuracy, precision, resolution, sensitivity – absolute and relative errors-Types of errors – gross error, systematic error and random error.-standards of measurements – classification of standards, time and frequency standards, electrical standards, standards of temperature and luminous intensity.

#### **UNIT – II Electrical Transducer Classification:**

Active and Passive transducers-resistive, inductive, capacitive, thermocouple and Piezoelectric transducers-Digital transducers.

#### **UNIT – III Amplifiers and Signal Conditioning:**

Instrumentation amplifiers- Isolation amplifiers- Chopper amplifiers- Voltage to frequency and frequency to voltage converters- Frequency multipliers- logarithmic amplifiers, S/H Circuits Active filters-Low pass, High pass, Band pass and Band stop filters – Butterworth filters- All Pass filters. Phase sensitive detectors (PSD)- Phase lock loop (PLL) – Lock-in-amplifier.

#### **UNIT-IV Signal Analysis:**

Wave Analyzers-Audio frequency Wave analyzer- Heterodyne wave analyzer- Harmonic distortion analyzers-Resonant harmonic distortion analyzer-Heterodyne harmonic distortion analyzer- Fundamental suppression harmonic distortion analyzer- Spectrum analyzer- Spectra of CW, AM, FM and PM waves.

#### **UNIT – V Electronic Measuring Instruments:**

Q-meter- Vector impedance meter- Digital frequency meter – Digital voltmeter – Phase meter- RF power and voltage measurement – Power factor meter – Vector voltmeter. Display and Recording: X-t, X-Y Recorders- Magnetic Tape recorders- Storage Oscilloscope. Characteristics of digital displays: LED- LCD – Dot matrix and Seven Segment display systems.

#### **Recommended Text Books:**

1. Modern Electronic Instrumentation and Measurement Techniques – A.O. Hefnick and W.D. Cooper., Prentice Hall India Publications.
2. Introduction to Instrumentation and Control – A.K. Ghosh - Prentice Hall India Publications

#### **References:**

1. Electrical & Electronics Measurement & Instrumentation - A.K. Sawhney
2. Modern Electronic Instrumentation – W.D. Cooper
3. Instrumentation Devices and Systems – C.S. Rangan, G.R. Sharma and VSV Mani, Tata McGraw Hill Publications.

**THIRD SEMESTER**  
**PAPER IX- NUCLEAR & PARTICLE PHYSICS**

**Unit I: Nuclear Structure**

Distribution of Nuclear Charge-Nuclear Mass-Mass Spectroscopy-Mass Spectrometer-Theories of Nuclear Composition (proton-electron, proton-neutron)- Bound States of Two Nucleons-Spin States- Pauli's Exclusion Principle-Tensor Force-Static Force-Exchange Force.

**Unit II: Radioactivity**

**Alpha Decay:** Properties of  $\alpha$  Particles-Gamow's Theory of  $\alpha$  Decay-Geiger Nuttal Law-  $\alpha$  Ray Energies-Fine Structure of  $\alpha$  Rays-  $\alpha$  Disintegration Energy-Long Range  $\alpha$  Particles.

**Beta Decay:** Properties of  $\beta$  Particles-General Features of  $\beta$  Ray Spectrum-Pauli's Hypothesis-Fermi's Theory of  $\beta$  Decay-Forms of Interactions and Selection Rules.

**Gamma Decay:** Absorption of  $\gamma$  Rays by Matter-Interaction of  $\gamma$  Rays with Matter-Measurement of  $\gamma$  Ray Energies-Internal Conversion.

**Unit III: Nuclear Models**

**Liquid Drop Model:** Bohr Wheeler Theory of Fission-Condition for Spontaneous Fission-Activation Energy.

**Shell Model:** Explanation of Magic Numbers-Prediction of Shell Model-Prediction of Nuclear Spin and Parity-Nuclear Statistics-Magnetic Moment of Nuclei-Nuclear Isomerism.

**Collective Model:** Explanation of Quadrupole Moments.

**Unit IV: Nuclear Reactions**

Kinds of Reactions and Conservation Laws-Energy of Nuclear Reaction-Iso Spin-Continuum Theory of Nuclear Reaction-Resonance-Breit and Wigner Dispersion Formula-Stages of a Nuclear Reaction- Statistical Theory of Nuclear Reaction-Kinematics of Stripping and Pickup Reaction.

**Unit V: Particle Physics**

Leptons-Hadrons-Mesons-Hyperons-Pions-Mesons, Resonances-Strange Mesons and Baryons-Gell-Mann Okuba Mass formula for Baryons-CP Violation in Neutral Kaon ( $K_0$ ) Decay- Symmetry and Conservation Laws-Quark Model-Reaction and Decays.

