Dr. Shyama Prasad Mukherjee University

Ranchi

DEPARTMENT OF PHYSICS

Proposed

UNDER GRADUATE PROGRAMME

COURSES OF STUDY FOR B.Sc. (HONOURS)

Under CBCS Pattern

COURSE STRUCTURE (PHYSICS-HONOURS)

S.no.	Course	Credits
1.	**CORE COURSE** (14 Papers, C1 to C14)	14×4= 56
	Core Practical (14 Papers LAB I-XIV)	14×2= 28
2.	**ELECTIVE COURSE** (4 Papers)	
	Discipline Specific Elective (4 Papers, DSE 1 to DSE 4)	4×6= 24
3.	**GENERIC ELECTIVE**	
	Generic Elective (Theory) (4 Papers, GE 1 to GE 4)	6×4= 24
4.	**ABILITY ENHANCEMENT COURSES (AEC)**	
	Ability Enhancement Compulsory (2 Papers) Environmental Science English/MIL Communication	2×2= 4
	Ability Enhancement Elective (Skill based) (2 Papers)	2×2= 4
	TOTAL	**140**

PROPOSED SCHEME FOR CHOICE BASED CREDIT SYSTEM IN
B. Sc. Honours (PHYSICS)

SEM	CORE COURSE (14 Papers)	AEC Compulsory Course (AECC) (2 Papers)	AEC Elective Course (SEC) skill based (2 Papers)	Elective DSE (4 Papers)	Elective Generic (4 Papers)	Total Credits
I	Mathematical Physics-I (4-0-2 credits) Mechanics (4-0-2 credits)	*Eng./MIL Comm^{n}/* Env. Sc. (2 credits)			GE-1 (6 credits)	**20**
II	Thermal Physics (4-0-2 credits) Current electricity (4-0-2 credits)	*Env. Sc./* Eng./MIL Comm^{n} (2 credits)			GE-2 (6 credits)	**20**
III	Mathematical Physics-II (4-0-2 credits) Electrostatics and Magnetism (4-0-2 credits) Wave and Acoustics (4-0-2 credits)		SEC-1 (2 credits)		GE-3 (6 credits)	**26**
IV	Optics (4-0-2 credits) Quantum Mechanics (4-0-2 credits) Electromagnetic Theory (4-0-2 credits)		SEC-2 (2 credits)		GE-4 (6 credits)	**26**
V	Relativity, Atomic and Molecular (4-0-2 credits) Analog Electronics and Applications (4-0-2 credits)			DSE-1 (4-0-2 credits) DSE-2 (4-0-2 credits)		**24**
VI	Solid State Physics (4-0-2 credits) Statistical Mechanics (4-0-2 credits)			DSE-3 (4-0-2 credits) DSE-4 (4-0-2 credits)		**24**
Credits	**84**	**04**	**04**	**24**	**24**	**140**

CORE PAPERS

(Credit: 4-0-2 each)

C1. Mathematical Physics-I
C2. Mechanics
C3. Thermal Physics
C4. Current electricity
C5. Mathematical Physics II
C6. Electrostatics and Magnetism
C7. Wave and Acoustics
C8. Optics
C9. Quantum Mechanics
C10. Electromagnetic Theory
C11. Relativity, Atomic and Molecular Physics
C12. Analog Electronics and Applications
C13. Solid State Physics
C14. Statistical Mechanics

DISCIPLINE SPECIFIC ELECTIVE PAPERS

(Credit: 4-0-2 each)
Any four of the following subjects

DSE1. Mathematical Physics III
DSE2. Nuclear and Particle Physics
DSE3. Classical mechanics
DSE4. Digital electronics
DSE5. Experimental techniques
DSE6. Nano-science & technology
DSE7. Modern optics
DSE8. Dissertation

SKILL ENHANCEMENT COURSES

(Credit: 02 each) Any two of the following subjects

SEC1. Electrical Circuit Network Skills
SEC2. Basic Instrumentation Skills
SEC3. Renewable Energy And Energy Harvesting
SEC4. Applied Optics
SEC5. Computers and C Programming

CORE COURSE (HONOURS IN PHYSICS)
SEMESTER I

PHYSICS-C I: MATHEMATICAL PHYSICS-I
(Credits: Theory-04) Theory: 60 Lectures

Mid Semester: 15 **End Semester: 60** **Full Marks: 75**

Short Answer Type: 4 Marks (3 out of 5) & Long Answer Type: 12 Marks (4 out of 6)

Calculus: First Order Differential Equations and Integrating Factor.
Second Order Differential equations: Homogeneous Equations with constant coefficients.. Statement of existence and Uniqueness Theorem for Initial Value Problems. Particular Integral for typical source terms like polynomials, exponential, sine, cosine etc.
Calculus of multivariable functions: Partial derivatives, exact differentials. Integrating factor, with simple illustration.
Vector Calculus: Recapitulation of vectors: Properties of vectors under rotations. Scalar product and its invariance under rotations. Vector product, Scalar triple product and their geometrical interpretation. Scalar and Vector fields.
Vector Differentiation: Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities.
Vector Integration: Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems and their applications. Dirac Delta function and its properties:
Orthogonal Curvilinear Coordinates: Orthogonal Curvilinear Coordinates. Expression for Gradient, Divergence, Curl and Laplacian in orthogonal curvilinear co-ordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems.

Reference Books:

- Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn., Elsevier.
- An introduction to ordinary differential equations, E.A. Coddington, 2009, PHI learning
- Differential Equations, George F. Simmons, 2007, McGraw Hill.
- Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
- Mathematical methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Book

PHYSICS LAB- LAB C I (2 Credits) FM: 25

Topics	Description with Applications
Introduction and Overview	Computer architecture and organization, memory and Input/output devices
Basics of scientific computing	Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow &overflow emphasize the importance of making equations in terms of dimensionless variables, Iterative methods
Errors and error Analysis	Truncation and round off errors, Absolute and relative errors, Floating point computations.

Review of C & C++ Programming fundamentals	Introduction to Programming, constants, variables and data types, operators and Expressions, I/O statements, scanf and printf, c in and c out, Manipulators for data formatting, Control statements (decision making and looping statements) (*If-statement. If-else Statement. Nested if Structure. Else-if Statement. Ternary Operator. Goto Statement. Switch Statement. Unconditional and Conditional Looping. While Loop. Do-While Loop. FOR Loop. Break and Continue Statements. Nested Loops*), Arrays (*1D & 2D*) and strings, user defined functions, Structures and Unions, Idea of classes and objects
Programs:	Sum & average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending descending order, Binary search
Random number generation	Area of circle, area of square, volume of sphere, value of $\boldsymbol{\pi}$
Solution of Algebraic and Transcendental equations by Bisection, Newton Raphson and Secant methods	Solution of linear and quadratic equation, solving $\alpha = \tan\alpha$; $I = I_o [(\sin\alpha)/\alpha]^2$ in optics
Interpolation by Newton Gregory Forward and Backward difference formula, Error estimation.	Evaluation of trigonometric functions e.g. *sinθ, cosθ, tanθ, etc.*

Also attempt some problems on differential equations like:

1. Solve the coupled first order differential equations

   $$\frac{dx}{dt} = y + x - \frac{x^3}{3}$$

   $$\frac{dy}{dt} = -x$$

   for four initial conditions x(0) = 0, y(0) = -1, -2, -3, -4. Plot x vs y for each of the four initial conditions on the same screen for $0 \le t \le 15$.
2. The ordinary differential equation describing the motion of a pendulum is

   $\vartheta'' = -\sin(\vartheta)$

   The pendulum is released from rest at an angular displacement α i.e. $\vartheta(0) = \alpha$, $\vartheta'(0) = 0$. Use the RK4 method to solve the equation for α = 0.1, 0.5 and 1.0 and plot ϑ as a function of time in the range $0 \le t \le 8\pi$. Also, plot the analytic solution valid in the small ϑ ($\sin\vartheta \approx \vartheta$).
3. Solve the differential equation:

   $$x^2 \frac{d^2y}{dx^2} - 4x(1+x)\frac{dy}{dx} + 2(1+x)y = x^3$$

   with the boundary conditions: at x = 1, $y = (1/2)e^2$, $dy/dx = -(3/2)e^2 - 0.5$, in the range $1 \le x \le 3$. Plot y and dy/dx against x in the given range. Both should appear on the same graph.

PHYSICS-C II: MECHANICS

(Credits: Theory-04) Theory: 60 Lectures

Mid Semester: 15 End Semester: 60 Full Marks: 75

Short Answer Type: 4 Marks (3 out of 5) & Long Answer Type: 12 Marks (4 out of 6)

Fundamentals of Dynamics: Reference frames. Inertial frames; Review of Newton's Laws of Motion. Dynamics of a system of particles. Centre of Mass. Principle of conservation of momentum. Impulse. Momentum of variable-mass system: motion of rocket.

Rotational Dynamics: Angular momentum of a particle and system of particles. Torque. Principle of conservation of angular momentum. Moment of Inertia. Calculation of moment of inertia for rectangular, cylindrical and spherical bodies. Kinetic energy of rotation. Motion involving both translation and rotation.

Elasticity: Elastic constants and interrelation between them. Twisting torque on a Cylinder or Wire and twisting couple.

Flexure of beam: Bending of beam, Cantilever.

Surface Tension: Ripples and Gravity waves, Determination of Surface Tension by Jaeger's and Quinke's methods. Temperature dependance of Surface Tension.

