THE BHAWANIPUR EDUCATION SOCIETY COLLEGE

A MINORITY RUN COLLEGE. AFFILIATED TO UNIVERSITY OF CALCUTTA
RECOGNISED UNDER SECTION 2(F) & 12 (B) OF THE UGC ACT, 1956

Programme Specific Outcomes (PSO)

B.Sc. (Honours) Physics 2019-2020

1. **The students will be familiar the fundamentals of physical theory and practical application.**
2. **The students will know the theoretical foundations related to different natural phenomena.**
3. **The students will learn the theory and techniques of professional and engineering practices.**
4. **The students should know how to become effective and ethical practitioners contributing to social and national development.**

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Programme Outcome (PO)

B.Sc. (Honours) Physics 2019-2020

	Program Outcome	Description
PO1	**Subject Knowledge**	Knowing the fundamentals of the different areas of discussion within the subject which will enable the students to consider applying the theoretical principles.
	Method of Measurement:	**Assessment (Internal & university exam)**
PO2	**Communication Skills**	Encouraging the students to apply the principles of physics in their own lives, both professional and personal, thus, they can communicate with society and nation with scientific view.
	Method of Measurement:	**Regular Internal Assessment**
PO3	**Technical Skill Development**	Knowing and developing the technical skills expected from the students professional area.
	Method of Measurement:	**Assessment (Internal & Final)**
PO4	**Personality Development**	Personality development skills to the students that are likely to be developed and enlighten their professional and personal lives, thus making them responsible and sincere citizens.
	Method of Measurement:	**Regular Mentoring**

PO5	**Higher Study Foundation**	Encouraging the students to pursue higher studies and research in the subject and enhance their knowledge on the same.
	Method of Measurement:	**Regular Teacher-Student Interactive Sessions**
PO6	**Research Orientation and Aptitude**	Encouraging the students to pursue research related to the subject either in the academic or in the professional sphere that may lead to a vibrant knowledge economy.
	Method of Measurement:	**Regular Teacher-Student Interactive Sessions**
PO7	**Spirit of Team Work**	Encouraging the students to coordinate with one another in a team environment and perform well as a team rather than trying to excel individually at the cost of group performance efficiency.
	Method of Measurement:	**Group Activity Assignments Assessment**
PO8	**Socio-Cultural and Environmental Responsibility**	Encouraging the students to be socio-culturally and environmentally responsible citizens and work accordingly towards the betterment of the society and the nation.
	Method of Measurement:	**Regular Teacher-Student Interactive Sessions**

Semester – 1 Course Outcomes

PAPER	COURSE OUTCOME
PHS-A-CC-1-1-TH: Mathematical Physics	
1. Calculus (a) Recapitulation: Limits, continuity, average and instantaneous quantities, differentiation. Plotting functions. Intuitive ideas of continuous, differentiable, etc. functions and plotting of curves. Approximation: Taylor and binomial series (statements only). (b) First Order and Second Order Differential equations: First Order Differential Equations and Integrating Factor. Homogeneous Equations with constant coefficients. Wronskian and general solution. Statement of existence and Uniqueness Theorem for Initial Value Problems. Particular Integral. (c) Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. Constrained Maximization using Lagrange Multipliers.	1. Student must know the properties of partial differentiation. .

2. Vector Algebra and Vector Calculus (a) Recapitulation of Vector Algebra. Idea of linear independence, completeness, basis and representation of vectors. Properties of vectors under rotations. Scalar product and its invariance under coordinate rotations. Vector product, Scalar triple product and their interpretation in terms of area and volume respectively. (b) Vector Differentiation: Scalar and Vector fields. 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. (c) 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).	2. How to apply vector analysis in the field of different areas of physics.
3. Orthogonal Curvilinear Coordinates (a) Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems. 14 4. Matrices (a) Addition and Multiplication of Matrices. Null Matrices. Diagonal, Scalar and Unit Matrices. Transpose of a Matrix. Symmetric and Skew-Symmetric Matrices. Conjugate of a Matrix. Hermitian and Skew- Hermitian Matrices. Singular and Non-Singular matrices. Orthogonal and Unitary Matrices. Trace of a Matrix. Inner Product. (b) Eigen-values and Eigenvectors. Cayley- Hamiliton Theorem. Diagonalization of Matrices. Solutions of Coupled Linear Ordinary Difierential Equations. Functions of a Matrix.	3. Students must learn how to interpret mathematics physically. 4. Student should know on matrix theory.

Introduction and Overview (a) Computer architecture and organization, memory and Input/output devices. 2. Basics of scientific computing (a) 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.	5.Through the course of practical student should know the elementary programming with python and gnuplot.
3. Errors and error Analysis. (a) Truncation and round off errors, Absolute and relative errors, Floating point computations.	Through the course of practical student should know the elementary error analysis
4. Introduction to plotting graphs with Gnuplot / QtiPlot (or some other GUI based free software like Grace, Origin etc.) (a) Basic 2D graph plotting - plotting functions and data files, fitting data using gnuplot's fit function, polar and parametric plots, modifying the appearance of graphs, exporting plots.	Through the course of practical student should know the elementary graph drawing with python and gnuplot.
5. Introduction to programming in python: (a) Introduction to programming, constants, variables and data types, dynamical typing, operators and expressions, modules, I/O statements, file handling, iterables, compound statements, indentation in python, the if-elif-else block, for and while loops, nested compound statements.	Through the course of practical student should know the elementary programming with python and numerical analysis
6. Programs (a) Elementary calculations with difierent type of data e.g., area and volume of regular shapes using formulae. Creation and handling one dimensional array. Sum and average of a list of numbers stored in array, finding the largest and lowest number from a ist, swapping two data in a list, sorting of numbers in an array using bubble sort, insertion sort ethod. Calculation of term value in a series and	Through the course of practical student should know the elementary programming with python and able to analyze data.

