DAV AUTONOMOUS COLLEGE,TITILAGARH

**B.SC. (CORE) PHYSICS SYLLABUS**

**SEM-I CORE I: MATHEMATICAL PHYSICS-I**

**Full Marks- Internal-15+ Practical-25+Sem End Exam-60**

**UNIT-I** -**Calculus**:

Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. Constrained Maximization using Lagrange Multipliers.

**Dirac Delta function and its properties**:

Definition of Dirac delta function. Representation as limit of a Gaussian function and rectangular function. Properties of Dirac delta function.

**UNIT-II- Orthogonal Curvilinear Coordinates:**

Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems. Comparison of velocity and acceleration in cylindrical and spherical coordinate system.

**UNIT-III** -**Vector Calculus**:

Recapitulation of vectors: Properties of vectors under rotations. Scalar product and its invariance under rotations. Vector product, Scalar triple product and their interpretation in terms of area and volume respectively. Scalar and Vector fields.

**UNIT-IV-Vector Differentiation:** Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities, Gradient, divergence, curl and Laplacian in spherical and cylindrical coordinates.

**UNIT-V-Vector Integration:** Ordinary Integrals of Vectors. Multiple integrals, Jacobian. Notion of infinitesimal line, surface and volume elements. Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems and their applications (no rigorous proofs).

**Each unit shall have one long question carrying 12 marks and as option to the long questions 2/3(Two or Three) short questions carrying 6/4(Six or Four) marks each will be asked.**

**SEM-I CORE II: MECHANICS**

**Full Marks- Internal-15+ Practical-25+Sem End Exam-60**

**UNIT-I** -**Rotational Dynamics**: Centre of Mass and Laboratory frames. Angular momentum of a particle and system of particles. Torque. Principle of conservation of angular momentum. Rotation about a fixed axis. Moment of Inertia. Calculation of moment of inertia for rectangular, cylindrical and spherical bodies. Kinetic energy of rotation. Motion involving both translation and rotation.

**Non-Inertial Systems:** Non-inertial frames and fictitious forces. Uniformly rotating frame. Laws of Physics in rotating coordinate systems. Centrifugal force. Coriolis force and its applications.

**UNIT-II**- **Elasticity:** Relation between Elastic constants. Twisting torque on a Cylinder or Wire.

**Fluid Motion:** Kinematics of Moving Fluids: Poiseuille’s Equation for Flow of a Liquid through a Capillary Tube.

**UNIT-III- Gravitation and Central Force Motion:** Law of gravitation. Gravitational potential energy. Inertial and gravitational mass. Potential and field due to spherical shell and solid sphere.

Motion of a particle under a central force field. Two-body problem and its reduction to one-body problem and its solution. The energy equation and energy diagram. Kepler’s Laws. Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness. Basic idea of global positioning system (GPS). Physiological effects on astronauts.

**UNIT-IV** -**Oscillations:** SHM: 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; power dissipation and Quality Factor.

**UNIT-V- Special Theory of Relativity:** Michelson-Morley Experiment and its outcome. Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity and order of events. Lorentz contraction. Time dilation. Relativistic transformation of velocity, frequency and wave number. Relativistic addition of velocities. Variation of mass with velocity. Massless Particles. Mass-energy Equivalence. Relativistic Doppler effect. Relativistic Kinematics. Transformation of Energy and Momentum. Energy-Momentum Four Vector.

**Each unit shall have one long question carrying 12 marks and as option to the long questions 2/3(Two or Three) short questions carrying 6/4(Six or Four) marks each will be asked.**

**SEM-II CORE- III: ELECTRICITY AND MAGNETISM**

**Full Marks- Internal-15+ Practical-25+Sem End Exam-60**

**UNIT-I**

**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. The Uniqueness Theorem. Potential and Electric Field of a dipole. Force and Torque on a dipole.

**UNIT-II**

Electrostatic energy of system of charges. Electrostatic energy of a charged sphere. Conductors in an electrostatic Field. Surface charge and force on a conductor. Capacitance of a system of charged conductors. Parallel-plate capacitor. Capacitance of an isolated conductor. Method of Images and its application to: (1) Plane Infinite Sheet and (2) Sphere.

**Dielectric Properties of Matter:** Electric Field in matter. Polarization, Polarization Charges. Electrical Susceptibility and Dielectric Constant. Capacitor (parallel plate, spherical, cylindrical) filled with dielectric. Displacement vector **D**. Relations between **E**, **P** and **D**. Gauss’ Law in dielectrics.

**UNIT-III**

**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) point charge (2) current carrying wire (3) between current elements. Torque on a current loop in a uniform Magnetic Field. Ballistic Galvanometer**:** Torque on a current Loop. Ballistic Galvanometer: Current and Charge Sensitivity. Electromagnetic damping. Logarithmic damping. CDR.

**UNIT-IV**

**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.

**Electromagnetic Induction:** Faraday’s Law. Lenz’s Law. Self Inductance and Mutual Inductance. Reciprocity Theorem. Energy stored in a Magnetic Field.

**UNIT-V**

**Electrical 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.

**Network theorems:** Ideal Constant-voltage and Constant-current Sources. Network Theorems: Thevenin theorem, Norton theorem, Superposition theorem, Reciprocity theorem, Maximum Power Transfer theorem. Applications to dc circuits.