**Books for Study:**

1. Concepts of Nuclear Physics-Bernard L. Cohen-Tata McGraw Hill- New Delhi 1600,1978
2. Introductory Nuclear Physics-Kenneth S. Krane-John Wiley & Sons

**References:**

1. Nuclear Physics- D.C. Sharma-K.Nath & Co-Meerut 1600
2. Nuclear and Particle Physics-Pandya and Yadav
3. Nuclear Physics-J.C. Tayal-Umesh Prakashan-Gujarat
4. Physics of Nucleus and Particles-Volume I & II-B. Nermeir & Sheldon
5. The Investigations of Physics World-G.Torl di Froncia-Cambridge University Press 8. Auto Nuclear-Evan-McGraw Hill

### **THIRD SEMESTER** **PAPER X-SPECTROSCOPY**

#### **Unit I: Atomic & Microwave Spectroscopy**

Spectra of Alkali Metal Vapours-Normal Zeeman Effect-Anomalous Zeeman Effect-Magnetic Moment of Atom and the G Factor-Lande's 'g' Formula-Paschen Back Effect-Hyperfine Structure of Spectral Lines.

**Microwave Spectroscopy**-Experimental Methods-Theory of Microwave Spectra of Linear, Symmetric Top Molecules-Hyperfine Structure-Quadrupole Moment-Inversion Spectrum of Ammonia.

#### **Unit II: Infrared & Raman Spectroscopy**

**IR Spectroscopy:** Practical Aspects-Theory of IR RotationVibration Spectra of Gaseous Diatomic Molecules-Applications-Basic Principles of FTIR Spectroscopy.

**Raman Spectroscopy:** Classical and Quantum Theory of Raman Effect-Rotation Vibration Raman Spectra of Diatomic and Polyatomic Molecules-Applications-Laser Raman Spectroscopy.

#### **Unit III: Electronic Spectra: Fluorescence & Phosphorescence Spectroscopy**

Electronic Excitation of Diatomic Species-Vibrational Analysis of Band Systems of Diatomic Molecules-Deslandre's Table-Intensity Distribution-Franck Condon Principle-Rotational Structure of Electronic Bands-Resonance and Normal Fluorescence-Intensities of Transitions-Phosphorescence-Population of Triplet State and Intensity-Experimental Methods-Applications of Fluorescence and Phosphorescence.

#### **Unit IV: NMR & NQR Spectroscopy**

**NMR Spectroscopy:** Quantum Mechanical and Classical Description-Bloch Equations-Relaxation Processes-Experimental Technique-Principle and Working of High Resolution NMR Spectrometer- Chemical Shift

**NQR Spectroscopy:** Fundamental Requirements-General Principle-Experimental Detection of NQR Frequencies-Interpretation and Chemical Explanation of NQR Spectroscopy

#### **Unit V: ESR & Mossbauer Spectroscopy**

**ESR Spectroscopy:** Basic Principles-Experiments-ESR Spectrometer-Reflection Cavity and Microwave Bridge-ESR Spectrum-Hyperfine Structure

**Mossbauer Spectroscopy:** Mossbauer Effect-Recoilless Emission and Absorption-Mossbauer Spectrum-Experimental Methods-Hyperfine Interaction-Chemical Isomer Shift-Magnetic Hyperfine and Electric Quadrupole Interaction

#### **Books for Study:**

1. Molecular Structure and Spectroscopy – G. Aruldas

#### **References:**

1. Spectroscopy: Volumes I, II and III-B.P. Straugham & S. Walker
2. Fundamental of molecular spectroscopy – C.B.Banwell
3. Introduction to molecular spectroscopy - G.M.Barrow.
4. Atomic Physics - J.B.Rajam, S.Chand Publications.

**THIRD SEMESTER**  
**PAPER XI- COMMUNICATION ELECTRONICS**

**Unit I: Antennas & Wave Propagation**

Terms and Definition-Effect of Ground on Antennas-Grounded  $\lambda/4$  Antenna-Ungrounded  $\lambda/2$  Antenna- Antenna Arrays-Broadside and End Side Arrays-Antenna Gain-Directional High Frequency Antennas- Sky Wave Propagation-Ionosphere-Eccles& Larmor Theory-Magneto Ionic Theory-Ground Wave Propagation.

**Unit II: Microwaves**

Microwave Generation-Multicavity Klystron-Reflex Klystron-Magnetron-Travelling Wave Tubes (TWT) and other Microwave Tubes-MASER-Gunn Diode.