Finding the other terms with a seed (value of particular term) and calculation of different quantities with series. Convergence and accuracy of series. Introduction of three dimensional array. Simple calculations of matrices e.g., addition, subtraction, multiplication.	Through the course of practical student should know the elementary programming with python and series handling.

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Paper-PHS-A-CC-1-2-TH : Mechanics	
Fundamentals of Dynamics (a) Review of Newtons Laws: Mechanistic view of the Universe. Concepts of Inertial frames, force and mass. Solution of the equations of motion (E.O.M.) in simple force fields in one, two and three dimensions using cartesian, cylindrical polar and spherical polar oordinate systems. Dynami cs of systems of particles: Dificulty of solving the E.O.M. for systems of particles. Newton's third Law. External and Internal forces. Momentum and Angular Momentum of a system. Torque acting on a system. Conservation of Linear and Angular Momentum. Centre of mass and its properties. Two-body problem. (b) Variable- mass system: motion of rocket.	1.Ability to analyze kinematics of the three-dimensional particle motion in various coordinate systems: cartesian, natural and cylindrical
2. Work and Energy (a) Work - Kinetic Energy Theorem. Conservative Forces: Force as the gradient of a scalar field - concept of Potential Energy. Other equivalent definitions of a Conservative Force. Conservation of Energy. (b) Qualitative study of one dimensional motion from potential energy curves. Stable and Unstable equilibrium. (c) Energy of a system of particles.	2.Student must know how to solve equation of motion using newtons law and calculate work,power and energy
3. Gravitation and Central Force Motion (a) Central Force. Reduction of the two body central force problem to a one-body problem. Setting up the E.O.M. in plane polar coordinates. (b) Difierential equation for the path. Motion under an Inverse-square force. Newton's Law of Gravitation. Inertial and gravitational mass. Kepler's Laws. Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness. Basic idea of global positioning system (GPS).	3.Ability to analyze particle dynamics for a system of particles

(c) Gravitational potential energy. Potential and field due to spherical shell and solid sphere.	
4. Non-Inertial Systems (a) Galilean transformations and Galilean invariance. (b) Non-inertial frames and idea of fictitious forces. E.O.M with respect to a uniformly accelerating frame. E.O.M with respect to a uniformly rotating frame - Centrifugal and Coriolis forces. Laws of Physics in a laboratory on the surface of the earth.	4.Ability to analyze particle dynamics for a system of particles
5. Rotational Dynamics (a) The Rigid Body: Constraints defining the rigid body. Degrees of freedom for a rigid body; (b) Relation between Angular momentum and Angular Velocity – Moment of Inertia Tensor. Calculation of moment of inertia for rectangular, cylindrical and spherical bodies. (c) E.O.M for rotation about a fixed axis. (d) Principal Axes transformation. Transformation to a body fixed frame. E.O.M for the rigid body with one point fixed (Euler's equations of motion). General motion of a rigid body - translation plus rotation. Kinetic energy of rotation.	5.Ability to analyze particle dynamics for a system of particles

7. Fluid Motion (a) Kinematics of Moving Fluids: Idea of compressible and incompressible fiuids, Equation of continuity; streamline and turbulent fiow, Reynold's number. Euler's Equation. The special case of fiuid statics ~F = rp: Simple applications (e.g: Pascal's law and Archimedes principle). (b) Poiseuille's equation for Flow of a viscous Liquid through a CapillaryTube.	7. They will learn the properties of liquid and gas. They will learn how to measure the general properties of materials

Practical 1. To determine the Moment of Inertia of a metallic cylinder / rectangular bar about an axis passing through the C.G. and to determine the Modulus of Rigidity of the suspension wire.	Through the course of practical student should know the elementary properties of materials and measure them.
2. To determine the Moment of Inertia of a Flywheel.	Through the course of practical student should know the elementary properties of Moment of Inertia and measure them.
3. To determine Coeficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).	Through the course of practical student should know the elementary properties of Coeficient of Viscosity and measure them.
4. Determination of Young's modulus of the material of a beam by the method of fiexure.	Through the course of practical student should know the elementary properties of Young's modulus and measure them.
5. To determine the elastic constants of a material by Searle's method.	Through the course of practical student should know the elementary properties of elastic constants and measure them.
6. To determine the value of g using Bar Pendulum.	Through the course of practical student should know the elementary properties of Bar Pendulum and measure them.
7. To determine the height of a building using sextant.	Through the course of practical student should know the elementary properties of sextant and measure with them.