**Each unit shall have one long question carrying 12 marks and as option to the long questions 2/3(Two or Three) short questions carrying 6/4(Six or Four) marks each will be asked.**

**PHYSICS LAB-C III LAB**

1. Use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, (d) Capacitances, and (e) Checking electrical fuses.

2. To study the characteristics of a series RC Circuit.

3. To determine an unknown Low Resistance using Potentiometer.

4. To determine an unknown Low Resistance using Carey Foster’s Bridge.

5. To compare capacitances using De’Sauty’s bridge.

6. Measurement of field strength B and its variation in a solenoid (determine dB/dx)

7. To verify the Thevenin and Norton theorems.

8. To verify the Superposition, and Maximum power transfer theorems.

9. To determine self inductance of a coil by Anderson’s bridge.

10. To study response curve of a Series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Band width.

11. To study the response curve of a parallel LCR circuit and determine its (a) Antiresonant frequency and (b) Quality factor Q.

12. Measurement of charge and current sensitivity and CDR of Ballistic Galvanometer

13. Determine a high resistance by leakage method using Ballistic Galvanometer.

14. To determine self-inductance of a coil by Rayleigh’s method.

15. To determine the mutual inductance of two coils by Absolute method.

**SEM-II CORE- IV: WAVES AND OPTICS**

**Full Marks- Internal-15+ Practical-25+Sem End Exam-60**

**UNIT-I**

**Geometrical optics:** Fermat’s principle, reflection and refraction at plane interface, Matrix formulation of geometrical Optics. Idea of dispersion. Application to thick lense, Ramsden and Huygens eyepiece.

**UNIT-II**

**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. Water Waves: Ripple and Gravity Waves.

**UNIT-III**

**Superposition of two perpendicular Harmonic Oscillations**: Graphical and Analytical Methods. Lissajous Figures (1:1 and 1:2) and their uses. Superposition of N harmonic waves.

**Wave Optics:** Electromagnetic nature of light. Definition and properties of wave front. Huygens Principle. Temporal and Spatial Coherence.

**UNIT-IV**

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

**Interferometer**: Michelson Interferometer-(1) Idea of form of fringes (No theory required), (2) Determination of Wavelength, (3) Wavelength Difference, (4) Refractive Index, and (5) Visibility of Fringes. Fabry-Perot interferometer.

**UNIT-V**

**Fraunhofer diffraction**: Single slit. Circular aperture, Resolving Power of a telescope. Double slit. Multiple 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’s Integral, Fresnel diffraction pattern of a straight edge, a slit and a wire.

**Each unit shall have one long question carrying 12 marks and as option to the long questions 2/3(Two or Three) short questions carrying 6/4(Six or Four) marks each will be asked.**

**PHYSICS LAB- C IV LAB**

1. To determine the frequency of an electric tuning fork by Melde’s experiment and verify λ2 –T law.

2. To investigate the motion of coupled oscillators.

3. To study Lissajous Figures.

4. Familiarization with: Schuster`s focusing; determination of angle of prism.

5. To determine refractive index of the Material of a prism using sodium source.

6. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.

7. To determine the wavelength of sodium source using Michelson’s interferometer.

8. To determine wavelength of sodium light using Fresnel Biprism.

9. To determine wavelength of sodium light using Newton’s Rings.

10. To determine the thickness of a thin paper by measuring the width of the interference fringes produced by a wedge-shaped Film.

11. To determine wavelength of (1) Na source and (2) spectral lines of Hg source using plane diffraction grating.

12. To determine dispersive power and resolving power of a plane diffraction grating.

**SEM-III-CORE- V: MATHEMATICAL PHYSICS-II**

**Full Marks- Internal-15+ Practical-25+Sem End Exam-60**

**UNIT-I**

**Fourier Series**: Periodic functions. Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Complex representation of Fourier series. Expansion of functions with arbitrary period. Expansion of non-periodic functions over an interval. Even and odd functions and their Fourier expansions. Application. Summing of Infinite Series. Term-by-Term differentiation and integration of Fourier Series. Parseval Identity.

**UNIT-II**

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

**UNIT-III**

**Frobenius Method and Special Functions**: Singular Points of Second Order Linear Differential Equations and their importance, Frobenius method and its applications to differential equations: Legendre & Hermite Differential Equations. Properties of Legendre & Hermite Polynomials: Rodrigues Formula, Generating Function, Orthogonality. Simple recurrence relations. Expansion of function in a series of Legendre Polynomials. Associated Legendre polynomials and spherical harmonics.

**UNIT-IV**

**Theory of Errors:** Systematic and Random Errors. Propagation of Errors. Normal Law of Errors. Standard and Probable Error.

**UNIT-V**

**Partial Differential Equations**: Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry. Conducting and dielectric sphere in an external uniform electric field. Wave equation and its solution for vibrational modes of a stretched string.

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**SEM-III-CORE- VI: THERMAL PHYSICS**

**Full Marks- Internal-15+ Practical-25+Sem End Exam-60**

**UNIT-I**

**Introduction to Thermodynamics**

Recapitulation of Zeroth and First law of thermodynamics:

**Second Law of Thermodynamics**: Reversible and Irreversible process with examples. Conversion of Work into Heat and Heat into Work. Heat Engines. Carnot’s Cycle, Carnot engine & efficiency. Refrigerator & coefficient of performance, 2nd Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Carnot’s Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale.

**UNIT-II**

**Entropy**: Concept of Entropy, Clausius Theorem. Clausius Inequality, Second Law of Thermodynamics in terms of Entropy. Entropy of a perfect gas. Principle of Increase of Entropy. Entropy Changes in Reversible and Irreversible processes with examples. Entropy of the Principle of Increase of Entropy. Temperature–Entropy diagrams for Carnot’s Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero.