**Unit III: Radar and Television**

Elements of a Radar System-Radar Equation-Radar Performance Factors-Radar Transmitting Systems- Radar Antennas-Duplexers-Radar Receivers and Indicators-Pulsed Systems-Other Radar Systems- Colour TV Transmission and Reception.

**Unit III: Communication Electronics**

Analog and Digital Signals – Modulation – Types of Modulation- Amplitude modulation theory – Frequency spectrum of the AM wave – Representation of AM – Power relations in the AM wave – Generation of AM – Basic requirements- Description of frequency and phase modulation – Mathematical representation of FM – Frequency spectrum of the FM wave - Effects of noise on carrier.

**Unit V: Optical Fibres**

Propagation of Light in an Optical Fibre-Acceptance Angle-Numerical Aperture-Step and Graded Index Fibres-Optical Fibre as a Cylindrical Wave Guide-Wave Guide Equations-Wave Equations in Step Index Fibres-Fibre Losses and Dispersion-Applications.

**Books for Study:**

1. Electronic Communication System-George Kennedy & Davis -Tata McGraw Hill 4th edition 1989
2. Optical fibre and fibre optic communication systems – S K Sarkar – S.Chand Pub – 2007 edition

**References:**

1. Principles of Communication Systems-Taub Schilling-TMH 1986
2. Communication Systems-Simon Haykin-John Wiley & Sons 2005
3. Electronics & Radio Engineering-F.E.Terman- McGraw Hill
4. Communication Systems-Carlson- McGraw Hill 3rd Edition 1986
5. Fibre Optics technology & Applications-Stewart D. Personick-Khanna Publishers-Delhi

## FOURTH SEMESTER

### PAPER XII-CONDENSED MATTER PHYSICS

#### **Unit I: Crystal Structure & Diffraction**

Lattice Constant and Density-Reciprocal Lattice Concept-Graphical Construction-Vector Development of Reciprocal Lattice-Properties-Reciprocal Lattice to BCC, FCC Lattices-Bragg Condition in terms of Reciprocal Lattice-Rotary Crystal Method of X-Ray Diffraction-Neutron Diffraction-Principle- Advantage-Experiment

#### **Unit II: Crystal Defects & Dislocations**

**Defects:** Classification-Point Defects-Schottky Defect-Frenkel Defect-Colour Centers-F Centre-Other Colour Centers-Production of Colour Centers by X-Rays and Irradiation.

**Dislocations:** Slip and Plastic Deformation-Shear Strength of Single Crystals-Edge Dislocation-Screw Dislocation-Stress Field around an Edge Dislocation

#### **Unit III: Lattice Vibrations, Semiconductors & Dielectrics**

Vibrations of One Dimensional Diatomic Linear Lattice-Acoustic and Optical Branches-Phonon State- Semiconductors-Conductivity of Semiconductors-Model for Intrinsic and Impurity Semiconductors-Hall Effect-Dielectrics-Ferro Electric Crystals-Ferro Electric Domains

#### **Unit IV: Metals & Superconductors**

Heat Capacity of Electron Gas-Experimental Electrical Resistivity of Metals-Superconductivity-Electron Phonon Interaction-Cooper Pairs-BCS Theory-Energy Gap and its Temperature Dependence-London Equation-Josephson Effect & Applications-High Temperature Superconductivity.

#### **Unit V: Magnetism**

Langevin Theory of Paramagnetism-Quantum Theory of Paramagnetism-Curie Law-Ferromagnetism-Weiss Molecular Field Theory-Domain Theory-Anti Ferromagnetism-Neel Theory-Ferrimagnetism-Ferrites-Spin Waves-Experimental Techniques to Study Magnetic Properties.

#### **Books for Study:**

1. Introduction to Solid State Physics-C. Kittel-Wiley Eastern-New Delhi 7th Edition 2000

#### **References:**

1. Solid State Physics-B.S. Saxena, R.C. Gupta & P.N. Saxena-Pragati Prakashan-Meerut
2. Solid State Physics-A.J. Dekker-Macmillan India 1995
3. Solid State Physics-S.L. Kakani & C. Hemaranjani-Sultan Chand & Sons
4. Solid State Physics-H.E. Hall-John Wiley & Sons
5. An Introduction to Solid State Physics & Its Applications-R.J. Elliot & A.P. Gibson-ELBS & Macmillan
6. Principles of Solid State-H.V. Keer-Wiley Eastern
7. Physics of Solids-C.A. Wert & R.M. Thomson-McGraw Hill 1600
8. Fundamentals of Solid State Physics-J.R. Christmann- John Wiley & Sons 1600

## **FOURTH SEMESTER**

### **PAPER XIII - THERMODYNAMICS AND STATISTICAL PHYSICS**

#### **UNIT I: Thermodynamics and Radiation:**

Second law of thermodynamics- Entropy and Second law of thermodynamics- Entropy and Disorder- Thermodynamic Potential and Reciprocity relation- Thermodynamic Equilibria- Chemical Potential- Blackbody radiation- Planck's Radiation law.