Semester – 2 Course Outcomes	
Paper-CCIII Electricity and Magnetism	
Electrostatic Field (a) Coulombs law and Principle of superposition leading to the definition of Electrostatic Field. Field lines. (b) Divergence of the Electrostatic field. Flux, Gauss's theorem of electrostatics. Applications of Gauss theorem to find Electric field due to charge configurations with spherical, cylindrical and planar symmetry. (c) Curl of the Electrostatic Field and its conservative nature. Electric potential. Potential for a uniformly charged spherical shell and solid sphere. Calculation of electric field from potential. (d) Laplace's and Poisson equations. Uniqueness Theorems. Method of Images and its application to: (1) Plane Infinite Sheet and (2) Sphere. (e) Conductors: Electric field and charge density inside and on the surface of a conductor. Conductors in an electrostatic field. Force per unit area on the surface. Capacitance of a conductor. Capacitance an isolated spherical conductor. Parallel plate condenser. (f) Electrostatic energy of system of charges. Electrostatic energy of a charged sphere. (g) Energy per unit volume in electrostatic field.	1.know basic models of magnetism and electrostatics
2. Dielectric properties of matter (a) Electric potential and field due to an electric dipole. Electric dipole moment. Force and torque on a dipole. (b) Electric Fields inside matter: Electric Polarization. Bound charges. Displacement vector. Relations between E, P and D. Gauss's theorem in dielectrics. Linear Dielectric medium. Electric Susceptibility and	2. learn to solve electrostatic boundary value problems

Permittivity. Capacitor (parallel plate, spherical, cylindrical) filled with dielectric.	
3. The Magnetostatic Field (a) Biot-Savart's law. Force on a moving point charge due to a magnetic field: Lorentz force law. Application of Biot-Savart's law to determine the magnetic field of a straight conductor, circular coil. Force between two straight current carrying wires. (b) Divergence of the magnetic field - its solenoidal nature. Magnetic vector potential. (1) Curl of the magnetic field. Ampere's circuital law. Its application to Infinite straight wire, (2) Infinite planar surface current, and (3) Solenoid.	3. learn the applications of Gauss' theorem
4. Magnetic properties of matter. (a) Potential and field due to a magnetic dipole. Magnetic dipole moment. Force and torque on a magnetic dipole in a uniform magnetic field. (b) Magnetization. Bound currents. The magnetic intensity - H. Relation between B, H and M. Linear media. Magnetic Susceptibility and Permeability. Brief introduction of dia-, para- and ferro- magnetic materials. B-H curve and hysteresis.	4.Knowledge of various specialized fields and genres of journalism
5. Electro-magnetic induction (a) Ohms law and definition of E.M.F. Faraday's laws of electromagnetic induction, Lenz's law. Self-Inductance and Mutual Inductance. Reciprocity Theorem. Introduction to Maxwell's Equations. Charge conservation. Displacement current and resurrection of Equation of Continuity. (b) Energy stored in magnetic field.	5. Knowledge of various specialized fields and genres of journalism

6. Electrical circuits (a) AC Circuits: Kirchhofi'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	6. Learn to solve network analysis.
7. Network theorems (a) 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.	7. Learn to solve network analysis.

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Paper-CC IV Waves and Optics	
Oscillations (a) SHM: Simple Harmonic Oscillations. Difierential 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.	1.In this course student should learn the physics of vibration, oscillation and resonance
2. Superposition of Harmonic Oscillations (a) Superposition of Collinear Harmonic oscillations: Linearity and Superposition	2. In this course student should learn the physics of vibration, oscillation and resonance
3. Wave motion (a) Plane and Spherical Waves. Longitudinal and Transverse Waves. Plane Progressive (Traveling) Waves. Wave Equation. Particle and Wave Velocities. Difierential Equation. Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave. (b) Water Waves: Ripple and Gravity Waves.	3. In this course student should learn the physics of vibration, oscillation and resonance
4. Velocity of Waves (a) Velocity of Transverse Vibrations of Stretched Strings. (b) Velocity of Longitudinal Waves in a Fluid in a Pipe. Newton's Formula for Velocity of Sound. Laplace's Correction.	4. In this course student should learn the physics of vibration, oscillation and resonance

5. Superposition of Harmonic Waves (a) Standing (Stationary) Waves in a String: Fixed and Free Ends. Analytical Treatment. Changes with respect to Position and Time. Energy of Vibrating String. Transfer of Energy. Normal Modes of Stretched Strings. Plucked and Struck Strings. Melde's Experiment. (b) Longitudinal Standing Waves and Normal Modes. Open and Closed Pipes. (c) Superposition of N Harmonic Waves. Phase and Group Velocities.	5. In this course student should learn the physics of vibration, oscillation and resonance
6. Wave optics (a) Electromagnetic nature of light. Definition and properties of wave front. Huygens Principle. Temporal and Spatial Coherence.	6. Learn physics of light and able to understand underlying magnificent phenomena of light.
7. Interference (a) Division of amplitude and wavefront. Young's double slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on refiection: 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.	7. Learn the mechanism of optical instruments.
8. Interferometers (a) Michelson Interferometer-(1) Idea of form of fringes (No theory required), (2) Determination ofWavelength, (3)WavelengthDifierence, (4) Refractive Index, and (5) Visibility of Fringes. (b) Fabry-Perot interferometer.	7. Student should learn Modern optical instruments and their basic principles