Fluid Motion: Poiseuille's Equation for Flow of a Liquid through a Capillary Tube and the corrections.

Central Force Motion: Motion of a particle under a central force field. Two-body problem and its reduction to one-body problem and its solution.. Kepler's Laws.. Weightlessness.

Reference Books:

- An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw-Hill.
- Mechanics, Berkeley Physics, vol.1, C.Kittel, W.Knight, et.al. 2007, Tata McGraw-Hill.
- Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.
- Analytical Mechanics, G.R. Fowles and G.L. Cassiday. 2005, Cengage Learning.
- Feynman Lectures, Vol. I, R.P.Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education
- Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.

PHYSICS LAB- LAB C II (2 Credits) FM: 25

1. Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope.
2. To study the random error in observations.
3. To study the Motion of Spring and calculate (a) Spring constant, (b) **g** and (c) Modulus of rigidity.
4. To determine the Moment of Inertia of a Flywheel.
5. To determine **g** and velocity for a freely falling body using Digital Timing Technique
6. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
7. To determine the Modulus of Rigidity of a bar by method of bending.
8. To determine the elastic Constants of a wire by Searle's method.
9. To determine the value of g using Bar Pendulum.
10. To determine the value of g using Kater's Pendulum.

SEMESTER II

PHYSICS-C III: THERMAL PHYSICS
(Credits: Theory-04) Theory: 60 Lectures

Mid Semester: 15 **End Semester: 60** **Full Marks: 75**

Short Answer Type: 4 Marks (3 out of 5) & Long Answer Type: 12 Marks (4 out of 6)

Ideal gas: Review of the kinetic model of an ideal gas; interpretation of temperature. Equipartition of energy; Specific heats of gases,

Real gas: Van der Waals model; equation of state, critical constants. **Transport Phenomena:** Mean free path, transport of momentum (viscosity), of energy (thermal conduction) and matter (diffusion).

Joule-Thomson and adiabatic cooling: Joule-Thomson expansion; Joule expansion of an ideal gas; cooling in J-T expansion, adiabatic expansion of an ideal gas, principles of regenerative and cascade cooling, liquefaction of gases.

The laws of thermodynamics:, Carnot engine and its efficiency, Carnot's theorem, the second law of thermodynamics. Entropy as a thermodynamic variable; reversible and irreversible processes. Principle of increase of entropy. Thermodynamic scale of temperature; its identity with perfect gas scale, impossibility of attaining the absolute zero (third law).

Thermodynamic relationships: Maxwell's equations; application to Clausius-Clapeyron equation and Joule-Thomson effect. Thermodynamic potentials: Relation to thermodynamic variables;

Black body radiation: Stefan-Boltzmann law, Wien's displacement law. Rayleigh-Jeans law, Planck's hypothesis, mean energy of an oscillator and Planck's law

Reference Books:

1. Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.
2. A Treatise on Heat, Meghnad Saha, and B.N.Srivastava, 1958, Indian Press
3. Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw-Hill
4. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
5. Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa.

PHYSICS LAB- LAB C III (2 Credits) FM: 25

1. To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus.
2. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee's disc method.
3. To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT).
4. To study the variation of Thermo-Emf of a Thermocouple with Difference of Temperature of its Two Junctions.
5. To calibrate a thermocouple to measure temperature in a specified Range using (1) Null Method and to determine Neutral Temperature.
6. Determination of Stefan's constant.
7. Verification of Planks radiation formulae.

PHYSICS-C IV: CURRNT ELECTRICITY
(Credits: Theory-04) Theory: 60 Lectures

Mid Semester: 15 **End Semester: 60** **Full Marks: 75**

Short Answer Type: 4 Marks (3 out of 5) & Long Answer Type: 12 Marks (4 out of 6)

Magnetic Field: Magnetic force between current elements and definition of Magnetic Field **B**. Biot-Savart's Law and its simple applications: straight wire and circular loop. Current Loop as a Magnetic Dipole and its Dipole Moment (Analogy with Electric Dipole). Ampere's Circuital Law and its application to (1) Solenoid and (2) Toroid. Properties of **B**: curl and divergence. Vector Potential. Magnetic Force on (1) on point charge (2) on current carrying wire (3) between current elements.

DC circuits: growth and decay of current in CR and LR circuits, Growth and decay of currents in Series LCR circuit.

AC Circuits: AC Circuits: Kirchhoff's laws for AC circuits. Complex Reactance and Impedance. Series LCR Circuit: (1) Resonance, (2) Power Dissipation and (3) Quality Factor, and (4) Band Width. Parallel LCR Circuit.

Ballistic Galvanometer: Torque on a current Loop. Ballistic Galvanometer: Current and Charge Sensitivity. Logarithmic damping.

AC bridges; Anderson's, Owen's, Schering and Carey-Foster's bridges with their vector diagrams.

Network theorems: 2-port network and its T and π representations, T and π equivalence, h- parameters representations, Thevenin, Nortion, Superposition, Reciprocity and Maximum power transfer theorems, Miller theorem.

Reference Books:

- Electricity, Tayal D. C.
- Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw
- Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education
- Electricity and Magnetism, Chattopadhyaya and Rakshit
- Electricity and Magnetism, Mahajan and Rangwala
- Electricity and Magnetism, K. K. Tewary.

PHYSICS LAB- LAB C IV (2 Credits) FM: 25

1. To verify the Thevenin and Norton theorems.
2. To verify the Superposition and Maximum power transfer theorems.
3. To determine self inductance of a coil by Anderson's bridge.
4. To determine an unknown Low Resistance using Potentiometer.
5. To compare capacitances using De'Sauty's bridge.
6. Determination of constants of a ballistic galvanometer.
7. Determination of figure of merit of a moving coil galvanometer.

SEMESTER III

PHYSICS-C V: MATHEMATICAL PHYSICS-II

(Credits: Theory-04) Theory: 60 Lectures

Mid Semester: 15 End Semester: 60 Full Marks: 75

Short Answer Type: 4 Marks (3 out of 5) & Long Answer Type: 12 Marks (4 out of 6)

Frobenius Method and Special Functions: Frobenius method and its applications to differential equations. Legendre, Bessel, Hermite and Confluent Hypergeometric Differential Equations. Properties of Legendre Polynomials: Rodrigues Formula, Generating Function, Orthogonality. Simple recurrence relations. Expansion of function in a series of Legendre Polynomials. Bessel Functions of the First Kind: Generating Function, simple recurrence relations. Zeros of Bessel Functions and Orthogonality.

Some Special Integrals: Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. Error Function (Probability Integral).

Partial Differential Equations: Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular and spherical symmetry. Wave equation and its solution for vibrational modes of a stretched string.

Reference Books:

- Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.
- Fourier Analysis by M.R. Spiegel, 2004, Tata McGraw-Hill.
- Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.
- Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.
- Partial Differential Equations for Scientists & Engineers, S.J. Farlow, 1993, Dover Pub.
- Mathematical methods for Scientists & Engineers, D.A. McQuarrie, 2003, Viva Books

PHYSICS LAB- LAB C V (2 Credits) FM: 25

Topics	Description with Applications
Introduction to Numerical computation software Scilab	Introduction to Scilab, Advantages and disadvantages, Scilab environment, Command window, Figure window, Edit window, Variables and arrays, Initialising variables in Scilab, Multidimensional arrays, Subarray, Special values, Displaying output data, data file, Scalar and array operations, Hierarchy of operations, Built in Scilab functions, Introduction to plotting, 2D and 3D plotting, Branching Statements and program design, Relational & logical operators, the while loop, for loop, details of loop operations, break & continue statements, nested loops, logical arrays and vectorization. User defined functions, Introduction to Scilab functions, variable passing in Scilab, optional arguments, preserving data between calls to a function, Complex and Character data, string function, Multidimensional arrays an introduction to Scilab file processing, file opening and closing, Binary I/o functions, comparing binary and formatted functions,

	Numerical methods and developing the skills of writing a program.
Curve fitting, Least square fit, Goodness of fit, standard deviation	Ohms law to calculate R, Hooke's law to calculate spring constant
Solution of Linear system of equations by Gauss elimination method and Gauss Seidal method. Diagonalization of matrices, Inverse of a matrix, Eigen vectors, eigen values problems	Solution of mesh equations of electric circuits (3 meshes) Solution of coupled spring mass systems (3 masses)
Solution of ODE First order Differential equation Euler, modified Euler and Runge-Kutta second order methods Second order differential equation Fixed difference method	First order differential equation, Radioactive decay, Current in RC, LC circuits with DC source, Newton's law of cooling, Classical equations of motion, Second order Differential Equation, Harmonic oscillator (no friction), Damped Harmonic oscillator, Over damped, Critical damped, Oscillatory, Forced Harmonic oscillator, Transient and, Steady state solution Apply above to LCR circuits also.

PHYSICS-C VI: ELECROSTATICS AND MAGNETISM

(Credits: Theory-04) Theory: 60 Lectures

Mid Semester: 15 End Semester: 60 Full Marks: 75

Short Answer Type: 4 Marks (3 out of 5) & Long Answer Type: 12 Marks (4 out of 6)

Electric Field and Electric Potential

Electric field: Electric field lines. Electric flux. Gauss' Law with applications to charge distributions with spherical, cylindrical and planar symmetry.

Conservative nature of Electrostatic Field. Electrostatic Potential. Laplace's and Poisson Equations and their solutions . The Uniqueness Theorem. Potential and Electric Field due to a dipole. Force and Torque on a dipole.