#### **UNIT II: Basic Concepts:**

Phase space- Volume in phase space-Number of phase cells in given energy range of harmonic oscillator- Number of phase cell in the given energy range of 3-dimensional free particle- Concept of ensemble- Micro canonical ensemble-Canonical ensemble- Grand Canonical ensemble- Density distribution in phase space- Liouville's theorem- Postulate of equal a priori probability- Statistical equilibrium- Thermal equilibrium- Mechanical equilibrium-Particle equilibrium-Connection between Statistical and thermodynamic quantities.

#### **UNIT III: Classical Distribution Law:**

Microstates and Macro states-Classical Maxwell-Boltzmann distribution law- Evaluation of constants,  $\alpha$  and  $\beta$ - Maxwell's law of Distribution of velocities- Principle of equi-partition of energy- Gibbs paradox- Partition function and its correlation with thermodynamics quantities- Partition functions and its properties- Comparison of ensembles- Equipartition theorem- Applications

#### **UNIT IV: Quantum Statistics:**

Indistinguishability and quantum statistics- Statistical weight and a priori probability- Identical particles and symmetry requirements- Bose Einstein's Statistics- Fermi Dirac Statistics- Results of three statistics- Thermodynamic interpretation of parameters  $\alpha$  and  $\beta$ - Blackbody radiation and Planck radiation- Specific heat of solids: Dulong and Petit's law- Einstein's Theory- Debye theory.

#### **UNIT V: Application of Quantum Statistics:**

Energy and pressure of ideal Bose Einstein gas- Bose Einstein condensation- Liquid helium- Energy and pressure of ideal Fermi Dirac gas- Free electron model and electronic emission- Onsager relations- Fluctuation; Energy, Pressure, Enthalpy- Bragg William Approximation- One dimensional Ising model

#### **References:**

1. Statistical Mechanics, Gupta & Kumar, 20<sup>th</sup> edition, Pragati Prakashan Meerut, 2003.
2. Fundamentals Of Statistical Mechanics, Keiser Huang, Revised edition

#### **Book for study:**

1. Fundamentals of statistical & thermal physics – F.Reif- wareland press - 2010

## FOURTH SEMESTER

### **PAPER XIV - INTRODUCTORY ASTRONOMY, ASTROPHYSICS & COSMOLOGY**

#### **Unit – I History of Astronomy:**

Introductory History of Astronomy-Ptolemy's Geocentric Universe-Copernicus' Heliocentric Universe-Tycho Brahe and Galileo's Observations-Kepler's Laws of Planetary Motion-Newtonian Concept Of Gravity-Highlights of Einstein's Special and General Theory Of Relativity-Curved Space Time-Evidence of Curved Space Time-Bending Of Light-Time Dilation

#### **Unit – II Stars & Galaxies:**

Stars and Galaxies-Distances-Trigonometric Parallax-Inverse Square Law-Magnitude of Stars-Apparent Magnitude-Absolute Magnitude and Luminosity-Color and Temperature-Composition of Stars-Velocity, Mass and Sizes of Stars-Types of Stars- Temperature Dependence-Spectral Types-Hertzsprung-Russell (HR) Diagram-Spectroscopic Parallax

#### **Unit – III Lives and death of stars:**

Stellar Evolution-Mass Dependence-Giant Molecular Cloud-Protostar-Main Sequence Star-Subgiant, Red Giant, Supergiant-Core Fusion-Red Giant (Or) Supergiant- Planetary Nebula (Or) Supernova-White Dwarfs-Novae And Supernovae- Neutron Stars-Pulsars-Black Holes-Detecting Black Holes-The Sun-Its Size and Composition- Sun's Interior Zones-Sun's Surface-Photosphere-Chromosphere-Corona-Sun's Power Source-Fusion Reaction Mechanism.