**UNIT-III**

**Thermodynamic Potentials**: Extensive and Intensive Thermodynamic Variables. Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb’s Free Energy. Their Definitions, Properties and Applications. Surface Films and Variation of Surface Tension with Temperature. Magnetic Work, Cooling due to adiabatic demagnetization, First and second order Phase Transitions with examples, Clausius Clapeyron Equation and Ehrenfest equations

**Maxwell’s Thermodynamic Relations**: Derivations and applications of Maxwell’s Relations, Maxwell’s Relations:(1) Clausius Clapeyron equation, (2) Values of Cp-Cv, (3) Tds Equations, (4) Joule-Kelvin coefficient for Ideal and Van der Waal Gases, (5) Energy equations, (6) Change of Temperature during Adiabatic Process.

**UNIT-IV**

**Kinetic Theory of Gases**

**Distribution of Velocities**: Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas and its Experimental Verification. Stern’s Experiment. Mean, RMS and Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy (No proof required). Specific heats of Gases.

**Molecular Collisions**: Mean Free Path. Collision Probability. Estimates of Mean Free Path. Transport Phenomenon in Ideal Gases: (1) Viscosity, (2) Thermal Conductivity and (3) Diffusion. Brownian Motion and its Significance.

**UNIT-V**

**Real Gases:** Behavior of Real Gases: Deviations from the Ideal Gas Equation. The Virial Equation. Andrew’s Experiments on CO2 Gas. Critical Constants. Continuity of Liquid and Gaseous State. Vapour and Gas. Boyle Temperature. Van der Waal’s Equation of State for Real Gases. Values of Critical Constants. Law of Corresponding States. Comparison with Experimental Curves. p-V Diagrams. Joule’s Experiment. Free Adiabatic Expansion of a Perfect Gas. Joule-Thomson Porous Plug Experiment. Joule- Thomson Effect for Real and Van der Waal Gases. Temperature of Inversion. Joule- Thomson Cooling.

**Each unit shall have one long question carrying 12 marks and as option to the long questions 2/3(Two or Three) short questions carrying 6/4(Six or Four) marks each will be asked.**

**SEM-III-CORE- VII: DIGITAL SYSTEMS AND APPLICATIONS**

**Full Marks- Internal-15+ Practical-25+Sem End Exam-60**

**UNIT-I**

**Integrated Circuits** (Qualitative treatment only): Active & Passive components. Discrete components. Wafer. Chip. Advantages and drawbacks of ICs. Scale of integration: SSI, MSI, LSI and VLSI (basic idea and definitions only). Classification of ICs. Examples of Linear and Digital lCs.

**UNIT-II**

**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 (realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates and application as Parity Checkers.

**UNIT-III**

**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.

**Introduction to CRO:** Block Diagram of CRO. Electron Gun, Deflection System and Time Base. Deflection Sensitivity. Applications of CRO: (1) Study of Waveform, (2) Measurement of Voltage, Current, Frequency, and Phase Difference.

**UNIT-IV**

**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. Half & Full Subtractors, 4-bit binary Adder/Subtractor.

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

**UNIT-V**

**Introduction to Computer Organization**: Input/Output Devices. Data storage (idea of RAM and ROM). Computer memory. Memory organization & addressing. Memory Interfacing. Memory Map.

**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.

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**SEM-IV-CORE-VIII: MATHEMATICAL PHYSICS-III**

**Full Marks- Internal-15+ Practical-25+Sem End Exam-60**

**UNIT-I**

**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.

**UNIT-II**

Singular functions: poles and branch points, order of singularity, branch cuts. 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.

**UNIT-III**

**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,

**UNIT-IV**

Convolution theorem. Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.). Three dimensional Fourier transforms with examples. Application of Fourier Transforms to differential equations: One dimensional Wave and Diffusion/Heat Flow Equations.

**UNIT-V**

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, Dirac Delta function, Periodic Functions. Convolution Theorem. Inverse LT. Application of Laplace Transforms to Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits.

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**PHYSICS PRACTICAL-C VIII LAB**

***Scilab based simulations experiments based on Mathematical Physics problems like***

1. Solve differential equations:

dy/dx = e-x with y = 0 for x = 0

dy/dx + e-xy = x2

d2y/dt2 + 2 dy/dt = -y

d2y/dt2 + e-tdy/dt = -y

2. Dirac Delta Function:

Evaluate d*x for σ=1,0.1, 0.01 and show it tends to 5*

3. Fourier Series: Program to sum

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

4. Frobenius method and Special functions: Plot Pn(x), Jν(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.

7. Evaluation of trigonometric functions e.g. *sin θ,* Given Bessel’s function at N

points find its value at an intermediate point. Complex analysis: Integrate 1/(x2+2) numerically and check with computer integration. 26

8. Integral transform: FFT of e-x2

**SEM-IV CORE- IX: ELEMENTS OF MODERN PHYSICS**

 **Full Marks- Internal-15+ Practical-25+Sem End Exam-60**

**UNIT-I**

**Atomic Spectra and Models**

Inadequacy of classical physics, Brief Review of Black body Radiation , Photoelectric effect, Compton effect, dual nature of radiation, wave nature of particles. Atomic spectra, Line spectra of hydrogen atom, Ritz Rydberg combination principle. Alpha Particle Scattering, Rutherford Scattering Formula, Rutherford Model of atom and its limitations, Bohr’s model of H atom, explanation of atomic spectra, correction for finite mass of the nucleus, Bohr correspondence principle, limitations of Bohr model, discrete energy exchange by atom, Frank Hertz Expt. Sommerfeld's Modification of Bohr’s Theory.

**UNIT-II**

**Wave Particle Duality**

de Broglie hypothesis, Experimental confirmation of matter wave, Davisson Germer Experiment, velocity of de Broglie wave, wave particle duality, Complementarity. Superposition of two waves, phase velocity and group velocity , wave packets ,Gaussian Wave Packet , spatial distribution of wave packet, Localization of wave packet in time.