9. Difiraction and Holography (a) Fraunhofer diffraction: Single slit. Circular aperture, Resolving Power of a telescope. Double slit. Multiple slits. Difiraction grating. Resolving power of grating. (b) 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. (c) Holography: Principle of Holography. Recording and Reconstruction Method. Theory of Holography as Interference between two Plane Waves. Point source holograms.	8. Student should learn Modern optical instruments and their basic principles
Practical 2. To determine refractive index of the Material of a prism using sodium source.	From the experimental course student must learn to calibrate an optical instrument and measure refractive index of the Material of a
3. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.	4. From the experimental course student must learn to calibrate an optical instrument and measure dispersive power and Cauchy constants of the material
5. To determine wavelength of sodium light using Fresnel Biprism.	From the experimental course student must learn to calibrate an optical instrument and measure wavelength of sodium light
6. To determine wavelength of sodium light using Newton's Rings?	From the experimental course student must learn to calibrate an optical instrument and measure wavelength of sodium light
7. To determine the thickness of a thin paper by measuring the width of the interference fringes produced by a wedge-shaped Film.	From the experimental course student must learn to calibrate an optical instrument and measure the thickness of a thin paper

8. Measurement of the spacing between the adjacent slits in a grating by measuring sin(x) vs wave length graph of a certain order of grating spectra.	From the experimental course student must learn to calibrate an optical instrument and measure the spacing between the adjacent slits

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Semester – 3 Course Outcomes	
Paper-CC V: Mathematical Physics – II	
1. Fourier Series (a) 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 difierentiation and integration of Fourier Series. Parseval Identity.	1.Student must know the method of expansion in eigenfunction.
2. Frobenius Method and Special Functions (a) Singular Points of Second Order Linear Difierential Equations and their importance. Frobenius method and its applications to difierential equations. Legendre, Bessel, Hermite and Laguerre Difierential 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 (Jo(x) and J1(x))and Orthogonality.	2.Student must know the properties of special function.
3. Some Special Integrals	3. Student must know the properties of special function and their properties must be clear to them.

(a) Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. Error Function (Probability Integral).	
4. Variational calculus in physics (a) Functionals. Basic ideas of functionals. Extremization of action as a basic principle in mechanics. Lagrangianfomulation. Euler's equations of motion for simple systems: harmonics oscillators, simple pendulum, spherical pendulum, coupled oscillators. Cyclic coordinates. Symmetries and conservation laws. Legendre transformations and the Hamiltonian formulation of mechanics. Canonical equations of motion. Applications to simple systems.	4. Student must know the advanced techniques like variational principle should be familiar to them.
5. Partial Difierential Equations (a) Solutions to partial difierential equations, using separation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry. Wave equation and its solution for vibrational modes of a stretched string, rectangular and circular membranes. Difiusion Equation.	5. Student must know how to solve the partial differential equation and common application and the behaviour of daily life phenomena of hearing and sound production must be clear to them.

Practical 1. Introduction to Numerical computation using numpy and scipy. (a) Introduction to the python numpy module. Arrays in numpy, array operations, array item selection, slicing, shaping arrays. Basic linear algebra using the linalg submodule. Introduction to online graph plotting using matplotlib. Introduction to the scipy module. Uses in optimization and solution of difierential equations.	. Student must learn how to represent data and experimental results are also be the outcome of the course.
2. Solution of Linear system of equations by Gauss elimination method and Gauss Seidel method.	Student must learn how to represent data and analyze with Gauss elimination method and Gauss Seidel method
3. Diagonalization of matrices, Inverse of a matrix, Eigen vectors, eigen values problems (a) Solution of mesh equations of electric circuits (3 meshes) (b) Solution of coupled spring mass systems (3 masses)	Student must learn how to represent data and analyze with matrices
4. Generation of Special functions using User defined functions (a) Generating and plotting Legendre Polynomials Generating and plotting Bessel function (Make use of generating function and recursion formula).	Student must learn how to represent data and analyze with Special functions
5. Root finding: Bisection and Newton-Raphson method.	Student must learn how to represent data and analyze with Bisection and Newton-Raphson method
6. Interpolation by Lagranges method.	Student must learn how to represent data and analyze with Lagranges method
7. Numerical difierentiation - forward and backward difierence formulae.	Student must learn how to represent data and analyze with Numerical difierentiation
8. Numerical integration - trapezoidal and simpsons rule.	Student must learn how to represent data and analyze with Numerical integration
9. Solution of ODE: First order Difierential equation - Euler's method.	Student must learn how to represent data and analyze with Solution of ODE
10. Basic 3D graph plotting - plotting functions and data files, parametric plots, Surface and contour plots.	Student must learn how to represent data and analyze with Basic 3D graph plotting

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Paper- CC VI Heat and Thermodynamics	
1. Introduction to Thermodynamics (a) Zeroth and First Law of Thermodynamics: Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics & Concept of Temperature. Concept of Work & Heat, State Functions, Internal Energy and First Law of Thermodynamics. Its difierential form, First Law & various processes. Applications of First Law: General Relation between CP and CV, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Co-eficient. (b) 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 &eficiency. Refrigerator &coeficient of performance, 2nd Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. (c) Carnot's Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale. (d) 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 Universe. Entropy Changes in Reversible and Irreversible	1.Student should able to understand heat work and the relation between them.