#### **Unit –IV Cosmology I:**

Introduction to Cosmology-Basic Observations and implications-Olbers' Paradox -Expanding Universe-Gravitational Redshift-Doppler Effect-Hubble's Law and the Age of the Universe - Cosmological Principle-The Perfect Cosmological Principle- Observation and interpretation of Cosmic Microwave background Radiation (CMBR)- Evidence Supporting the General Big Bang Theory-Salient features of Steady State Theory

#### **Unit – V Cosmology II:**

Fate of the Universe-Dependence on Mass (Curvature of Space)-Critical density-Open Universe-Closed Universe-Homogenous and Isotropic Freidman-Robertson-Walker Universes-Deriving the Geometry of the Universe from the Background Radiation-Flatness Problem- Horizon Problem-Inflation and its effect on the universe-The Cosmological Constant

#### **REFERENCES:**

1. Lectures on Astronomy, Astrophysics, And Cosmology-Luis A. Anchordoqu-
2. Lecture Notes of Department of Physics, University of Wisconsin-Milwaukee
3. Astrophysics of the Solar System -K.D. Abhayankar
4. An Introduction to Planetary Physics - Kaula. W.M.
5. Astrophysics of the Sun - Harold Zirin.

**Study material available in the website: [www.astronomynotes.com](http://www.astronomynotes.com)**

**PRACTICAL III- ADVANCED PRACTICALS**

**(Examination at the end of Fourth Semester)**

Any Twelve Experiments

1. AIO Band
2. CN Band
3. Arc Spectra-Constant Deviation Spectrograph-Copper, Iron & Barium
4. Michelson Interferometer-  $\lambda$ ,  $d\lambda$  and Thickness of Mica Sheet
5. Susceptibility-Guoy and Quincke's Method
6. Compressibility of a Liquid-Ultrasonic Method
7. Hall Effect and its application
8. e/m-Zeeman Effect
9. e/m-Magnetron Method
10. B-H Curve-Anchor Ring
11. B-H Curve-Solenoid
12. Double Slit-Wavelength Determination
13. G.M Counter-Characteristics
14. Kelvin's Double Bridge-Determination of Very Low Resistance & Temperature Coefficient of Resistance.
15. **He-Ne Laser determination of particle size**
16. Conductance of photoconductor, photovoltaic cell(solar cell)and photodiode.
17. Study of Fluorescent Spectrum of DCN Dye and Determination of Quantum Yield of Fluorescence Maxima and Full Width Maxima using Monochromator.
18. Matlab Programming-Radioactive Decay
19. Matlab Programming-Numerical Integration
20. Matlab Programming-Double Integration
21. Matlab Programming-Solution of Ordinary Differential Equations
22. Matlab Programming-Computer Simulation of Equations of Motion for a System of Particles
23. Matlab Programming-Computer Simulation of 1-D and 2-D Lattice Vibrations
24. Matlab Programming-Computer Simulation of Kronig-Penney Model
25. Matlab Programming-Numerical simulation of Wave-Functions of Simple Harmonic Oscillator
26. Matlab Programming-Simulation of Wave Functions for a Particle in Critical Box
27. Matlab Programming-Solution of Diffusion Equation

**PRACTICAL IV-SPECIAL ELECTRONICS**

**(Examination at the end of Fourth Semester)**

Any Ten Experiments

1. Op-Amp: Simultaneous Addition & Subtraction
2. Op-Amp: Instrumentation Amplifier-Temperature Measurement
3. Op-Amp: Instrumentation Amplifier-Light Intensity-Inverse Square Law
4. Op-Amp: V to I & I to V Converter
5. Op-Amp: Circuits Using Diodes-Half Wave, Full Wave, Peak Value, Clipper, Clamper
6. Op-Amp: Log and Antilog Amplifier
7. Op-Amp: Analog Computation-Second Order Differential Equation
8. Op-Amp Comparator-Zero Crossing Detector, Window Detector, Time Marker
9. IC 555 Timer Application-Monostable, Linear & Astable
10. A/D Converters-Any One Method
11. D/A Converters-Binary Weighted & Ladder Methods
12. IC Counters with Feedback
13. Microprocessor: LED Interfacing
14. Microprocessor: Stepper Motor Interfacing
15. Microprocessor: Traffic Control Simulation
16. Microprocessor: ADC Interface-Wave Form Generation
17. Microprocessor: Hex Keyboard Interfacing
18. Microprocessor: Musical Tone Generator Interface
19. Microcontroller: Blinking of LEDs either 8051 or 16F84
20. Microcontroller: Controlling LED with switch.
20. Microcontroller: DC motor control.
21. Microcontroller: triangle wave generator.

**ELECTIVE GROUP A- (I SEMESTER)**

**PAPER I - PHYSICS OF NON-CONVENTIONAL ENERGY RESOURCES**

**UNIT-I**

Introduction-Various non-conventional energy resources- Introduction, availability, classification, relative merits and demerits.