Time development of a wave Packet ; Wave Particle Duality, Complementarity .

**UNIT-III**

Heisenberg Uncertainty Principle ,Illustration of the Principle through thought Experiments of Gamma ray microscope and electron diffraction through a slit. Estimation of ground state energy of harmonic oscillator and hydrogen atom, non existence of electron in the nucleus. Uncertainty and Complementarities.

**UNIT-IV**

**Nuclear Physics**

Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Nature of nuclear force, NZ graph, Liquid Drop model: semi-empirical mass formula and binding energy, Nuclear Shell Model and magic numbers.

**UNIT-V**

Radioactivity: stability of the nucleus; Law of radioactive decay; Mean life and half-life; Alpha decay; Beta decay- energy released, spectrum and Pauli's prediction of neutrino; Gamma ray emission, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus.

Fission and fusion- mass deficit, relativity and generation of energy; Fission - nature of fragments and emission of neutrons. Nuclear reactor: slow neutrons interacting with Uranium 235; Fusion and thermonuclear reactions driving stellar energy (brief qualitative discussions).

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**PHYSICS PRACTICAL-C IX LAB**

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 vacuumdiode.

4. To determine the Planck’s constant using LEDs of at least 4 different colours.

5. To determine the wavelength of H-alpha emission line of Hydrogen atom.

6. To determine the ionization potential of mercury.

7. To determine the absorption lines in the rotational spectrum of Iodine vapour.

8. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.

9. To setup the Millikan oil drop apparatus and determine the charge of an electron.

10. To show the tunneling effect in tunnel diode using I-V characteristics.

11. To determine the wavelength of laser source using diffraction of single slit. 28

12. To determine the wavelength of laser source using diffraction of double slits.

13. To determine (1) wavelength and (2) angular spread of He-Ne laser using plane diffraction grating

**SEM-IV CORE- X: ANALOG SYSTEMS AND APPLICATIONS**

**Full Marks- Internal-15+ Practical-25+Sem End Exam-60**

**Unit-I**

**Semiconductor Diodes:** P and N type semiconductors. Energy Level Diagram. Conductivity and Mobility, Concept of Drift velocity. PN Junction Fabrication (Simple Idea). Barrier Formation in PN Junction Diode. Static and Dynamic Resistance. Current Flow Mechanism in Forward and Reverse Biased Diode. Drift Velocity. Derivation for Barrier Potential, Barrier Width and Current for Step Junction.

**Two-terminal Devices and their Applications:** (1) Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, (2) Zener Diode and Voltage Regulation. Principle and structure of (1) LEDs, (2) Photodiode, (3) Solar Cell.

**UNIT-II**

**Bipolar Junction transistors:** n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Current gains α and β Relations between α and β. Load Line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow. Active, Cutoff and Saturation Regions.

**Unit-III**

**Amplifiers:** Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Transistor as 2-port Network. h-parameter Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains. Classification of Class A, B & C Amplifiers.

**Coupled Amplifier:** RC-coupled amplifier and its frequency response.

**UNIT-IV**

**Feedback in Amplifiers:** Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise.

**Sinusoidal Oscillators:** Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency. Hartley & Colpitts oscillators.

**UNIT-V**

**Operational Amplifiers (Black Box approach):** Characteristics of an Ideal and Practical Op-Amp. (IC 741) Open-loop and Closed-loop Gain. Frequency Response. CMRR. Slew Rate and concept of Virtual ground.

**Applications of Op-Amps:** (1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor,

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**PHYSICS PRACTICAL-C X LAB**

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 study the various biasing configurations of BJT for normal class A operation.

6. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.

7. To study the frequency response of voltage gain of a RC-coupled transistor amplifier.

8. To design a Wien bridge oscillator for given frequency using an op-amp.

9. To design a phase shift oscillator of given specifications using BJT.

10. To study the Colpitt`s oscillator.

11. To design a digital to analog converter (DAC) of given specifications.

12. To study the analog to digital convertor (ADC) IC.

13. To design an inverting amplifier using Op-amp (741,351) for dc voltage of given gain

14. To design inverting amplifier using Op-amp (741,351) and study its frequency response Differentiator, (5) Integrator, (6) Log amplifier, (7) Zero crossing detector (8) Wein bridge oscillator

15. To design non-inverting amplifier using Op-amp (741,351) & study its frequency response

16. To study the zero-crossing detector and comparator

17. To add two dc voltages using Op-amp in inverting and non-inverting mode

18. To design a precision Differential amplifier of given I/O specification using Op-amp.

19. To investigate the use of an op-amp as an Integrator.

20. To investigate the use of an op-amp as a Differentiator.

21. To design a circuit to simulate the solution of a 1st/2nd order differential equation

**SEM-V CORE- XI: QUANTUM MECHANICS AND APPLICATIONS**

**Full Marks- Internal-15+ Practical-25+Sem End Exam-60**

**Unit-I**

**Schrodinger equation & the operators**: Time dependent Schrodinger equation and dynamical evolution of a quantum state; Properties of Wave Function. Interpretation of Wave Function Probability and probability current densities in three dimensions; Conditions for Physical Acceptability of Wave Functions. Normalization. Linearity and Superposition Principles. Hermitian operator, Eigen values and Eigen functions. Position, momentum and Energy operators; commutator of position and momentum operators; Expectation values of position and momentum. Wave Function of a Free Particle.

**UNIT-II**

**Time independent Schrodinger equation**-Hamiltonian, stationary states and energy eigen values; expansion of an arbitrary wave function as a linear combination of energy eigen functions; General solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states; Application to spread of Gaussian wave-packet for a free particle in one dimension; wave packets, Fourier transforms and momentum space wave function; Position-momentum uncertainty principle.