Processes Principle of Increase of Entropy. Temperature-Entropy diagrams for Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero.	
2. Thermodynamic Potentials (a) 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 (b) Maxwell's Thermodynamic Relations (c) 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.	2. Students are able to learn the underlying principles of engines and principles of entropy.
3. Kinetic Theory of Gases (a) Distribution of Velocities: Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas and its Experimental Verification. Doppler Broadening of Spectral Lines and Stern's Experiment. Mean, RMS and Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy (No proof required). Specific heats of Gases. (b) Molecular Collisions: Mean Free Path. Collision Probability. Estimates	3.Understand the nature of real gas, atmosphere and radiation

of Mean Free Path. Transport Phenomenon in Ideal Gases: (1) Viscosity, (2) Thermal Conductivity and (3) Difiusion. Brownian Motion and its Significance.	
4. Conduction of Heat	4. The working principles of engines should be clear to them.
Paper- CC VII Digital Systems and Applications	
1. (a) Blackbody Radiation, Planck's quantum hypothesis, Planck's constant (derivation of Planck formula is not required). Photoelectric effect and Compton scattering - light as a collection of photons. Davisson-Germer experiment. De Broglie wavelength and matter waves. Wave-particle duality. Wave description of particles by wave packets. Group and Phase velocities and relation between them. Probability interpretation: Normalized wave functions as probability amplitudes. (b) Two-slit experiment with photons and electrons. Linear superposition principle as a consequence. (c) Position measurement, gamma ray microscope thought experiment. Heisenberg uncertainty principle (Statement with illustrations). Impossibility of a particle following a trajectory.	. Students are able to learn the underlying principles and applications of quantum concepts in simple and complex systems.
2. Basics of Quantum Mechanics (a) Quantum measurements: Deterministic vs probabilistic view points. States as normalised vectors (normalised wave functions). Dynamical variables as linear Hermitian operators (position, momentum, angular momentum, and energy as examples). Schrödinger equation as a first principle. Probabilistic interpretation of wavefunction and equation of continuity (in 1D). Time evolution of wavefunction and exp(iHt/~) as the evolution operator. Stationary states. Eigenvalue equation. (c) Application to one dimensional systems: Boundary conditions on wave functions. Particle in an infinitely rigid box: energy eigenvalues and eigenfunctions, normalization. Quantum dot. Quantum mechanical tunnelling across a step potential & rectangular potential barrier, α-decay as an example. (d) Simultaneous measurements: Compatible and incompatible observables and their relation to commutativity.Heisenberg's uncertainty relation for a pair of incompatible observables. Illustration of the ideas using [xi, pj] and [Li,Lj].	Students are able to learn the underlying principles and applications of quantum mechanics in simple and complex systems.
3. Nuclear Structure (a) 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. (b) Nature of nuclear force, NZ graph. (c) Nuclear Models: Liquid Drop model. semi-empirical mass formula and binding energy. Nuclear Shell Model.	Students are able to learn the underlying principles and applications of quantum mechanics in simple and complex systems.
4. Interaction with and within nucleus (a) Radioactivity: 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. (b) 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	Students are able to learn the underlying principles and theories of nuclear physics.

thermonuclear reactions driving stellar energy (brief qualitative discussions)	
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. Basic lasing action	Students are able to learn the underlying principles and theories of LASER physics.
Measurement of Plank constant using LED	Students are able to learn the underlying principles and measurements of Plank constant using LED
2. Verification of Stefan’s law of radiation by the measurement of voltage and current of a torch bulb glowing it beyond draper point.	Students are able to learn the underlying principles and measurements of Stefan’s law of radiation by the measurement of voltage and current of a torch bulb
3. Determination of e/m of electrons by using bar magnet. .	Students are able to learn the underlying principles and measurements of of e/m of electrons by using bar magnet
4. To study the photoelectric effect: variation of photocurrent versus intensity and wavelength of light.	Students are able to learn the underlying principles and measurements of photoelectric effect
5. To show the tunneling effect in tunnel diode using I-V characteristics	Students are able to learn the underlying principles and measurements of the tunneling effect in tunnel diode using I-V characteristics

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SEC A-1 (Technical Skill) Scientific Writing (Project type)

1. Introduction to LATEX The difference between WYSIWYG and WYSIWYM. Preparing a basic LATEX file. Compiling LATEX file.	Students are able to write their scientific content in LATEX.
2. Document classes : Different type of document classes, e.g., article, report, book etc. 3. Page Layout 2 Lectures Titles, Abstract, Chapters, Sections, subsections, paragraph, verbatim, References, Equation references, citation.	Students are able to write their scientific content in LATEX using different type of document classes, e.g., article, report, book etc.
4. List structures: Itemize, enumerate, description etc.	Students are able to write their scientific content in LATEX using List structures
5. Representation of mathematical equations Inline math, Equations, Fractions, Matrices, trigonometric, logarithmic, exponential functions, line-surfacevolume integrals with and without limits, closed line integral, surface integrals, Scaling of Parentheses, brackets etc.	Students are able to write their scientific content in LATEX using mathematical equations
6. Customization of fonts Bold fonts, emphasise, mathbf, mathcal etc. Changing sizes Large, Larger, Huge, tiny etc.	Students are able to write their scientific content in LATEX using different fonts
7. Writing tables Creating tables with different alignments, placement of horizontal, vertical lines.	Students are able to write their scientific content in LATEX using Writing tables
8. Figures Changing and placing the figures, alignments	Students are able to write their scientific content in LATEX using Figures

Course CC8

1. Complex Analysis (a) Brief Revision of Complex Numbers and their Graphical Representation. Euler’s formula, Roots of Complex Numbers. Functions of Complex Variables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions. 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. only single valued integrals; simple poles on and off the real axis.	Students are able to learn the underlying principles and applications of Complex Analysis
2. Variational calculus in Physics Functionals. Basic ideas of functionals. Extremization of action as a basic principle in mechanics. Lagrangian formulation. Euler’s equations of motion for simple systems: harmonic oscillators, simple pendulum, spherical pendulum, coupled oscillators. Cyclic coordinates. Symmetries and conservation laws. Legendre transformations and the	Students are able to learn the underlying principles and applications of . Variational calculus in Physics