**Solar Cells:** Theory of solar cells. Solar cell materials, solar cell array, solar cell power plant, limitations.

**UNIT-II Solar Thermal Energy:** Solar radiation, flat plate collectors and their materials, applications and performance, focussing of collectors and their materials, applications and performance; solar thermal power plants, thermal energy storage for solar heating and cooling, limitations.

**UNIT-III**

**Geothermal Energy:** Resources of geothermal energy, thermodynamics of geo-thermal energy conversion-electrical conversion, non-electrical conversion, environmental considerations.

**Magneto-hydrodynamics (MHD):** Principle of working of MHD Power plant, performance and limitations.

**Fuel Cells:** Principle of working of various types of fuel cells and their working, performance and limitations.

**UNIT-IV Wind Energy:**

Wind power and its sources, site selection, criterion, momentum theory, classification of rotors,

Concentrations and augments, wind characteristics. Performance and limitations of energy conversion systems.

**UNIT-V**

**Bio-mass:** Availability of bio-mass and its conversion theory.

**Ocean Thermal Energy Conversion (OTEC):** Availability, theory and working principle, performance and limitations.

**Wave and Tidal Wave:** Principle of working, performance and limitations.

**Text Books:**

1. Introduction to Non-Conventional Energy Resources -Raja etal, SciTech Publications.

**References:**

1. Renewal Energy Resources -John Twideu and Tony Weir, BSP Publications, 2006.
2. Energy Resources: Conventional & Non-Conventional -M.V.R. Koteswara Rao, BSP Publications, 2006.
3. Non-conventional Energy Resources -D.S. Chauhan, New Age International.
4. Renewal Energy Technologies: A Practical Guide for Beginners C.S. Solanki-PHI Learning

**ELECTIVE GROUP A- (II SEMESTER)**

**PAPER II ATMOSPHERIC PHYSICS**

**Unit-I: Physical & Dynamic Meteorology**

Physical Meteorology: Structure of Earth's Atmosphere and Composition-Law of Thermodynamics of the Atmosphere- Adiabatic Process-Potential Temperature-Clausius-Clapyeron Equation-Laws of Black Body Radiation-Solar and Terrestrial Radiation-Albedo-Green House Effect-Heat Balance of Earth Atmosphere System.

**Unit-II: Dynamic Meteorology:**

Fundamental Forces-Structure of Static Atmosphere-Momentum, Continuity and Energy Equations-Thermodynamics of the Dry Atmosphere-Elementary Applications of the Basic Equations-Circulation Theorem-Vorticity-Potential Vorticity and Potential Vorticity Equations.

**Unit-II: Climate & Monsoon Dynamics**

Climate Classification-Polar, Artic, Antarctic, Temperate & Tropical Climates  
Wind, Temperature & Pressure Distribution over India in the Lower, Middle and Upper Atmosphere during Pre- Post- and Mid-Monsoon Season-Dynamics of Monsoon Depression and Easterly Waves-Intra Seasonal and Interannual Variability of Monsoon-Quasi-Bi Weekly and 30-60 Day Oscillations-Walker Circulation, Southern Oscillations & El Nino

**Unit-III: Atmospheric Pollution:**

Role of Meteorology in Atmospheric Pollution-Atmospheric Boundary Layer-Air Stability-Local Wind Structure-Ekman Spiral-Turbulence & Boundary Layer Scaling-Residence Time and Reaction Rates of Pollutants-Sulphur Compounds-Carbon Compounds-Organic compounds-Aerosols- Toxic Gases and Radio Active Particles-Trace Gases

**Unit-IV Radar Meteorology:**

Basic Meteorology-Radar Principles and Technology-Radar Signal Processing & Display-Weather Radar- Observation of Precipitating Systems-Estimation of Precipitation-Radar observation of Tropical Storms & Cyclones-Use of Weather Radar in Aviation-Clear Air Radars-Observation of a Clear Air Phenomena

**Books for Study :**

1. The Atmosphere-Frederick K. Lutgens and Edward J. Tarbuk

**References:**

1. Dynamic Meteorology-J.R. Holton-Academic Press- NY
2. The Physics of Monsoons-R.N. Keshvamurthy & M. Shankar Rao-Allied Publishers
3. Principles of Air Pollution Meteorology-Tom Lyons & Prillscott-CBS Publishers & Distributors
4. Radar Meteorology-Henry Saugageot.

**ELECTIVE GROUP A- (III SEMESTER)**

**PAPER III LASER PHYSICS AND NON LINEAR OPTICS**

**UNIT I: Lasers-Fundamentals and Types**

Basic Construction and Principle of Lasing-Einstein Relations and Gain Coefficient -Creation of a Population Inversion- Three-Level System - Four-Level System -Threshold Gain Coefficient for Lasing- Laser types-He-Ne Laser-CO<sub>2</sub> Laser- Nd:YAG Laser- Semiconductor Laser.