**Unit-III**

**General discussion of bound states in an arbitrary potential**- continuity of wave function, boundary condition and emergence of discrete energy levels; application to one-dimensional problem-square well potential; Quantum mechanics of simple harmonic oscillator-energy levels and energy eigen functions ground state, zero point energy.

**UNIT-IV**

Uncertainty principle: One dimensional infinitely rigid box- energy eigen values and eigen functions, normalization; Quantum dot as example; Quantum mechanical scattering and tunnelling in one dimension-across a step potential & rectangular potential barrier.

**Unit-V**

**Atoms in Electric & Magnetic Fields**: Electron angular momentum. Space quantization. Electron Spin and Spin Angular Momentum. Larmor’s Theorem. Spin Magnetic Moment. Stern-Gerlach Experiment. Zeeman Effect: Electron Magnetic Moment and Magnetic Energy, Gyromagnetic Ratio and Bohr Magneton.

**Atoms in External Magnetic Fields**:- Normal and Anomalous Zeeman Effect. Paschen Back and Stark Effect (Qualitative Discussion only).

**Each unit shall have one long question carrying 12 marks and as option to the long questions 2/3(Two or Three) short questions carrying 6/4(Six or Four) marks each will be asked.**

**PHYSICS PRACTICAL-C XI LAB**

***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:

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 = 0.511x106 eV/c2. 32

2. Solve the s-wave radial Schrodinger equation for an atom: 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 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 = 0.511x106 eV/c2, 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: For the anharmonic oscillator potential 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/c2, k = 100 MeV fm-2, b = 0, 10, 30 MeV fm-3In 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: Where μ is the reduced mass of the two-atom system for the Morse potential 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/C2, D = 0.755501 eV, α = 1.44, ro = 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

**SEM-V CORE- XII: SOLID STATE PHYSICS**

**Full Marks- Internal-15+ Practical-25+Sem End Exam-60**

**Unit-I**

**Crystal Structure:** Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis – Central and Non-Central Elements. Unit Cell. Miller Indices. Types of Lattices, Reciprocal Lattice. Brillouin Zones. Diffraction of X-rays by Crystals. Bragg’s Law. Atomic and Geometrical Factor.

**UNIT-II**

**Elementary Lattice Dynamics:** Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic Chains. Acoustical and Optical Phonons. Qualitative Description of the Phonon Spectrum in Solids. Dulong and Petit’s Law, Einstein and Debye theories of specific heat of solids. T3 law

**Unit-III**

**Magnetic Properties of Matter:** Dia-, Para-, Ferri- and Ferromagnetic Materials. Classical Langevin Theory of dia–and Paramagnetic Domains. Curie’s law, Weiss’s Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis and Energy Loss.

**UNIT-IV**

**Dielectric Properties of Materials:** Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mosotti Equation. Classical Theory of Electric Polarizability.

**Lasers:** Einstein’s A and B coefficients. Metastable states. Spontaneous and Stimulated emissions. Optical Pumping and Population Inversion. Three-Level and Four-Level Lasers. Ruby Laser and He-Ne Laser.

**Unit-V**

**Elementary band theory:** Kronig Penny model. Band Gap. Conductor, Semiconductor (P and N type) and insulator. Conductivity of Semiconductor, mobility, Hall Effect. Measurement of conductivity (04 probe method) & Hall coefficient.

**Superconductivity:** Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, London’s Equation and Penetration Depth. Isotope effect. Idea of BCS theory (No derivation)

**Each unit shall have one long question carrying 12 marks and as option to the long questions 2/3(Two or Three) short questions carrying 6/4(Six or Four) marks each will be asked.**

**PHYSICS PRACTICAL-C XII LAB**

1. Measurement of susceptibility of paramagnetic solution (Quinck`s Tube Method)

2. To measure the Magnetic susceptibility of Solids.

3. To determine the Coupling Coefficient of a Piezoelectric crystal.

4. To measure the Dielectric Constant of a dielectric Materials with frequency

5. To determine the complex dielectric constant and plasma frequency of metal using Surface Plasmon resonance (SPR)

6. To determine the refractive index of a dielectric layer using SPR

7. To study the PE Hysteresis loop of a Ferroelectric Crystal.

8. To draw the BH curve of Fe using Solenoid & determine energy loss from Hysteresis.

9. To measure the resistivity of a semiconductor (Ge) with temperature by four-probe method (room temperature to 150 oC) and to determine its band gap.

10. To determine the Hall coefficient of a semiconductor sample.

**SEM-VI CORE- XIII: ELECTROMAGNETIC THEORY**

**Full Marks- Internal-15+ Practical-25+Sem End Exam-60**

**Unit-I**

**Maxwell Equations:** Maxwell’s equations. Displacement Current. Vector and Scalar Potentials. Gauge Transformations: Lorentz and Coulomb Gauge. Boundary Conditions at Interface between Different Media. Wave Equations. Plane Waves in Dielectric Media. Poynting Theorem and Poynting Vector. Electromagnetic (EM) Energy Density. Physical Concept of Electromagnetic Field Energy Density.

**UNIT-II**

**EM Wave Propagation in Unbounded Media:** Plane EM waves through vacuum and isotropic dielectric medium, transverse nature of plane EM waves, refractive index and dielectric constant, wave impedance.

Propagation through conducting media, relaxation time, skin depth. Electrical conductivity of ionized gases, plasma frequency, refractive index, skin depth, application to propagation through ionosphere.

**UNIT-III**

**EM Wave in Bounded Media:** 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. Metallic reflection (normal Incidence)

**Optical Fibres:-** Numerical Aperture. Step and Graded Indices (Definitions Only). Single and Multiple Mode Fibres (Concept and Definition Only).