Hamiltonian formulation of mechanics. Canonical equations of motion. Applications to simple systems.	
3. Special theory of Relativity (a) 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. Relativistic Dynamics. Variation of mass with velocity. Massless Particles. Mass-energy Equivalence. Transformation of Energy and Momentum. (b) A short introduction to tensors Covariant and contravariant vectors. Contraction. Covariant, contravariant, and mixed tensors of rank-2, transformation properties. The metric tensor (flat space-time only). Raising and lowering of indices with metric tensors. (Consistent use of convention → diag(1,-1,-1,-1).) (c) Relativity in Four Vector Notation: Four-vectors, Lorentz Transformation and Invariant interval, Space-time diagrams. Proper time and Proper velocity. Relativistic energy and momentum - Four momentum. Conservation of four momentum and applications to collisions. Minkowski Force.	Students are able to learn the underlying principles and applications of Special theory of Relativity

Semester – 4 Course Outcomes	
Paper-CC IX: Analog Electronics	
1. Circuits and Network Discrete components, Active & Passive components, 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.	1. Students can learn techniques of solving circuits involving different active and passive elements,to analyze the behavior of the circuit's response in time domain. To understand the significance of network functions.

2. Semiconductor Diodes and application (a) 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. (b) Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, L and C filter. Circuit and operation of clipping and clamping circuit. (c) Principle and structure of • LEDs • Photodiode • Solar Cell • Varactor diode	2. Students will be able to tell theory of semiconductors. • Explains an atom and basic terms related with an atom. • Recognizes conductor, semiconductor, and insulator and explains characteristics of these materials.
3. Bipolar Junction transistors and biasing (a) n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Physical Mechanism of Current Flow. Current gains α and β, Relations between them. Active, Cut-off and saturation Regions. DC Load line and Q-point. (b) Transistor Biasing and Stabilization Circuits; Fixed Bias, collector to base bias, emitter or self-bias, 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.	3. Students learn principle of operation, construction and characteristics of various electronic devices. •They know about different applications of these devices • They acquire the concepts involved in design of Electronic Circuits
4. Field Effect transistors JFET and MOSFET (both depletion and enhancement type) as a part of MISFET. Basic structure & principle of operations and their characteristics. Pinch off, threshold voltage and short channel effect.	4. Students will be able to • list the various major forms of field-effect transistor (FET); • describe the characteristics common to all forms of FET and explain how these characteristics make them suitable for use in amplifiers; • explain the notation and symbols used in FET circuits; • describe the physical operation of both MOSFETs and JFETs and explain how this influences the characteristics of these devices; • outline the behaviour of FETs; • discuss the use of FETs in a range of amplifier circuits; • suggest a number of other uses of FETs in electronic circuits.

5. Regulated power supply Load regulation and line regulation. Zener diode as a voltage regulator. The problem with the zener regulator circuit. Requirement of feedback and error amplifier. Study of series regulated power supply using pass and error transistor assisted by zener diode as a reference voltage supplier.	5. Students will be able to • Describe about the Power Supply and their classifications. • Identify the Linear Power Supply.
6. Amplifiers Transistor amplifier; CB, CE and emitter follower circuit and their uses. Load Line analysis of Transistor amplifier. Classification of Class A, B & C Amplifiers with respect to placement to Q point. Frequency response of a CE amplifier. The role of series and parallel capacitors for cut off frequencies. The idea about the value of coupling and bypass capacitor with respect to lower cut-off frequencies. Miller capacitance and its role in higher cut-off frequency	6. Students will be able to • Analyze different biasing circuits and low frequency response of an amplifier using h parameters. • Develop an ability to analyze high frequency transistor model. • Explain various multistage and power amplifier configurations. • Explain the concept of feedback and its characteristics.
7. Feedback amplifiers and OPAMP (a) Effects of Positive and Negative Feedback. Voltage series, current series, voltage shunt and current shunt feedback and uses for specific amplifiers. Estimation of Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise for voltage series feedback (b) Operational Amplifiers (Black Box approach): Characteristics of an Ideal and Practical Op-Amp. (IC 741) Open-loop and Closed-loop voltage Gain. Frequency Response. CMRR. Slew Rate and concept of Virtual ground. (c) Application of OPAMP: D.C. Application: • Inverting and non-inverting amplifiers • Inverting and non-inverting Adder Differentiator as Subtractor • Logarithmic & anti logarithmic amplifiers • Error amplifier – Comparator – Schmidt Trigger A.C. Application: • Differentiator • Integrator	7. Students will be able to • Apply op-amps fundamentals in design and analysis of op-amps applications. • Apply op-amps fundamentals and computer tools in project design, evaluation, and analysis.

8. Multivibrator: Transistor as a switch, Explanation using CE output characteristics. Calculation of component values for a practical transistor switch. Transistor switching times, use of speed up capacitor (Physical explanation only) Construction and operation, using wave shapes of collector coupled Bistable, Monostable andAstable Multivibrator circuits, Expression for time period.	8. Students will be able to • Design of multistage amplifier and oscillators • Analyze the importance of feedback in amplifiers. • Analyze the performance of power amplifiers and its applications. • Design mutivibrators for some particular application.
9.Oscillators Sinusoidal Oscillators: Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, Wein Bridge oscillator, determination of feedback factor and frequency of oscillation. Reactive network feedback oscillators: Hartley's & Colpitt's oscillators. Relaxation oscillator using OPAMP.	9. The studentwill be able to: • Analyze different biasing circuits and low frequency response of an amplifier using h parameters. • Develop an ability to analyse high frequency transistor model. • Explain the principles of oscillation and design various oscillator circuits.