Electrostatic energy of system of charges. Conductors in an electrostatic Field. Surface charge and force on a conductor. Parallel-plate capacitor. Capacitance of an isolated spherical conductor.

Separation of variable: rectangular Cartesian coordinate, spherical coordinate

Method of images: point charge close to a grounded conducting plane, point charge near a grounded conducting sphere;

Multipole expansion ; Multipole expansion of the electrostatic potential, monopole, dipole, quadrupole approximations at large distances,

Dielectric Properties of Matter: Electric Field in matter. Polarization, Polarization Charges. Electrical Susceptibility and Dielectric Constant. Displacement vector **D**. Relations between **E**, **P** and **D**. Gauss' Law in dielectrics. Claussius-Mossotti equation, Langevin- Debye equation

Magnetic Properties of Matter: Magnetization vector (**M).** Magnetic Intensity (**H).** Magnetic Susceptibility and permeability. Relation between **B, H, M**. Ferromagnetism. B-H curve and hysteresis. Boundary conditions at the interface of two media and application to a sphere of magnetic material placed in a uniform magnetic induction, Damagnetizing factor. Origin of magnetic moment. Langevin's theory of Diamagnetism and Paramagnetism.

Reference Books:

- Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education
- Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.
- Feynman Lectures Vol.2, R.P.Feynman, R.B.Leighton, M. Sands, 2008, Pearson Education
- Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press.
- Electricity and Magnetism, J.H.Fewkes & J.Yarwood. Vol. I, 1991, Oxford Univ. Press.

PHYSICS LAB- LAB C VI (2 Credits) FM: 25

1. Measurement of field strength B and its variation in a solenoid
2. Measurement of susceptibility of paramagnetic solution (Quinck`s Tube Method)
3. To measure the Magnetic susceptibility of Solids.
4. Verification of Curie-Weiss Law for a ferroelectric material.
5. To draw the BH curve of Fe using Solenoid & determine energy loss from Hysteresis.

PHYSICS-C VII: WAVE AND ACOUSTICS
(Credits: Theory-04) Theory: 60 Lectures

Mid Semester: 15 End Semester: 60 Full Marks: 75

Short Answer Type: 4 Marks (3 out of 5) & Long Answer Type: 12 Marks (4 out of 6)

Fourier Series: Periodic functions. Orthogonality of sine and cosine functions, Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Complex representation of Fourier series. Even and odd functions and their Fourier expansions. Application. Analysis of saw-tooth and square wave.

Oscillations: Simple Harmonic Oscillations. Differential equation of SHM and its solution. Kinetic energy, potential energy, total energy and their time-average values. Damped oscillation. Forced oscillations: Transient and steady states; Resonance, sharpness of resonance;

Wave Motion: Plane and Spherical Waves. Longitudinal and Transverse Waves. Plane Progressive (Travelling) Waves. Wave Equation. Particle and Wave Velocities. Differential Equation. Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave.

Velocity of Waves: Velocity of Transverse Vibrations of Stretched Strings. Velocity of Longitudinal Waves in a Fluid in a Pipe. Newton's Formula for Velocity of Sound. Laplace's Correction.

Acoustics: The acoustics of halls, Reverberation period, Sabine's formula. Acoustic defects in a hall and their correction.

Reference Books

- Waves and Acoustics, P. K. Chakraborty and Satyabrata Chowdhury.
- The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
- The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.
- Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.

PHYSICS LAB- LAB C VII (2 Credits) FM: 25

1. Verification of laws of transverse vibration in a string using sonometer.
2. Determination of speed of sound using Kundt's tube.
3. To determine the frequency of electrically maintained tuning fork by Melde's experiment.
4. To determine the Density of material of wire using sonometer.
5. To determine the Velocity of sound by resonance column.

SEMESTER IV

PHYSICS-C VIII: OPTICS
(Credits: Theory-04) Theory: 60 Lectures

Mid Semester: 15 End Semester: 60 Full Marks: 75

Short Answer Type: 4 Marks (3 out of 5) & Long Answer Type: 12 Marks (4 out of 6)

Wave Optics: Electromagnetic nature of light. Definition and properties of wave front. Huygens Principle.

Interference: Division of amplitude and wavefront. Young's double slit experiment. Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination; Fringes of equal thickness. Newton's Rings: Measurement of wavelength and refractive index.

Interferometer: Michelson Interferometer, Idea of formation of fringes, Determination of Wavelength, Wavelength Difference. Fabry-Perot interferometer – theory and applications.

Fraunhofer diffraction: Single slit. Circular aperture, Resolving Power of a telescope.. N slits. Diffraction grating. Resolving power of grating.

Fresnel Diffraction: Fresnel's Assumptions. Fresnel's Half-Period Zones for Plane Wave. Explanation of Rectilinear Propagation of Light. Theory of a Zone Plate: Multiple Foci of a Zone Plate, Fresnel diffraction pattern of a straight edge, a slit and a wire.

Polarization: Description of Linear, Circular and Elliptical Polarization. Double Refraction. Nicol Prism. Ordinary & extraordinary refractive indices. Production & detection of Plane, Circularly and Elliptically Polarized Light. Phase Retardation Plates: Quarter-Wave and Half-Wave Plates.

Rotatory Polarization: Optical Rotation. Biot's Laws for Rotatory Polarization. Calculation of angle of rotation. Specific rotation. Laurent's half-shade polarimeter.

Reference Books

- Introduction to Geometrical and Physical Optics, B. K. Mathur.
- Geometrical and Physical Optics, P. K. Chakraborty.
- Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill
- Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press.
- Optics, Ajoy Ghatak, 2008, Tata McGraw Hill

PHYSICS LAB- LAB C VIII (2 Credits) FM: 25

1. Familiarization with: Schuster`s focusing; determination of angle of prism.
2. To determine refractive index of the Material of a prism using sodium source.
3. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
4. To determine wavelength of sodium light using Fresnel Biprism.
5. To determine wavelength of sodium light using Newton's Rings.
6. To determine the thickness of a thin paper by measuring the width of the interference fringes produced by a wedge-shaped Film.
7. To determine wavelength of (1) Na source and (2) spectral lines of Hg source using plane diffraction grating.
8. To determine dispersive power and resolving power of a plane diffraction grating.

PHYSICS-C IX: QUANTUM MECHANICS AND APPLICATIONS

(Credits: Theory-04) Theory: 60 Lectures

Mid Semester: 15 End Semester: 60 Full Marks: 75

Short Answer Type: 4 Marks (3 out of 5) & Long Answer Type: 12 Marks (4 out of 6)

Schrodinger theory: Inadequcy of classical mechanics, Origin of old Quantum theory, Discretness of energy: Franck and Hertz experiment, Wave – particle duality of matter and radiation (Photoelectric effect, Compton effect, Davisson and Germer experiment), Wave function and its physical meaning, Wave packets, Schrodinger time – independent and time – dependent equations, Concept of stationary states, Probabilty density and probability current density.

Operators: Eigenvalues and eigenfunction; linear operators, product of two operators, commuting and noncommuting operators, simulataneous eigenfunctions, orthogonal functions. Hermitian operators, their eigenvalues, Hermitian adjoint operators, expectation values of an operator.

One-dimensional problems: Rectangular potential barrier, Square well potential of finite and infinite depth, Particle in a rectangular box.

Heisenberg's uncertainity principle: Derivation of uncertainity relation using Schawrtz inequality and simple applications of uncertainity principle, expectation value of Time derivative of operators, Ehrenfest theorem.

Application to 1-D Problem: Simple harmonic oscillator, eigenfunctions and eigenvalues of the ground state and excited states; zero-point energy. Orthogonality *of* wave functions. Rigid rotator.

Reference Books:

- Introduction to Quantum mechanics, Nikhil Ranjan Roy, 2016, Vikash Publishing House Pvt. Ltd.
- A Text book of Quantum Mechanics, P.M.Mathews and K.Venkatesan, 2nd Ed., 2010, McGraw Hill
- Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.
- Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
- Quantum Mechanics, G. Aruldhas, 2nd Edn. 2002, PHI Learning of India.
- Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.
- Quantum Mechanics: Foundations & Applications, Arno Bohm, 3rd Edn., 1993, Springer

PHYSICS LAB- LAB C IX (2 Credits) FM: 25

Use C/C++/Scilab for solving the following problems based on Quantum Mechanics like

1. Solve the s-wave Schrodinger equation for the ground state and the first excited state of the hydrogen atom:

$d^2y/dr^2 = A(r)u(r)$, $A(r) = 2m/h^2 \times [V(r) - E]$ where $V(r) = -e^2/r$

Here, m is the reduced mass of the electron. Obtain the energy eigenvalues and plot the corresponding wavefunctions. Remember that the ground state energy of the hydrogen atom is ≈ -13.6 eV. Take e = 3.795 $(eVÅ)^{1/2}$, ħc = 1973 (eVÅ) and m = 0.511x10^6 eV/c^2.

2. Solve the s-wave radial Schrodinger equation for an atom:

$d^2y/dr^2 = A(r)u(r)$, $A(r) = 2m/h^2 * [V(r) - E]$

where m is the reduced mass of the system (which can be chosen to be the mass of an electron), for the screened coulomb potential $V(r) = -e^2/r \times (e^{-r/a})$

Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wavefunction. Take e = 3.795 $(eVÅ)^{1/2}$, m = 0.511x10^6 eV/c^2, and a = 3 Å, 5 Å, 7 Å. In these units ħc = 1973 (eVÅ). The ground state energy is expected to be above -12 eV in all three cases.