**Unit-IV**

**Polarization of Electromagnetic Waves:** Description of Linear, Circular and Elliptical Polarization. Propagation of E.M. Waves in Anisotropic Media. Symmetric Nature of Dielectric Tensor. Fresnel’s Formula. Uniaxial and Biaxial Crystals. Light Propagation in Uniaxial Crystal. Double Refraction. Polarization by Double Refraction. Nicol Prism. Ordinary & extraordinary refractive indices.

**UNIT-V**

Production & detection of Plane, Circularly and Elliptically Polarized Light. Phase Retardation Plates: Quarter-Wave and Half-Wave Plates. Babinet Compensator and its Uses. Analysis of Polarized Light.

Rotatory Polarization: Optical Rotation. Biot’s Laws for Rotatory Polarization. Fresnel’s Theory of optical rotation. Calculation of angle of rotation. Experimental verification of Fresnel’s theory. Specific rotation. Laurent’s half-shade polarimeter.

**Each unit shall have one long question carrying 12 marks and as option to the long questions 2/3(Two or Three) short questions carrying 6/4(Six or Four) marks each will be asked.**

**PHYSICS PRACTICAL-C XIII LAB**

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 study dependence of radiation on angle for a simple Dipole antenna.

5. To determine the wavelength and velocity of ultrasonic waves in a liquid (Kerosene Oil, Xylene, etc.) by studying the diffraction through ultrasonic grating.

6. To study the reflection, refraction of microwaves

7. To study Polarization and double slit interference in microwaves.

8. To determine the refractive index of liquid by total internal reflection using Wollaston’s air- film.

9. To determine the refractive Index of (1) glass and (2) a liquid by total internal reflection using a Gaussian eyepiece.

10. To study the polarization of light by reflection and determine the polarizing angle for air- glass interface.

11. To verify the Stefan`s law of radiation and to determine Stefan’s constant.

12. To determine the Boltzmann constant using V-I characteristics of PN junction diode

**SEM-VI CORE- XIV: STATISTICAL MECHANICS**

**Full Marks- Internal-15+ Practical-25+Sem End Exam-60**

**Unit-I**

**Classical Statistics:** Macrostate & Microstate, Elementary Concept of Ensemble, Microcanonical, Canonical and grand canonical ensemble. Phase Space, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, Partition Function.

**UNIT-II**

Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox, Sackur Tetrode equation, Law of Equipartition of Energy (with proof) – Applications to Specific Heat and its Limitations, Thermodynamic Functions of a Two-Energy Levels System, Negative Temperature.

**Unit-III**

**Radiation:** Properties of Thermal Radiation. Blackbody Radiation. Pure temperature dependence. Kirchhoff’s law. Stefan-Boltzmann law: Thermodynamic proof. Radiation Pressure. Wien’s Displacement law. Wien’s Distribution Law. Saha’s Ionization Formula. Rayleigh-Jean’s Law. Ultraviolet Catastrophe.

**UNIT-IV**

Planck’s Law of Blackbody Radiation: Experimental Verification. Deduction of (1) Wien’s Distribution Law, (2) Rayleigh-Jeans Law, (3) Stefan-Boltzmann Law, (4) Wien’s Displacement law from Planck’s law.

**Unit-V**

**Quantum Statistics:** Identical particles, macrostates and micro states. Fermions and Bosons, Bose Einstein distribution function and Fermi-Dirac Distribution function. Bose-Einstein

Condensation, Bose deviation from Planck's law, Effect of temperature on F-D distribution function, degenarate Fermigas, Density of States, Fermi energy.

**Each unit shall have one long question carrying 12 marks and as option to the long questions 2/3(Two or Three) short questions carrying 6/4(Six or Four) marks each will be asked.**

**PHYSICS PRACTICAL-C XIV LAB**

***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.

**SEM-V PHYSICS-DSE (Discipline Specific Elective)**

**DSE-1 CLASSICAL DYNAMICS**

**Unit-I**

**Classical Mechanics of Point Particles:** Generalised coordinates and velocities. Hamilton's Principle, Lagrangian and Euler-Lagrange equations. Applications to simple systems such as coupled oscillators. Canonical momenta & Hamiltonian. Hamilton's equations of motion. Applications: Hamiltonian for a harmonic oscillator, particle in a central force field. Motion of charged particles in external electric and magnetic fields.

**Unit-II**

**Special Theory of Relativity:** Postulates of Special Theory of Relativity. Lorentz Transformations. Minkowski space. The invariant interval, light cone and world lines. Space-time diagrams. Time-dilation, length contraction & twin paradox. Four-vectors: space-like, time-like & light-like. Four-velocity and acceleration. Metric and alternating tensors. Four-momentum and energy-momentum relation. Doppler effect from a four vector perspective. Concept of four-force. Conservation of four-momentum. Relativistic kinematics. Application to two-body decay of an unstable particle.

**SEM-V PHYSICS-DSE-II: Nuclear and Particle Physics**

**Unit-I**

**General Properties of Nuclei**: Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, charge density (matter density), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/A plot, angular momentum, parity, magnetic moment, electric moments, nuclear excites states.

**Nuclear Models**: Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, two nucleon separation energies, evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model,

**Radioactivity decay**:(a) Alpha decay: basics of α-decay processes, theory of α- emission, Gamow factor, Geiger Nuttall law. (b) β-decay: energy kinematics for β-decay, positron emission, electron capture, neutrino hypothesis. (c) Elementary idea of Gamma decay.

**Nuclear Reactions:** Types of Reactions, Conservation Laws, kinematics of reactions, Q-value,

**Unit-II**

**Detector for Nuclear Radiations:** Gas detectors: estimation of electric field, mobility of particle, for ionization chamber and GM Counter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT). Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility), neutron detector.