Semester – 4 Course Outcomes	
Paper-CC X: Quantum Mechanics	
1. Wave packetdescription : Description of a particle using wave packets. Spread of the Gaussian wave-packet for a free particle in onedimension. Fourier transforms and momentum space wavefunction. Position-Momentum uncertainty.	1. The student will be able to: • Know type of potential energy including creating a double potential, • Height and width of the potential energy; • Energy of the Gaussian wave packet;

2. General discussion of bound states in an arbitrary potential: Continuity of wave function, boundary condition and emergence of discrete energy levels. Application to onedimensional square well potential of finite depth.	2. The student will be able to: • Know Continuity of wave function • Application to one dimensional square well
3. Quantum mechanics of simple harmonic oscillator Setting up the eigenvalue equation for the Hamiltonian. Energy levels and energy eigenfunctions in terms ofHermite polynomials (Solution to Hermite differential equation may be assumed). Ground state, zero point energy& uncertainty principle.	3. The student will be able to: • Describe the model of the quantum harmonic oscillator • Identify differences between the classical and quantum models of the harmonic oscillator • Explain physical situations where the classical and the quantum models coincide
4. Quantum theory of hydrogen-like atoms Reduction of a two body problem to a one body problem. The time independent Schrodinger equation fora particle moving under a central force, the Schrodinger equation in spherical polar coordinates. Separation ofvariables. Angular equation and orbital angular momentum. Spherical Harmonics (Solution to Legendre differentialequation may be assumed). Radial equation for attractive coulomb interaction - Hydrogen atom. Solution for theradial wavefunctions (Solution to Laguerre differential equation may be assumed). Shapes of the probability densitiesfor ground & first excited states. Orbital angular momentum quantum numbers l and m; s, p, d shells.	4. The student will be able toidentify the unique features of the hydrogen atom that make it important for calculations in quantum mechanics.
5. Generalized Angular Momenta and Spin (a) Generalized angular momentum. Electron's magnetic Moment and Spin Angular Momentum. J = L + S. Gyromagnetic Ratio and Bohr Magneton and the g factor. Energyassociated with a magnetic dipole placed inmagnetic field. Larmor's Theorem. Stern-Gerlach Experiment. (b) Addition of angular momenta - statement only. Allowed values of angular momentum.	5. The student will be able to • Define quantum number. • Calculate angle of angular momentum vector with an axis. • Define spin quantum number.
6. Spectra of Hydrogen atom and its fine structure (a) Formula for first order nondegenerate perturbative correction to the eigenvalue statement only. (b) Spin-orbit interaction and relativistic correction to the kinetic energy and Darwin term. (c) Fine structure of the hydrogen atom spectrum (No rigorous derivation is required).	6. The student will be able to know the relationship between atomic spectra and the electronic structure ofatoms.

7. Atoms in Electric & Magnetic Fields (a) Zeeman Effect: Normal and Anomalous Zeeman Effect (Formula for first order perturbative correction tothe eigenvalue to be assumed). (b) Paschen Back effect & Stark effects (Qualitative Discussion only).	7. The student will be able to carry out experimental and theoretical studies on atomic and molecular physics with focus on structure & dynamics of atoms and molecules.
8. Many electron atoms (a) Identical particles. Symmetric & Antisymmetric Wave Functions. Pauli's Exclusion Principle. Hund's Rule. Periodic table. (b) Fine structure splitting. L-S and J-J coupling scheme. Spectral Notations for Atomic States and Termsymbols. Spectra of Alkali Atoms (Na etc.).	8. The student will be able to write the electron configuration of any element and relate its electron configuration to its position in the periodic table.

SEC B -2 Electrical Circuits and Network skills (Theory)

1. DC generator (a) EMF generated in the armature for simplex lap and wave winding, concept of pole, Methods of Excitation, Armature reaction, Dc motor : Torque equation of D.C motor, speed& torque Operating Characteristics of separately excited, Shunt, Series &Compound motors with emphasis on application areas. (b) Three phase generator, concept of stator and rotor, star and delta connections – their current voltage relationships (both line and phase current & voltage).	The student will be able to know the working and construction principles of DC generator
2. Transformer : Types of transformer, basic emf equation, no load current, leakage inductance, Magnetising current and equivalent circuit of single phase transformer on no-load and on load, idea of star/star, star/delta, delta/star, and zig-zag connection of 3 phase transformer, 3 phase to 2 phase transformation, Scott T connection.	The student will be able to know the working and construction principles of Transformer
3. AC motor (a) Single phase AC motor – double field revolving theory, slip-speed characteristics, (b) Construction of 3 phase induction motor and its action using rotating field theory, equivalent circuit of induction motor, Speed control by V/f control of induction motor (block diagram only).	The student will be able to know the working and construction principles of AC motor
4. Measurements and faults (a)Measurement of three phase power by two and three wattmeter method,theory of induction type wattmeterand its use as energy meter in domestic house. Megger. (b) Unsymmetrical faults in distribution system, Common switchgear equipments like relay, circuit breakers and fuses, Simple oil circuit breaker and SF6 circuit breaker, Construction of protective relay in distribution bus-bar system, Block diagram of a utility distribution sub-station.	The student will be able to know the working and construction principles of Measurements and faults

Semester – 5 Course Outcomes	
PAPER	**COURSE OUTCOME**
PHS-A-CC-5-11-TH: Electromagnetic Theory	
1. Maxwell Equations Review of Maxwell’s equations. 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, Momentum Density and Angular Momentum Density.	Students will be able to understand the unification of electric and magnetic fields and Maxwell’s equations governing EM waves also EM energy flow and its conservation.