3. Solve the s-wave radial Schrodinger equation for a particle of mass m:

$d^2y/dr^2 = A(r)u(r)$, $A(r) = 2m/h^2 \times [V(r) - E]$

For the anharmonic oscillator potential V(r) = ½ kr^2 + 1/3br^3 for the ground state energy (in MeV) of particle to an accuracy of three significant digits. Also, plot the corresponding wave function. Choose m = 940 MeV/c^2, k = 100 MeV fm^{-2}, b = 0, 10, 30 MeV fm^{-3}. In these units, cħ = 197.3 MeV fm. The ground state energy I expected to lie between 90 and 110 MeV for all three cases.

4. Solve the s-wave radial Schrodinger equation for the vibrations of hydrogen molecule:

$d^2y/dr^2 = A(r)u(r)$, $A(r) = 2\mu/h^2 \times [V(r) - E]$
Where μ is the reduced mass of the two-atom system for the Morse potential
$(r) = D\ (e^{-2\alpha r'} - e^{-\alpha r'})$, r' = $(r-r_0)/r$
Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of three significant digits. Also plot the corresponding wave function.
Take: m = 940x106eV/C^2, D = 0.755501 eV, α = 1.44, r_o = 0.131349 Å.

Laboratory based experiments:

5. Study of Electron spin resonance- determine magnetic field as a function of the resonance frequency
6. Study of Zeeman effect: with external magnetic field; Hyperfine splitting
7. To show the tunneling effect in tunnel diode using I-V characteristics.
8. Quantum efficiency of CCDs
9. Verification of plcank's uncertainly principle
10. Determination of wavelength of an electron in ground state of hydrogen and establish de-Broglie relation.

PHYSICS-C X: ELECTROMAGNETIC THEORY

(Credits: Theory-04) Theory: 60 Lectures

Mid Semester: 15 End Semester: 60 Full Marks: 75

Short Answer Type: 4 Marks (3 out of 5) & Long Answer Type: 12 Marks (4 out of 6)

Maxwell Equations: Review of Maxwell's equations. Displacement Current. Boundary Conditions at Interface between Different Media. Wave Equations. Plane Waves in Dielectric Media. Poynting vector and Poynting Theorem. Electromagnetic (EM) Energy Density.

EM Wave Propagation in dielectric Media: Plane EM waves through vacuum and isotropic dielectric medium, transverse nature of plane EM waves, refractive index and dielectric constant, Boundary conditions at a plane interface between two media. Reflection & Refraction of plane waves at plane interface between two dielectric media-Laws of Reflection & Refraction. Fresnel's Formulae for perpendicular & parallel polarization cases, Brewster's law. Reflection & Transmission coefficients. Total internal reflection, evanescent waves.

EM Wave in conducting Media: Propagation through conducting media, relaxation time, skin depth. reflection at and transmission through a conducting surface Wave propagation through dilute plasma, electrical conductivity of ionized gases, plasma frequency, refractive index, skin depth. Electromagnetic theory of dispersion.

Electromagnetic potentials: Magnetic vector potential **A** and scalar potential φ. Lorentz gauge, Coulomb's gauge. Maxwell's equation in terms of potentials. Gauge invariance,

Radiation from accelerated charge: Retarded potential, Lenard- Weichart potential, electric dipole radiation, magnetic dipole radiation, Radiation from an accelerated charged particle along and perpendicular to the direction of motion.

Reference Books:

1. Electromagnetic Theory, Chopra and Agarwal.
2. Electromagnetics, B. B. Laud.
3. Electromagnetic Theory,, Satya Prakash
4. Electromagnetic Theory, Gupta and Kumar
5. Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.
6. Introduction to Electromagnetic Theory, T.L. Chow, 2006, Jones & Bartlett Learning

PHYSICS LAB- LAB C X (2 Credits) FM: 25

1. To verify the law of Malus for plane polarized light.
2. To determine the specific rotation of sugar solution using Polarimeter.
3. To analyze elliptically polarized Light by using a Babinet's compensator.
4. To determine the refractive Index of (1) glass and (2) a liquid by total internal reflection using a Gaussian eyepiece.
5. To study the polarization of light by reflection and determine the polarizing angle for air-glass interface.
6. To determine the Boltzmann constant using V-I characteristics of PN junction diode.

SEMESTER V

PHYSICS-C XI: RELATIVITY, ATOMIC AND MOLECULAR PHYSICS

(Credits: Theory-04) Theory: 60 Lectures

Mid Semester: 15 End Semester: 60 Full Marks: 75

Short Answer Type: 4 Marks (3 out of 5) & Long Answer Type: 12 Marks (4 out of 6)

The Lorentz transformations: Galilean transformations;, Michelson-Morley experiment. Einstein's basic postulates and derivation of Lorentz transformations; length contraction, simultaneity, synchronization and time dilation, Einstein's velocity addition rule, Doppler effect in light, aberration of light.

Relativistic dynamics*:* Variation of mass with velocity, mass-energy equivalence, relativistic formulae for momentum and energy.

The structure of space-time*:* Four-vectors; invariance of an interval, time-like, space-like and light-like intervals, Minkowski world.

Relativistic electrodynamics: Electric field of a point charge in uniform motion; transverse components, magnetism as a relativistic phenomenon. Invariance of Maxwell's equations

Atomic Physics: Bohr's theory of Hydrogen atom. Bohr- Somerfield theory, statement of selection rule for atomic transition and their applications to Na atom. vector atom model, L-S and j-j couplings. Normal and anomalous Zeeman effect using vector model of atom.

Molecular Physics: Rotational Spectra, molecules as rigid and non rigid rotator, Vibrational spectra, diatomic molecule as a harmonic and anharmonic oscillator, molecules as a vibrating rotator.

PHYSICS LAB- LAB C XI (2 Credits) FM: 25

1. Measurement of Planck's constant using black body radiation and photo-detector
2. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light.
3. To determine work function of material of filament of directly heated vacuum diode.
4. To determine the first excitation energy of Argon.
5. To determine the Planck's constant using LEDs of at least 4 different colours.
6. To show the tunneling effect in tunnel diode using I-V characteristics.
7. To determine the wavelength of laser source using diffraction of single slit.
8. To determine the wavelength of laser source using diffraction of double slits.
9. To determine (1) wavelength and (2) angular spread of He-Ne laser using plane diffraction grating

PHYSICS-C XII:ANALOG ELECTRONICS AND APPLICATION

(Credits: Theory-04) Theory: 60 Lectures

Mid Semester: 15 End Semester: 60 Full Marks: 75

Short Answer Type: 4 Marks (3 out of 5) & Long Answer Type: 12 Marks (4 out of 6)

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Semiconductor Physics : Semiconductor, Conduction in semiconductors, Energy bands and conduction, conductivity, mobility and resistivity, Doping, Diffusion, p-n junction, biasing, depletion layer capacitance, Diode equation, Zener diode.

Diode and wave shaping circuits: Diode as a circuit element, Diode parameters, Temperature effects, Diode model, Diode as a switch, Diode switching parameters, effects, Diode model, Diode rectifier circuits (half and full wave), Ripple factor, Smoothing RC filters, Limitation of diode as a rectifier, Clipping and clamping circuits. Zener diode, characteristics and Zener diode regulated power supply.

BJT-based circuits: Bipolar junction transistor structure, modes of operation, dc characteristics and dc parameters, Load line and Q-point, stabilization, Small -singal equivalent models (low and high frequencies).

FET-based circuits: Junction field -effect transistor structure, modes of operation, dc characteristics and dc parameters, Load line and Q-point, Biasing circuits (voltage divider and self bias) and Q-point stabilisation, Small -signal equivalent models (low and high frequencies).

Ampilifiers: Features of amplifier configurations, Analysis and design of RC coupled voltage amplifier using BJT (CE mode) and JFET (Cs mode), Frequency response, Concept of Bode plots, Classes of amplifiers, Push-pull class A and class B-amplifier.

Feedback AND OSCILLATION: Feedback concept and feedback equation, Positive and negative feedback, Characteristics of negative feedback, Criteria of oscillations, RC phase shift oscillator, RF oscillators (Hartley and Colpitt), Astable multivibrator using BJT.

PHYSICS LAB- LAB C XII (2 Credits) FM: 25

1. To study V-I characteristics of PN junction diode, and Light emitting diode.
2. To study the V-I characteristics of a Zener diode and its use as voltage regulator.
3. Study of V-I & power curves of solar cells, and find maximum power point & efficiency.
4. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
5. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.
6. To study the frequency response of voltage gain of a RC-coupled transistor amplifier.
7. To design a phase shift oscillator of given specifications using BJT.
8. To design inverting amplifier using Op-amp (741,351) and study its frequency response
9. To design non-inverting amplifier using Op-amp 741 & study its frequency response
10. To investigate the use of an op-amp as an Integrator and Differentiator.

SEMESTER VI

PHYSICS-C XIII: SOLID STATE PHYSICS
(Credits: Theory-04) Theory: 60 Lectures

Mid Semester: 15 End Semester: 60 Full Marks: 75

Short Answer Type: 4 Marks (3 out of 5) & Long Answer Type: 12 Marks (4 out of 6)

Crystal geometry: Crystal lattice; crystal planes and Miller indices, unit cells. Typical crystal structures;. Symmetry elements; rotation, inversion and reflection, point groups and crystal classes,.