**Particle Accelerators:** Van-de Graaff generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons.

**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, Isospin, Strangeness and charm. Elementary ideas of quarks and gluons.

**SEM-VI DSE-III COMPUTATIONAL PHYSICS**

**Unit-I**

**Introduction:** Importance of computers in Physics, paradigm for solving physics problems for solution**.** Usage of linux as an Editor. **Algorithms and Flowcharts:** Algorithm: Definition, properties and development. Flowchart: Concept of flowchart, symbols, guidelines, types. Examples: Cartesian to Spherical Polar Coordinates, Roots of Quadratic Equation, Sum of two matrices, Sum and Product of a finite series, calculation of sin(x) as a series, algorithm for plotting (1) lissajous figures and (2) trajectory of a projectile thrown at an angle with the horizontal.

**Scientific Programming**: Some fundamental Linux Commands (Internal and External commands). Development of FORTRAN, Basic elements of FORTRAN: Character Set, Constants and their types, Variables and their types, Keywords, Variable Declaration and concept of instruction and program. Operators: Arithmetic, Relational, Logical and Assignment Operators. Expressions: Arithmetic, Relational, Logical, Character and Assignment Expressions. Fortran Statements: I/O Statements (unformatted/formatted), Executable and Non-Executable Statements, Layout of Fortran Program, Format of writing Program and concept of coding, Initialization and Replacement Logic. Examples from physics problems.

**Unit-II**

**Control Statements:** Types of Logic (Sequential, Selection, Repetition), Branching Statements (Logical **IF**, Arithmetic IF, Block IF, Nested Block IF, SELECT CASE and ELSE IF Ladder statements), Looping Statements (DO-CONTINUE, DO-ENDDO, DOWHILE, Implied and Nested DO Loops), Jumping Statements (Unconditional GOTO, Computed GOTO, Assigned GOTO) Subscripted Variables (Arrays: Types of Arrays, DIMENSION Statement, Reading and Writing Arrays), Functions and Subroutines (Arithmetic Statement Function, Function Subprogram and Subroutine), RETURN, CALL, COMMON and EQUIVALENCE Statements), Structure, Disk I/O Statements, open a file, writing in a file, reading from a file. Examples from physics problems.

**Programming:**

1. Exercises on syntax on usage of FORTRAN

2. To print out all natural even/ odd numbers between given limits.

3. To find maximum, minimum and range of a given set of numbers.

4.To find a set of prime numbers and Fibonacci series

**PHYSICS-DSE-IV: Nano Materials and Applications**

**Unit-I**

**Nanoscale Systems:** Length scales in physics, Nanostructures: 1D, 2D and 3D nanostructures (nanodots, thin films, nanowires, nanorods)**,** Band structure and density of states of materials at nanoscale, Size Effects in nano systems, Quantum confinement: Applications of Schrodinger equation- Infinite potential well, potential step, potential box, quantum confinement of carriers in 3D, 2D, 1D nanostructures and its consequences.

**Synthesis Of Nanostructure Materials:** Top down and Bottom up approach, Photolithography. Ball milling. Gas phase condensation. Vacuum deposition. Physical vapor deposition (PVD): Thermal evaporation, E-beam evaporation, Pulsed Laser deposition. Chemical vapor deposition (CVD). Sol-Gel. Electro deposition. Spray pyrolysis. Hydrothermal synthesis. Preparation through colloidal methods. MBE growth of quantum dots.

**Unit-II**

**Characterization:** X-Ray Diffraction. Optical Microscopy. Scanning Electron Microscopy. Transmission Electron Microscopy. Atomic Force Microscopy. Scanning Tunneling Microscopy.

**Applications:** Applications of nanoparticles, quantum dots, nanowires and thin films for photonic devices (LED, solar cells). Single electron devices (no derivation). CNT based transistors. Nanomaterial Devices: Quantum dots heterostructure lasers, optical switching and optical data storage. Magnetic quantum well; magnetic dots - magnetic data storage. Micro Electromechanical Systems (MEMS), Nano Electromechanical Systems (NEMS).

**PHYSICS-DSE: Bio-Physics**

**Unit-I**

**Building Blocks & Structure of Living State:** Atoms and ions, molecules essential forblife, what is life. **Living state interactions:** Forces and molecular bonds, electric &bthermal interactions, electric dipoles, casimir interactions, domains of physics in biology.

**Heat Transfer in biomaterials:** Heat Transfer Mechanism, The Heat equation, Joule heating of tissue.

**Living State Thermodynamics:** Thermodynamic equilibrium, fIrst law of thermodynamics and conservation of energy. Entropy and second law of thermodynamics, Physics of many particle systems, Two state systems, continuous energy distribution, Composite systems, Casimir contribution of free energy, Protein folding and unfolding.

**Unit-II**

**Open systems and chemical thermodynamics:** Enthalpy, Gibbs Free Energy and chemical potential, activation energy and rate constants, enzymatic reactions, ATP hydrolysis & synthesis, Entropy of mixing, The grand canonical ensemble, Hemoglobin.

**Diffusion and transport** Maxwell-Boltzmann statistics, Fick’s law of diffusion, sedimentation of Cell Cultures, diffusion in a centrifuge, diffusion in an electric field, Lateral diffusion in membranes, Navier stokes equation, low Reynold’s Number Transport, Active and passive membrane transport.

**Fluids:** Laminar and turbulent fluid flow, Bernoulli’s equation, equation of continuity, venture effect, Fluid dynamics of circulatory systems, capillary action.