**UNIT II: Laser Operation**

Optical Resonator-Laser Modes-Axial modes- Transverse modes-Modification in Basic Laser Structure- Basic Principle of Mode Locking- Active Mode Locking -Passive Mode Locking-Q-Switching- Pulse Shaping.

**UNIT III: Laser Beam Characteristics:**

Wavelength-Coherence-Mode and Beam Diameter-Polarizations-Introduction to Gaussian Beam width-Divergence-Radius of Curvature-Rayleigh Range-Guoy Phase Shift-3-D Gaussian Beams -ABCD Law for Gaussian Beam-The Complex Radius of Curvature-Tensorial ABCD Law.

**UNIT IV:Focusing of Laser Beam**

Diffraction- Limited spot size- $M^2$ Concept of Beam Quality-Spherical Aberration-Thermal Lensing Effects-Depth of Focus-Tight focusing of laser beam - Angular Spectrum Representation of Optical Near Field-Aplanatic lens-Focusing of Higher-order laser modes-Radially Polarized Doughnut mode-Azimuthally Polarized Doughnut mode.

**UNIT V:Non Linear Optics**

Introduction-Nonlinear Optical Media-The Nonlinear Wave Equation-Scattering Theory Born Approximation-Second-order Nonlinear Optics-Second-Harmonic Generation (SHG) and Rectification-The Electro-Optic Effect-Three-Wave Mixing-Frequency and Phase Matching-Third Harmonic Generation-Optical Kerr Effect- Self-Focusing- Four-Wave Mixing (FWM) - Optical Phase Conjugation (OPC)- Use of Phase Conjugators in Wave Restoration.

**References:**

1. Nanomaterials: Processing and Characterization with Lasers.-Subhash Chandra Singh, Haibo Zeng, Chunlei Guo, and Weiping Cai -Wiley-VCH Verlag GmbH & Co. KGaA.(2012).
2. Walter Koechner-Solid state Laser Engineering-6<sup>th</sup> edition-Springer
3. Principles of Nano optics -L. Novotny and B. Hecht-Cambridge University Press(2006)
4. Encyclopedia of Optical Engineering- R.G.Driggers,C.Hoffman- Marcel Dekker(2003)
5. Laser Material Processing- M. Steen, J.Mazumder- Springer (2010)
6. Fundamentals of Photonics - Bahaa E. A. Saleh, Malvin Carl Teich-John Wiley & Sons, Inc.

**Books for study:**

1. Nonlinear Optics – D.L. Mills - Basic Concepts, Springer, Berlin 1998.
2. Lasers and Nonlinear Optics -B.B. Laud-2nd Edn. New Age International (P) Ltd., New Delhi, 1991

**ELECTIVE GROUP B- (I SEMESTER)**

**PAPER I ELEMENTS OF NANOSCIENCE AND NANOTECHNOLOGY**

**Unit I: Overview of Nanoscience**

Nanorevolution of the 20th century, Properties at Nanoscale (optical, electronic and magnetic). Theory, definitions and scaling.

**Unit II: Different Classes of Nanomaterials**

Metal and Semiconductor Nanomaterials, Quantum dots, Wells and Wires, Molecule to Bulk Transitions Bucky Balls and Carbon Nanotubes.

**Unit III: Synthesis of Nanomaterials**

Top-down (Nanolithography, CVD), bottom-up (sol-gel processing, chemical synthesis). Wet Deposition Techniques, Self-assembly (Supramolecular approach), Molecular Design and Modeling.

**Unit IV: Characterization**

TEM, SEM and SPM Technique, Fluorescence Microscopy and Imaging.

**Unit V: Applications**

Solar Energy Conversion and Catalysis, Molecular Electronics and Printed Electronics Nanoelectronics, Polymers with a special architecture, Liquid Crystalline Systems, Linear and Nonlinear Optical and Electro Optical properties, Applications in Displays and other devices, Advanced Organic Materials for Data Storage, Photonics, Plasmonics, Chemical and Biosensors, Nanomedicine and Nano Biotechnology.