Crystallography: Diffraction of X-rays by a crystal lattice. Laue's formulation of X-ray diffraction; reciprocal lattice, Bragg's equation, , Laue spots.

Types of binding in solids (Qualitative idea only): Covalent binding and its origin, Ionic binding, energy of binding, transition between covalent and ionic binding, metallic binding, Van der Waals binding, hydrogen bond.

Lattice Vibrations: Dynamics of a chain of atoms, chain of two types of atoms, optical and acoustic modes, interaction of light with ionic crystals, Einstein's and Debye's theories of specific heats of solids.

Conduction in metals: Drude's theory, Electrical conductivity, Hall effect and magnetoresistance, thermal conductivity of metals, thermal properties of free-electron gas, Sommerfeld's theory of conduction in metals.

Elementary band theory: Periodic potential and Bloach theorem, Kroning- Penny model, band gap, Effective mass, Band structure of metals, insulators and semiconductors. Conductivity of Semiconductor, mobility.

Superconductivity: Occurrence, Critical temperature and critical magnetic field, Meissner effect, Superconductivity- Type I, Type II.

Reference Books:

- Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.
- Elements of Solid State Physics, J.P. Srivastava, 2nd Edition, 2006, Prentice-Hall of India
- Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill
- Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning
- Solid-state Physics, H. Ibach and H. Luth, 2009, Springer
- Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India

PHYSICS LAB- LAB C XIII (2 Credits) FM: 25

1. To determine the Hall coefficient of a semiconductor sample.
2. To measure the resistivity of a semiconductor (Ge) with temperature by four-probe method (room temperature to 150^0C) and to determine its band gap.
3. To measure the Dielectric Constant of a dielectric Materials with frequency
4. To determine the refractive index of a dielectric layer using SPR
5. To determine the value of e/m by using a Bar magnet.

PHYSICS-C XIV: STATISTICAL MECHANICS

(Credits: Theory-04) Theory: 60 Lectures

Mid Semester: 15 End Semester: 60 Full Marks: 75

Short Answer Type: 4 Marks (3 out of 5) & Long Answer Type: 12 Marks (4 out of 6)

Classical Statistics: Macrostate & Microstate, Elementary Concept of Ensemble, Phase Space, Maxwell-Boltzmann Distribution Law, Partition Function, Thermodynamic Functions of an Ideal Gas, Gibbs Paradox, Sackur Tetrode equation, Law of Equipartition of Energy

Classical Theory of Radiation: Properties of Thermal Radiation. Blackbody Radiation. Kirchhoff's law. Stefan-Boltzmann law:. Wien's Displacement law. Wien's Distribution Law. Rayleigh-Jean's Law.

Bose-Einstein Statistics: B-E distribution law, Thermodynamic functions of a Degenerate Bose Gas, Bose Einstein condensation, properties of liquid He .

Fermi-Dirac Statistics: Fermi-Dirac Distribution Law, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals,

Reference Books:

• Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.
• Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill
• Statistical and Thermal Physics, S. Lokanathan and R.S. Gambhir. 1991, Prentice Hall
• Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.
• Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer
• An Introduction to Statistical Mechanics & Thermodynamics, R.H. Swendsen, 2012, Oxford Univ. Pres

PHYSICS LAB- LAB C XIV (2 Credits) FM: 25

Use C/C++/Scilab for solving the problems based on Statistical Mechanics like

1. Plot Planck's law for Black Body radiation and compare it with Wein's Law and Raleigh-Jeans Law at high temperature (room temperature) and low temperature.
2. Plot Specific Heat of Solids by comparing (a) Dulong-Petit law, (b) Einstein distribution function, (c) Debye distribution function for high temperature (room temperature) and low temperature and compare them for these two cases
3. Plot Maxwell-Boltzmann distribution function versus temperature.
4. Plot Fermi-Dirac distribution function versus temperature.
5. Plot Bose-Einstein distribution function versus temperature.

DISCIPLINE SPECIFIC ELECTIVE

PHYSICS-DSE I: MATHEMATICAL PHYSICS-III
(Credits: Theory-04) Theory: 60 Lectures
Mid Semester: 15 End Semester: 60 Full Marks: 75
Short Answer Type: 4 Marks (3 out of 5) & Long Answer Type: 12 Marks (4 out of 6)

Complex Analysis: Brief Revision of Complex Numbers and their Graphical Representation. Euler's formula, De Moivre's theorem, Roots of Complex Numbers. Functions of Complex Variables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions. Singular functions: poles, order of singularity, Integration of a function of a complex variable. Cauchy's Inequality. Cauchy's Integral formula. Simply and multiply connected region. Laurent and Taylor's expansion. Residues and Residue Theorem. Application in solving Definite Integrals.

Integrals Transforms:
Fourier Transforms: Fourier Integral theorem. Fourier Transform. Examples. Fourier transform of trigonometric, Gaussian, finite wave train & other functions. Representation of Dirac delta function as a Fourier Integral. Fourier transform of derivatives, Inverse Fourier transform, Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.).

Laplace Transforms: Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. LTs of Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Convolution Theorem. Inverse LT. Application of Laplace Transforms to Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits.

Reference Books:

- Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press
- Mathematics for Physicists, P. Dennery and A.Krzywicki, 1967, Dover Publications
- Complex Variables, A.S.Fokas & M.J.Ablowitz, 8th Ed., 2011, Cambridge Univ. Press
- Complex Variables and Applications, J.W. Brown & R.V. Churchill, 7th Ed. 2003, Tata McGraw-Hill
- First course in complex analysis with applications, D.G. Zill and P.D. Shanahan, 1940, Jones & Bartlett.
- Mathematical Physics, B. D. Gupta.
- Mathematical Physics, B. S. Rajput.
- Mathematical Physics, H. K. Dass.
- Mathematical methods in Physics, E. Butkov.
- Mathematical methods in Physics, Potter and Goldberg.

PHYSICS LAB- LAB DSE I (2 Credits) FM: 25

Scilab based simulations experiments based on Mathematical Physics problems like

1. Solve differential equations:

$\frac{dy}{dx} = e^{-x} \quad with \quad y = 0 \; for \; x = 0$

$\frac{dy}{dx} + e^{-x} y = x^2$

$\frac{d^2y}{dt^2} + 2\frac{dy}{dt} = -y$

$\frac{d^2y}{dt^2} + e^{-t}\frac{dy}{dt} = -y$

2. Dirac Delta Function:

Evaluate $\frac{1}{\sqrt{2\pi\sigma^2}} \int e^{\frac{-(x-2)^2}{2\sigma^2}} (x+3)dx,$ for $\boldsymbol{\sigma}$ = 1, 0.1, 0.01 and show it tends to 5.

3.Fourier Series:

Program to sum $\sum_{n=1}^{\infty} (0.2)^n$

Evaluate the Fourier coefficients of a given periodic function (square wave).

4. Frobenius method and Special functions:

$\int_{-1}^{+1} P_n(\mu) P_m(\mu) d\mu = \delta_{n,m}$

$Plot \quad P_n(x), \quad j_v(x)$

Show recursion relation.

5. Calculation of error for each data point of observations recorded in experiments done in previous semesters (choose any two).

6. Calculation of least square fitting manually without giving weightage to error. Confirmation of least square fitting of data through computer program.

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PHYSICS-DSE II: NUCLEAR AND PARTICLE PHYSICS

(Credits: Theory-04) Theory: 60 Lectures

Mid Semester: 15 End Semester: 60 Full Marks: 75

Short Answer Type: 4 Marks (3 out of 5) & Long Answer Type: 12 Marks (4 out of 6)

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Structure on nucleus; discovery of the nucleus, composition. Basic properties; charge, mass, size, spin, magnetic moment, electric quadrupole moment, binding energy, binding energy per necleon and its observed variation with mass number of the nucleus, semi empirical mass formulae, explanation of the binding energy curve. Liquid drop model of the nucleus.

Nuclear forces: two-nucleon system, deuteron problem, binding energy, nuclear potential well, pp and pn scattering experiments, meson theory of nuclear forces, e.g. Bartlett, Heisenberg, Majorana forces and potentials, mirror nuclei, nuclear energy levels, nuclear gamma rays.

Radioactivity: decay constant, half-life, mean life; Geiger-Nuttal law, Successive disintegration, secular and transient equilibrium, neutrino and antineutrino. basics of α-decay processes, theory of α-emission, Gamow factor

Detectors for charged particles; Ion chamber, Geiger-Muller counter, resolving time, Scintillation counter.

Accelerators: Need for accelerators; cyclotron, synchrocyclotron, variable energy cyclotron, phase stability.

Nuclear reactions; Rutherford's experiments of nuclear transmutation, conservation theorems, Q-value, threshold energy, cross-section of nuclear reactions. Concept of compound and direct Reaction, resonance reaction,

Artificial radioactivity: Nuclear fission, Neutron reactions, Fermi and transuranic elements, chain reaction, criticality, moderators.

Particle physics: Particle interactions; basic features, types of particles and its families. Symmetries and Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Concept of quark model.