**Bioenergetics and Molecular motors:** Kinesins, Dyneins, and microtubule dynamics, Brownian motion, ATP synthesis in Mitochondria, Photosynthesis in Chloroplasts, Light absorption in biomolecules, vibrational spectra of bio-biomolecules.

**DSE-IV : Project (Compulsory)**

**Skill Enhancement Course (SEC-2)** Full marks-10+40

**RENEWABLE ENERGY AND ENERGY HARVESTING (To be tought)**

**Unit-I**

**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 plate collector, solar distillation, solar cooker, solar green houses, solar cell, absorption air conditioning. Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems.

**Unit-II**

**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.

**SEM-III GE-I: MECHANICS**

**Full Marks- Internal-15+ Practical-25+Sem End Exam-60**

**UNIT-I**

**Vectors:** Vector algebra. Scalar and vector products. Derivatives of a vector with respect to a parameter.

**Ordinary Differential Equations:** 1st order homogeneous differential equations. 2nd order homogeneous differential equations with constant coefficients.\

**Laws of Motion:** Frames of reference. Newton’s Laws of motion. Dynamics of a system of particles. Centre of Mass.

**Momentum and Energy:** Conservation of momentum. Work and energy. Conservation of energy. Motion of rockets.

**UNIT-II**

**Rotational Motion:** Angular velocity and angular momentum. Torque. Conservation of angular momentum.

**Oscillations:** Simple harmonic motion. Differential equation of SHM and its solutions. Kinetic and Potential Energy, Total Energy and their time averages. Damped oscillations

**UNIT-III**

**Gravitation:** Newton’s Law of Gravitation. Motion of a particle in a central force field (motion is in a plane, angular momentum is conserved, areal velocity is constant). Kepler’s Laws (statement only). Satellite in circular orbit and applications. Geosynchronous orbits. Basic idea of global positioning system (GPS). Weightlessness. Physiological effects on astronauts.

**UNIT-IV**

**Elasticity:** Hooke’s law - Stress-strain diagram - Elastic moduli-Relation between elastic constants - Poisson’s Ratio-Expression for Poisson’s ratio in terms of elastic constants - Work done in stretching and work done in twisting a wire - Twisting couple on a cylinder - Determination of Rigidity modulus by static torsion - Torsional pendulum-Determination of Rigidity modulus and moment of inertia - q, *η* and σ by Searles method

**UNIT-V**

**Special Theory of Relativity:** Constancy of speed of light. Postulates of Special Theory of Relativity. Length contraction. Time dilation. Relativistic addition of velocities.

**Each unit shall have one long question carrying 12 marks and as option to the long questions 2/3(Two or Three) short questions carrying 6/4(Six or Four) marks each will be asked.**

**PHYSICS LAB: GE LAB: MECHANICS**

1.Measurements of length (or diameter) using vernier caliper or screw gauge or

 travelling microscope & determine absolute error.

2. To determine the Height of a Building using a Sextant.

3. To determine the Moment of Inertia of CYLINDER.

4. To determine the Young's Modulus of BEAM.

5. To determine the Modulus of Rigidity of a Wire .

6. To determine the Elastic Constants of a Wire by Searle’s method.

7. To determine g by Bar Pendulum.

8. To determine g by Kater’s Pendulum.

9. To study the Motion of a Spring and calculate (a) Spring Constant, (b) g.

**SEM-IV GE-II: ELEMENTS OF MODERN PHYSICS**

**Full Marks- Internal-15+ Practical-25+Sem End Exam-60**

**UNIT-I**

Planck’s quantum, Planck’s constant and light as a collection of photons; Photoelectric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment.

**UNIT-II**

Problems with Rutherford model- instability of atoms and observation of discrete atomic spectra; Bohr's quantization rule and atomic stability; calculation of energy levels for hydrogen like atoms and their spectra.

Position measurement- gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle- impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle.

**UNIT-III**

 Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in nucleus as a consequence of the uncertainty principle. Nature of nuclear force, NZ graph, semi-empirical mass formula and binding energy.

Radioactivity: stability of nucleus; Law of radioactive decay; Mean life and half-life; α decay; β decay - energy released, spectrum and Pauli's prediction of neutrino; γ-ray emission.

Fission and fusion - mass deficit, relativity and generation of energy; Fission - nature of fragments and emission of neutrons. Nuclear reactor: slow neutrons interacting with Uranium 235; Fusion and thermonuclear reactions.

**UNIT-IV**

 Two slit interference experiment with photons, atoms & particles; linear superposition principle as a consequence; Matter waves and wave amplitude; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of wavefunction, probabilities and normalization; Probability and probability current densities in one dimension.

 **UNIT-V**

One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization; Quantum dot as an example; Quantum mechanical scattering and tunnelling in one dimension - across a step potential and across a rectangular potential barrier.

**Each unit shall have one long question carrying 12 marks and as option to the long questions 2/3(Two or Three) short questions carrying 6/4(Six or Four) marks each will be asked.**

**GE LAB: ELEMENTS OF MODERN PHYSICS**

1. To determine value of Boltzmann constant using V-I characteristic of PN diode.

2. To determine work function of material of filament of directly heated vacuum diode.

3. To determine the amplification factor of triods.

4. To determine value of Planck’s constant using LEDs of at least 4 different colours.

5. To determine the wavelength of H-alpha emission line of Hydrogen atom.

6. To determine the absorption lines in the rotational spectrum of Iodine vapour.

7. To study the diffraction patterns of single and double slits using laser and measure its intensity variation using Photosensor & compare with incoherent source – Na.

8. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light

9. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.

10. To setup the Millikan oil drop apparatus and determine the charge of an electron.

11. To determine value of plate resistance using V-I characteristic of PN diode

12. To study the characteristics of PNP/NPN- transtser