**Text book**

1. Nanostructured Materials and Nanotechnology -Hari Singh Nalwa, Academic Press, 2002

**Reference books**

1. Organic and Inorganic Nanostructures, A. Nabok- Artech House, 2005
2. Nanoscience: "Nanotechnologies and Nanophysics", C. Dupas, P. Houdy, M. Lahmani, Springer-Verlag Berlin Heidelberg, 2007
3. Introduction to Nanotechnology, Charles P. Poole, Frank J Owens, Wiley- Interscience
4. Nanosystem Characterization Tools in the Life Sciences edited by Challa Kumar
5. Nanostructures and Nanomaterials (Synthesis, Properties and Applications), Guozhong Cao

**ELECTIVE GROUP B- (II SEMESTER)**

**PAPER II PLASMA PHYSICS**

**Unit I Fundamental Concepts about Plasma**

Kinetic pressure in a partially ionized – mean free path and collision cross section- mobility of charged particles – Effect of magnetic field on the mobility of ions and electrons-Thermal conductivity- Effect of magnetic field- Quasi-neutrality of plasma Debye shielding distance – Optical properties of plasma.

**Unit II Motion of Charged Particles in Electric and Magnetic Field:**

Particle description of plasma- Motion of charged particle in electrostatic field- Motion of charged particle in uniform magnetic field - Motion of charged particle in electric and magnetic fields- Motion of charged particle in inhomogeneous magnetic field - Motion of charged particle in magnetic mirror confinement – motion of an electron in a time varying electric field- Magneto-hydrodynamics - Magneto-hydrodynamic equations – Condition for magneto hydrodynamic behavior.

**Unit III Plasma Oscillations and Waves**

Introduction, theory of simple oscillations - electron oscillation in a plasma – Derivations of plasma oscillations by using Maxwell's equation – Ion oscillation and waves in a magnetic field – thermal effects on plasma oscillations – Landau damping – Hydro magnetic waves – Oscillations in an electron beam.

**Unit IV Plasma Diagnostics Techniques**

Single probe method - Double probe method – Use of probe technique for measurement of plasma parameters in magnetic field – microwave method – spectroscopic method - -laser as a tool for plasma diagnostics-X-ray diagnostics of plasma – acoustic method – conclusion.

**Unit V Possible Applications of Plasma Physics**

Magneto hydrodynamic Generator – Basic theory – Principle of Working –Fuel in MHD Generator – Generation of Microwaves Utilizing High Density Plasma – Plasma Diode.

**Books for Study:**

1. Plasma Physics- Plasma State of Matter – S.N.Sen, Pragati Prakashan, Meerut

**References:**

1. Introduction to Plasma Physics – F.F.Chen, Plenum Press, London
2. Principles of Plasma Physics – Krall & Trivelpiece
3. Introduction to Plasma Theory-D.R. Nicholson
4. The Plasma State-J.L. Shohet
5. Introduction to Plasma Physics-M. Uman
6. Principles of Plasma Diagnostics-I.H. Hutchinson
7. Plasma Diagnostic Techniques-R.H. Huddlestone & S.L. Leonard

## **ELECTIVE GROUP B- (III SEMESTER)**

### **PAPER III THIN FILM PHYSICS**

#### **Unit I: Preparation of Thin Film**

Nature of Thin Film-Deposition Technology-Distribution of Deposit-Resistance Heating-Thermal Evaporation-Flash Evaporation

#### **Unit II: Deposition techniques:**

Electron Beam Method-Cathodic Sputtering-Glow Discharge Sputtering-Low Pressure Sputtering-Reactive Sputtering-RF Sputtering-Chemical Vapour Deposition-Chemical Deposition

#### **Unit III: Film Thickness & Its Control**

Mass Methods-Optical Method-Photometry-Ellipsometry-Interferometry-Other Methods-Substrate Cleaning-Microscopic Defect and Dislocation-Edge Dislocation-Screw Dislocation-Boundary Defect-Stress Effect-Removal of Defect-Defect and Energy State

#### **Unit IV: Thin Film Analysis**

Electron Diffraction Technique- High Energy Electron Diffraction-Low Energy Electron Diffraction-Electron Microscopy-Scanning Electron Microscopy-X Ray Photoelectron Spectroscopy-Mass Spectroscopy- Thermodynamics of Nucleation-Nucleation Theories- Film Growth-Incorporation of Defects, Impurities etc. in Film-Deposition Parameters and Grain Size

#### **Unit V: Thin Film Growth Process**

Epitaxy-Thin Film Structure-Substrate Effect-Epitaxial Deposit-Twinning and Multi twinning-Phase Transition-Dissociations-Film Thickness Effect-Crystal Growth Process

#### **Books for Study :**

1. Thin Film Fundamentals-A. Goswami-New Age International-New Delhi

#### **References:**

1. Thin Film Phenomena-K.L. Chopra
2. Handbook of Thin Film Technology-L.T. Meissel & R. Glang-McGraw Hill