Reference Books:

• Introductory nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
• Concepts of nuclear physics by Bernard L. Cohen. (Tata Mcgraw Hill, 1998).
• Introduction to the physics of nuclei & particles, R.A. Dunlap. (Thomson Asia, 2004).
• Introduction to High Energy Physics, D.H. Perkins, Cambridge Univ. Press
• Introduction to Elementary Particles, D. Griffith, John Wiley & Sons
• Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi
• Basic ideas and concepts in Nuclear Physics - An Introductory Approach by

PHYSICS LAB- LAB DSE II (2 Credits) FM: 25

1. Demonstration of presence of Static Electricity
2. Demonstration of phenomenon of Corona Discharge
3. To determine the plateau and optimal operating voltage of a Geiger-Müller
4. To determining the resolving (dead) time τ of a Geiger – Muller counter
5. DETERMINING THE EFFICIENCY OF A GEIGER-MULLER COUNTER
6. DETERMINING THE HALF LIFE OF A RADIO ISOTOPE USING GEIGER – MULLER COUNTER
7. Experiment with Alpha Scintillation Counter

PHYSICS-DSE III: CLASSICAL MECHANICS

(Credits: Theory-04) Theory: 60 Lectures

Mid Semester: 15 End Semester: 60 Full Marks: 75

Short Answer Type: 4 Marks (3 out of 5) & Long Answer Type: 12 Marks (4 out of 6)

Lagrangian : Generalised coordinates and velocities, Constraints, principle of virtual work Calculus of variation, Lagrange's equation, Applications to simple systems such as coupled oscillators. Cyclic coordinates, symmetries and conservation laws. Advantages of Lagrangian: electromechanical Analogies.

Hamiltonian: Canonical momenta & Hamiltonian. Hamilton's equations of motion. Principle of least action. Applications: Hamiltonian for a harmonic oscillator, compound pendulum. Canonical transformation, Poisson Brackets, Hamilton-Jacobi theory, solution of harmonic oscillator using Hamilton-Jacobi theory.

Motion under central force: two body problem, reduction to the equivalent one body problem, Differential equation for the orbit, Condition for stable circular orbit , keplar's law, center of mass and lab frame of reference, Rutherford scattering.

Rigid body dynamics: moment of inertia and product of inertia, rotating top, precession and nutation, Euler angles

Rotating frame of reference: rotating frame of reference, centrifugal force, corlisis force and its effects.

Reference Books:

1. Intoduction to Classical mechanics, Nikhil Ranjan Roy, 2016, Vikash Pub House Pvt. Ltd.
2. Classical Mechanics, H.Goldstein, C.P. Poole, J.L. Safko, 3rd Edn. 2002,Pearson Education.
3. Mechanics, L. D. Landau and E. M. Lifshitz, 1976, Pergamon.
4. The Classical Theory of Fields, L.D Landau, E.M Lifshitz, 4th Edn., 2003, Elsevier.
5. Introduction to Electrodynamics, D.J. Griffiths, 2012, Pearson Education.
6. Classical Mechanics: An introduction, Dieter Strauch, 2009, Springer.

PHYSICS LAB- LAB DSE III (2 Credits) FM: 25

1. To determine the acceleration due to gravity by object drop method
2. To determine the acceleration due to gravity by Simple Pendulum
3. To determine the acceleration due to gravity with the help of Compound Pendulum
4. To determine the radius of gyration and moment of inertia of a Compound Pendulum about its centre of gravity
5. Determination of the moment of inertia of given body using inertia table.
6. Determination of the moment of inertia of given body using inertia table using lamp and scale arrangement.
7. Prove the perpendicular axis theorem of moment of inertia using inertia table
8. Study two normal modes of Coupled Oscillator and record the oscillations to determine the time period for both the modes.
9. Record the oscillations for Resonance Mode. To determine the Coupled Time Period and Beat Time Period of the oscillation also compare the experimental values of time period with calculated values?
10. To determine the Spring Constant with the help of Coupled Oscillator

PHYSICS-DSE IV: DIGITAL SYSTEMS AND APPLICATIONS

(Credits: Theory-04) Theory: 60 Lectures

Mid Semester: 15 End Semester: 60 Full Marks: 75

Short Answer Type: 4 Marks (3 out of 5) & Long Answer Type: 12 Marks (4 out of 6)

Digital Circuits: Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. AND, OR and NOT Gates. NAND and NOR Gates as Universal Gates. XOR and XNOR Gates.

Boolean algebra: De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Idea of Minterms and Maxterms. Conversion of a Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map.

Data processing circuits: Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders.

Arithmetic Circuits: Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders, 4-bit binary Adder.

Sequential Circuits: SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop.

Timers: IC 555: block diagram and applications: Astable multivibrator and Monostable multivibrator.

Shift registers: Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in-Parallel-out Shift Registers (only up to 4 bits).

Counters (4 bits): Ring Counter. Asynchronous counters, Decade Counter. Synchronous Counter.

Reference Books:

1. Digital Principles and Applications, A.P. Malvino, D.P.Leach and Saha, 7th Ed., 2011, Tata McGraw
2. Fundamentals of Digital Circuits, Anand Kumar, 2nd Edn, 2009, PHI Learning Pvt. Ltd.
3. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
4. Digital Systems: Principles & Applications, R.J.Tocci, N.S.Widmer, 2001, PHI Learning
5. Logic circuit design, Shimon P. Vingron, 2012, Springer.
6. Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
7. Digital Electronics, Floyd.
8. Digital Computer Electronics, Malvino

PHYSICS LAB- LAB DSE IV (2 Credits) FM: 25

1. To design a switch (NOT gate) using a transistor.
2. To verify and design AND, OR, NOT and XOR gates using NAND gates.
3. To design a combinational logic system for a specified Truth Table.
4. To convert a Boolean expression into logic circuit and design it using logic gate ICs.
5. To minimize a given logic circuit.
6. Half Adder, Full Adder and 4-bit binary Adder.
7. Half Adder and Full Adder Truth table verification using I.C.
8. . To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.
9. To design an astable multivibrator of given specifications using 555 Timer.
10. To design a monostable multivibrator of given specifications using 555 Timer.

PHYSICS-DSE V: EXPERIMENTAL TECHNIQUES

(Credits: Theory-04) Theory: 60 Lectures

Mid Semester: 15 End Semester: 60 Full Marks: 75

Short Answer Type: 4 Marks (3 out of 5) & Long Answer Type: 12 Marks (4 out of 6)

Measurements: Accuracy and precision. Significant figures. Error and uncertainty analysis. Types of errors: Gross error, systematic error, random error. Statistical analysis of data (Arithmetic mean, deviation from mean, average deviation, standard deviation, chi-square) and curve fitting. Guassian distribution.

Signals and Systems: Periodic and aperiodic signals. Impulse response, transfer function and frequency response of first and second order systems. Fluctuations and Noise in measurement system. S/N ratio and Noise figure. Noise in frequency domain. Sources of Noise: Inherent fluctuations, Thermal noise, Shot noise, 1/f noise

Shielding and Grounding: Methods of safety grounding. Energy coupling. Grounding. Shielding: Electrostatic shielding. Electromagnetic Interference.

Transducers & industrial instrumentation (working principle, efficiency, applications): Static and dynamic characteristics of measurement Systems. Generalized performance of systems, Zero order first order, second order and higher order systems. Electrical, Thermal and Mechanical systems. Calibration. Transducers and sensors. Characteristics of Transducers. Transducers as electrical element and their signal conditioning. Temperature transducers: RTD, Thermistor, Thermocouples, Semiconductor type temperature sensors (AD590, LM35, LM75). Sinear Position transducer: Strain gauge, Linear variable differential transformer (LVDT), Capacitance change transducers. Radiation Sensors: Principle of Gas filled detector, ionization chamber, scintillation detector.

Digital Multimeter: Comparison of analog and digital instruments. Block diagram of digital multimeter, principle of measurement of I, V, C. Accuracy and resolution of measurement.

Vacuum Systems: Characteristics of vacuum: Gas law, Mean free path. Application of vacuum. Vacuum system- Chamber, Mechanical pumps, Diffusion pump & Turbo Modular pump, Pumping speed, Pressure gauges (Pirani, Penning, ionization).

Reference Books:

• Measurement, Instrumentation and Experiment Design in Physics and Engineering, M. Sayer and A. Mansingh, PHI Learning Pvt. Ltd.
• Experimental Methods for Engineers, J.P. Holman, McGraw Hill
• Introduction to Measurements and Instrumentation, A.K. Ghosh, 3rd Edition, PHI Learning Pvt. Ltd.
• Transducers and Instrumentation, D.V.S. Murty, 2nd Edition, PHI Learning Pvt. Ltd.
• Instrumentation Devices and Systems, C.S. Rangan, G.R. Sarma, V.S.V. Mani, Tata McGraw Hill
• Principles of Electronic Instrumentation, D. Patranabis, PHI Learning Pvt. Ltd.
• Electronic circuits: Handbook of design & applications, U.Tietze, Ch.Schenk, Springer

PHYSICS LAB- LAB DSE V (2 Credits) FM: 25

1. Determine output characteristics of a LVDT & measure displacement using LVDT
2. Measurement of Strain using Strain Gauge.
3. Measurement of level using capacitive transducer.
4. To study the characteristics of a Thermostat and determine its parameters.
5. Study of distance measurement using ultrasonic transducer.
6. Calibrate Semiconductor type temperature sensor (AD590, LM35, or LM75)
7. Comparison of pickup of noise in cables of different types (co-axial, single shielded, double shielded, without shielding) of 2m length, understanding of importance of grounding using function generator of mV level & an oscilloscope.
8. To design and study the Sample and Hold Circuit.
9. Design and analyze the Clippers and Clampers circuits using junction diode
10. To plot the frequency response of a microphone.
11. To measure Q of a coil and influence of frequency, using a Q-meter.

PHYSICS-DSE VI: NANO SCIENCE & TECHNOLOGY

(Credits: Theory-04) Theory: 60 Lectures

Mid Semester: 15 End Semester: 60 Full Marks: 75

Short Answer Type: 4 Marks (3 out of 5) & Long Answer Type: 12 Marks (4 out of 6)

NANOSCALE SYSTEMS: Length, energy, and time scales - Quantum confinement of electrons in semiconductor nanostructures: Quantum confinement in 3D, 2D, 1D and zero dimensional structures - Size effect and properties of nanostructures- Landauer-Buttiker formalism for conduction in confined geometries - Top down and Bottom up approach.

QUANTUM DOTS: Excitons and excitonic Bohr radius – difference between nanoparticles and quantum dots - Preparation through colloidal methods - Epitaxial methods- MOCVD and MBE growth of quantum dots - current-voltage characteristics - magneto tunneling measurements - spectroscopy of Quantum Dots: Absorption and emission spectra - photo luminescence spectrum - optical spectroscopy - linear and nonlinear optical spectroscopy.

SYNTHESIS OF NANOSTRUCTURE MATERIALS: Gas phase condensation – Vacuum deposition -Physical vapor deposition (PVD) - chemical vapor deposition (CVD) – laser ablationSol-Gel- Ball milling –Electro deposition- electroless deposition – spray pyrolysis – plasma based synthesis process (PSP) - hydrothermal synthesis.

CHARACTERIZATION: Principle and working of Atomic Force Microscopy (AFM) and Scanning tunneling microscopy (STM) - near-field Scanning Optical Microscopy – Principle of Transmission Electron Microscopy (TEM) – applications to nanostructures – nanomechanical characterization – nanoindentation

NANOTECHNOLOGY APPLICATIONS: Applications of nanoparticles, quantum dots, nanotubes and nanowires for nanodevice fabrication – Single electron transistors, coulomb blockade effects in ultra-small metallic tunnel junctions - nanoparticles based solar cells and quantum dots based white LEDs – CNT based transistors.

Text Books :

1. Hand book of Nanoscience, Engineering and Technology (The Electrical Engineering handbook series), Kluwer Publishers, 2002
2. “Sol-Gel Science”, C.J. Brinker and G.W. Scherrer, Academic Press, Boston (1994).
3. Nanoscale characterization of surfaces & interfaces, N John Dinardo, Weinheim Cambridge: Wiley-VCH, 2nd ed., 2000.
4. “Nanotechnology” G. Timp. Editor, AIP press, Springer-Verlag, New York, 1999
5. “Nanostructured materials and nanotechnology’’, Concise Edition, Editor:-Hari Singh Nalwa; Academic Press, USA (2002).

PHYSICS LAB- LAB DSE VI (2 Credits) FM: 25

1. Synthesis of at least two different sizes of Nickel Oxide/ Copper Oxide/ Zinc Oxide Nano Particles Using Sol-Gel Method
2. Polymer synthesis by suspension method / emulsion method
3. B-H loop of nanomaterials.
4. Magnetoresistance of thin films and nanocomposite, I-V characteristics and transient response.
5. Particle size determination by X-ray diffraction (XRD) and XRD analysis of the given XRD spectra
6. Determination of the particle size of the given materials using He-Ne LASER.
7. Selective area electron diffraction: Software based structural analysis based on TEM based experimental data from published literature. (Note: Later experiment may be performed in the lab based on availability of TEM facility).
8. Surface area and pore volume measurements of nanoparticles (a standard sample and a new sample (if available)).
9. Spectroscopic characterization of metallic, semiconducting and insulating nanoparticles.

PHYSICS-DSE VII: MODERN OPTICS

(Credits: Theory-04) Theory: 60 Lectures

Mid Semester: 15 End Semester: 60 Full Marks: 75

Short Answer Type: 4 Marks (3 out of 5) & Long Answer Type: 12 Marks (4 out of 6)

LASER: Elementary idea of spontaneous and induced emission. Life time of excited states (metastable states). Threshold condition for laser oscillation. Rate equations in two and three level system. Actual laser systems: He-Ne laser, Ruby laser. Properties and application of laser radiation.

FIBRE OPTICS: principle of light guidance in optical waveguides, Numerical aperture, fibre types. Electromagnetic analysis of simple optical waveguide: Basic waveguide equation, propagation mode of symmetric step index planar waveguide, TE and TM modes of symmetric step index planar waveguide, mode cut-off condition, mode theory for optical fibre waveguide, scalar wave-equation and modes of fibre, modal analysis for step index fibre. Pulse propagation in non-dispersive and dispersive medium, Pulse broadening and chirping, Group and phase velocity, Intermodal and intramodal dispersion, Group velocity (material and waveguide) dispersion, Fiber bandwidth.

Holography: Basic Principle of Holography, Construction and reconstruction of Image on hologram and applications of holography.

Text Books :

PHYSICS LAB- LAB DSE VII (2 Credits) FM: 25

1. Experiments on Single mode optical fibre.
2. Experiments on multi mode optical fibre.
3. Lasers : Study of Laser Beam Parameters.
4. Edser and Butler fringes - Thickness of air film.
5. Study on Mach–Zehnder interferometer
6. To determine the divergence of LASER beam
7. To Experimentally Verify the Sampling Theorem.
8. Study on losses in fusion based splices in optical fiber
9. Measuring the end separation, axial misalignment and angular misalignment loss optical fiber.
10. Study on Spectral analysis of optical fiber using optical spectrum analyser.
11. Study on Nd-YAG LASER.

PHYSICS-DSE8: DISSERTATION

(Credits: Theory-06)

Every student shall undertake one project dissertation approved by the concerned subject teacher of the Department/College of the department. The progress of the project dissertation shall be monitored, at regular intervals, by the faculty members.

SKILL ENHANCEMENT COURSES

SEC-1: ELECTRICAL CIRCUIT NETWORK SKILLS
(Credits: 2-0-0)

Basic Electricity Principles: Voltage, Current, Resistance, and Power. Ohm's law. Series, parallel, and series-parallel combinations. AC Electricity and DC Electricity. Familiarization with multimeter, voltmeter and ammeter.

Understanding Electrical Circuits: Main electric circuit elements and their combination. Rules to analyze DC sourced electrical circuits. Current and voltage drop across the DC circuit elements. Single-phase and three-phase alternating current sources. Rules to analyze AC sourced electrical circuits. Real, imaginary and complex power components of AC source. Power factor. Saving energy and money.

Generators and Transformers: DC Power sources. AC/DC generators. Inductance, capacitance, and impedance. Operation of transformers.

Electric Motors: Single-phase, three-phase & DC motors. Basic design. Interfacing DC or AC sources to control heaters & motors. Speed & power of ac motor.

Electrical Protection: Relays. Fuses and disconnect switches. Circuit breakers. Overload devices. Ground-fault protection. Grounding and isolating. Phase reversal. Surge protection. Interfacing DC or AC sources to control elements (relay protection device)

Electrical Wiring: Different types of conductors and cables. Basics of wiring-Star and delta connection. Voltage drop and losses across cables and conductors. Instruments to measure current, voltage, power in DC and AC circuits. Insulation.

Reference Books:

• A text book in Electrical Technology - B L Theraja - S Chand & Co.
• A text book of Electrical Technology - A K Theraja
• Performance and design of AC machines - M G Say ELBS Edn.

SEC-2: BASIC INSTRUMENTATION SKILLS

(Credits: 1-0-1)

Basic of Measurement: Instruments accuracy, precision, sensitivity, resolution range etc. Errors in measurements and loading effects. **Multimeter:** Principles of measurement of dc voltage and dc current, ac voltage, ac current and resistance. Specifications of a multimeter and their significance. **(4 Lectures)**

Electronic Voltmeter: Advantage over conventional multimeter for voltage measurement with respect to input impedance and sensitivity. Principles of voltage, measurement (block diagram only). Specifications of an electronic Voltmeter/ Multimeter and their significance. **AC millivoltmeter:** Type of AC millivoltmeters: Amplifier- rectifier, and rectifier- amplifier. Block diagram ac millivoltmeter**,** specifications and their significance. **(4 Lectures)**
Cathode Ray Oscilloscope: Block diagram of basic CRO. Construction of CRT, Electron gun, electrostatic focusing and acceleration (Explanation only– no mathematical treatment), brief discussion on screen phosphor, visual persistence & chemical composition. Time base operation, synchronization. Front panel controls. Specifications of a CRO and their significance.
Use of CRO for the measurement of voltage (dc and ac frequency, time period. Special features of dual trace, introduction to digital oscilloscope, probes. Digital storage Oscilloscope: Block diagram and principle of working. **(10 Lectures)**

Signal Generators and Analysis Instruments: Block diagram, explanation and specifications of low frequency signal generators. pulse generator, and function generator. Brief idea for testing, specifications. Distortion factor meter, wave analysis. **(4 Lectures)**

Digital Instruments: Principle and working of digital meters. Comparison of analog & digital instruments. Characteristics of a digital meter. Working principles of digital voltmeter.
(4 Lectures)
Digital Multimeter: Block diagram and working of a digital multimeter. Working principle of time interval, frequency and period measurement using universal counter/ frequency counter, time- base stability, accuracy and resolution. **(4 Lectures)**

The test of lab skills will be of the following test items:
1. Use of an oscilloscope.
2. CRO as a versatile measuring device.
3. Circuit tracing of Laboratory electronic equipment,
4. Use of Digital multimeter/VTVM for measuring voltages
7. Study the layout of receiver circuit.
8. Trouble shooting a circuit
9. Balancing of bridges

Laboratory Exercises:
1. To observe the loading effect of a multimeter while measuring voltage across a low resistance and high resistance.
2. To observe the limitations of a multimeter for measuring high frequency voltage and currents.

3. To measure Q of a coil and its dependence on frequency, using a Q- meter.
4. Measurement of voltage, frequency, time period and phase angle using CRO.
6. Measurement of rise, fall and delay times using a CRO.

Open Ended Experiments:
1. Using a Dual Trace Oscilloscope
2. Converting the range of a given measuring instrument (voltmeter, ammeter)

Reference Books:

• A text book in Electrical Technology - B L Theraja - S Chand and Co.
• Performance and design of AC machines - M G Say ELBS Edn.
• Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
• Logic circuit design, Shimon P. Vingron, 2012, Springer.
• Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
• Electronic Devices and circuits, S. Salivahanan & N. S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill
• Electronic circuits: Handbook of design and applications, U.Tietze, Ch.Schenk, 2008, Springer
• Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India

SEC 3: RENEWABLE ENERGY AND ENERGY HARVESTING
(Credits: 1-0-1)

Fossil fuels and Alternate Sources of energy: Fossil fuels and Nuclear Energy, their limitation, need of renewable energy, non-conventional energy sources. An overview of developments in Offshore Wind Energy, Tidal Energy, Wave energy systems, Ocean Thermal Energy Conversion, solar energy, biomass, biochemical conversion, biogas generation, geothermal energy tidal energy, Hydroelectricity.

Solar energy: Solar energy, its importance, storage of solar energy, solar pond, non convective solar pond, applications of solar pond and solar energy, solar water heater, flat plate collector, solar distillation, solar cooker, solar green houses, solar cell, absorption air conditioning.

Wind Energy harvesting: Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid
interconnection topologies.

Ocean Energy: Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices. Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass.

Geothermal Energy: Geothermal Resources, Geothermal Technologies.

Hydro Energy: Hydropower resources, hydropower technologies, environmental impact of hydro power sources.

Piezoelectric Energy harvesting: Introduction, Physics and characteristics of piezoelectric effect, materials and mathematical description of piezoelectricity, Piezoelectric parameters and modeling piezoelectric generators, Piezoelectric energy harvesting applications, Human power

Demonstrations and Experiments
1. Demonstration of Training modules on Solar energy, wind energy, etc.
2. Conversion of vibration to voltage using piezoelectric materials
3. Conversion of thermal energy into voltage using thermoelectric modules.

Reference Books:

- Non-conventional energy sources - G.D Rai - Khanna Publishers, New Delhi
- Solar energy - M P Agarwal - S Chand and Co. Ltd.
- Solar energy - Suhas P Sukhative Tata McGraw - Hill Publishing Company Ltd.
- Godfrey Boyle, “Renewable Energy, Power for a sustainable future”, 2004, Oxford University Press, in association with The Open University.
- Dr. P Jayakumar, Solar Energy: Resource Assesment Handbook, 2009
- J.Balfour, M.Shaw and S. Jarosek, Photovoltaics, Lawrence J Goodrich (USA).

SEC 4: APPLIED OPTICS
(Credits: 0-0-2)

Theory includes only qualitative explanation. Minimum five experiments should be performed covering minimum three sections.

(i) **Sources and Detectors** : Lasers, Spontaneous and stimulated emissions, Theory of laser action, Einstein's coefficients, Light amplification, Characterization of laser beam, He-Ne laser, Semiconductor lasers. Experiments on Lasers: a. Determination of the grating radial spacing of the Compact Disc (CD) by reflection using He-Ne or solid state laser. b. To find the width of the wire or width of the slit using diffraction pattern obtained by a He-Ne or solid state laser. c. To find the polarization angle of laser light using polarizer and analyzer d. Thermal expansion of quartz using laser Experiments on Semiconductor

(ii) **Fourier Optics** : Concept of Spatial frequency filtering, Fourier transforming property of a thin lens Experiments on Fourier Optics: a. Fourier optic and image processing 1. Optical image addition/subtraction 2. Optical image differentiation 3. Fourier optical filtering 4. Construction of an optical 4f system b. Fourier Transform Spectroscopy Fourier Transform Spectroscopy (FTS) is a powerful method for measuring emission and absorption spectra, with wide application in atmospheric remote sensing, NMR spectrometry and forensic science. Experiment: To study the interference pattern from a Michelson interferometer as a function of mirror separation in the interferometer. The resulting interferogram is the Fourier transform of the power spectrum of the source. Analysis of experimental interferograms allows one to determine the transmission characteristics of several interference filters. Computer simulation can also be done.

(iii) **Holography**: Basic principle and theory: coherence, resolution, Types of holograms, white light reflection hologram, application of holography in microscopy, interferometry, and character recognition Experiments on Holography and interferometry: 1. Recording and reconstructing holograms 2. Constructing a Michelson interferometer or a Fabry Perot interferometer 3. Measuring the refractive index of air 4. Constructing a Sagnac interferometer 5. Constructing a Mach-Zehnder interferometer 6. White light Hologram

(iv) **Photonics: Fibre Optics** : Optical fibres and their properties, Principal of light propagation through a fibre, The numerical aperture, Attenuation in optical fibre and attenuation limit, Single mode and multimode fibres, Fibre optic sensors: Fibre Bragg Grating Experiments on Photonics: Fibre Optics a. To measure the numerical aperture of an optical fibre b. To study the variation of the bending loss in a multimode fibre c. To determine the mode field diameter of fundamental mode in a single-mode fibre by measurements of its far field Gaussian pattern d. To measure the near field intensity profile of a fibre and study its refractive index profile e. To determine the power loss at a splice between two multimode fibre

Reference Books:

- Fundamental of optics, F. A. Jenkins & H. E. White, 1981, Tata McGraw hill.
- LASERS: Fundamentals & applications, K.Thyagrajan & A.K.Ghatak, 2010, Tata McGraw Hill.
- Fibre optics through experiments,M.R.Shenoy, S.K.Khijwania, et.al. 2009, Viva Books.
- Nonlinear Optics, Robert W. Boyd, (Chapter-I), 2008, Elsevier..
- Optics, Karl Dieter Moller, Learning by computing with model examples, 2007, Springer.
- Optical Systems and Processes, Joseph Shamir, 2009, PHI Learning Pvt. Ltd.
- Optoelectronic Devices and Systems, S.C. Gupta, 2005, PHI Learning Pvt. Ltd.
- Optical Physics, A.Lipson, S.G.Lipson, H.Lipson, 4th Edn., 1996, Cambridge Univ. Press

SEC 5: Computers and C Programming

(Credits: 1-0-1)

Introduction: Fundamental of computers, components of a computer system: hardware, software. Introduction to operating system, parts of windows, files and folders.

Importance of computers in Physics, paradigm for solving physicsproblems for solution**.** Algorithm: Definition, properties and development. Flowchart: Concept of flowchart,symbols, guidelines, types.

C Programming Language: Introduction, importance of C, characters set, tokens, keywords, identifier,constants, basic data types, variables: declaration & assigning values. Pre-processor directives, structure of C program. Operators: arithmetic operators, relational operators, logical operators, assignment operators, increment and decrementoperators, conditional operators, bit wise operators, expressions and evaluation of expressions, type cast operator, precedence of operators. Arrays: concepts, declaration, accessing elements,storing elements, two-dimensional and multi-dimensional arrays. Input-Output statements and library functions(math and string related functions).

Decision making, branching & looping: Decision making, branching and looping: if, if-else, else-if, switchstatements, break, for loop, while loop and do loop. Functions: Defining functions, function arguments andpassing, returning values from functions.

Structures: Definition and declaring a structure variables, accessing structure members, initializing a structure,copying and comparing structure variables, array of structures, arrays within structures, structures withinstructures, structures and functions. Pointers.

Suggested Books:

1. YashavantKanetkar, Let Us C , BPB Publications
2. Programming in ANSI C, Balagurusamy, TMH.
3. Byron S Gottfried, Programming with C ,Schaum Series.
4. Brian W. Kernighan, Dennis M. Ritchie, The C Programming Language, Prentice Hall.
5. YashavantKanetkar, Pointers in C, BPB Publications

C Programming Lab

1. Exercises on syntax on usage of C language.
2. Usage of Windows (GUI) commands and applications, familiarity with DOS commands andworking in an editor to write sources codes in C.
3. Generate the fibonacci series up to the given range N and also print the number of elements in theseries.
4. To print out all natural even/ odd numbers between given limits.
5. To find maximum, minimum and range of a given set of numbers.
6. Calculating Euler number using exp(x) series evaluated at x=1
7. Calculate factorial of a given number and in a range.
8. Find all the roots of a quadratic equation for non – zero coefficients A, B and C otherwise report error.
9. Calculate the value of sin (x) and cos (x) using the series. Also print sin (x) and cos (x) value using library function.
10. Generate and print prime numbers up to an integer N.
11. Find the sum & difference of two matrices of order P x Q and R x S.
12. Find the product of two matrices of order P x Q and R x S.
13. Find the transpose of given P x Q matrix.
14. Computations of various matrix operations.