2. 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.	Students will be able to analyze the nature of EM wave propagating through unbounded dielectric and conducting media.
3. 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, Reflection & Transmission coefficients, Brewster's law. Total internal reflection, evanescent waves. Metallic reflection (normal Incidence).	Students will be able to describe the propagation of EM waves through different media and interfaces can calculate reflection and transmission coefficients and explain different experimental facts.
4. Polarization Description of Linear, Circular and Elliptical Polarization. Propagation of E.M. Waves in birefringent medium.	Students will be able to differentiate different states of polarization of EM waves and explain propagation in birefringent medium.
5. Polarization in uniaxial crystals Uniaxial and Biaxial Crystals. Light Propagation in Uniaxial Crystal. Double Refraction. Polarization by Double Refraction. Nicol Prism. Ordinary & extraordinary refractive indices. Phase Retardation Plates: Quarter-Wave and Half-Wave Plates. Production & analysis of polarized light. Babinet Compensator and its Uses.	Students will be able to describe double refraction, retardation plate, Babinet compensator, Nicolprism which have practical application.
6. 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 and biquartz polarimeters.	Students will be able to explain optical activity of different materials. Can apply practically to polarimeter.

Paper: PHS-A-CC-5-11-Practical	
1. To determine Brewster's angle for air-glass interface using a prism. 2. To study Fresnels law by the reflection on the surface of a prism. 3. To verify the Malus law using a pair of polaroids. 4. To study the specific rotation of optically active solution using polarimeter. 5. To determine dispersive power and resolving power of a plane diffraction grating	Students will be able to study polarization of light, learn about the functions and uses of polarimeter, polaroid, grating and also the application of Brewster's law and Malus law.

Paper- CC XII STATISTICAL PHYSICS

1. Classical Statistical Mechanics (a) Macrostate & Microstate, Elementary Concept of Ensemble and Ergodic Hypothesis (statement only). Phase Space. (b) Microcanonical ensemble, Postulate of Equal a-priori probabilities. Boltzmann hypothesis: Entropy and Thermodynamic Probability. (c) Canonical ensemble, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox. Equivalence of microcanonical and canonical ensemble. (d) Sackur Tetrode equation, Law of Equipartition of Energy (with proof) Applications to Specific Heat and its Limitations. Thermodynamic Functions of a Two-Energy Level System. Negative Temperature. (e) Grand canonical ensemble. Application of ideal gas using grand canonical ensemble. chemical potential.	It gives an account of the theory of statistical mechanics and the approximations making a statistical description possible.

2. Systems of Identical particles Collection of non-interacting identical particles. Classical approach and quantum approach: distinguishability and indistinguishability. Occupation number and MB distribution, emergence of Boltzmann factor. Composite system postulate and symmetry postulate of quantum mechanics (for a pair of particles only). Bosons and Fermions. Symmetric and Antisymmetric wave functions. state counting for bosons and fermions.	It applies the **theory to understand gases and crystals** and in addition be able to construct microscopic models and from these derive thermodynamic observables.
3. Bose-Einstein Statistics B-E distribution law. Thermodynamic functions of a strongly degenerate Bose Gas, Bose Einstein condensation and properties of liquid He IV (qualitative description only).	Students will be able to understand how Bose-Einstein Statistics can be applied to **particles having integral spin number** and do not obey Pauli's principle.
4. Radiation: classical and quantum aspects (a) Spectral Distribution of Black Body Radiation. Rayleigh-jeans law, UV catastrophe, Planck's Quantum Postulates. Planck's Law of Blackbody Radiation: Experimental Verification. Deduction of Rayleigh- Jeans Law, Stefan-Boltzmann Law, Wien's Displacement law from Planck's law. (b) Bose derivation of Planck's law. Radiation as a photon gas and Thermodynamic functions of photon gas. chemical potential of photon gas.	**Blackbody radiation** is a cornerstone in the study of quantum mechanics.
5. Fermi-Dirac Statistics Fermi-Dirac Distribution Law. Thermodynamic functions of strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals due to electrons.	Student will get complete understanding of Fermi energy, the Fermi–Dirac distribution and total electronic energy of a free electron gas Fermi–Dirac statistics has many applications in **studying electrical and thermal conductivities, thermoelectricity, thermionic and photoelectric effects, specific heat of metals**

Paper- CC XII STATISTICAL MECHANICS (PRACTICAL)

1. Study of Random Numbers and Time series Introduction to the numpy.random() module • Histogram (by matplotlib.pyplot.hist) and autocorrelation function of a given time series. • Generating exponential variates from uniform variate using transformation • Gaussian variate from uniform variate using central limit theorem. • Study of histogram and moments of random sequences of different probability density using numpy.random.	Student will able to perform analysis of probabilistic events with random numbers and histograms.
2. Applications of Random Numbers • Coin tossing. Fit with binomial distribution. • Nuclear Decay: Simulation assuming a constant decay probability per unit time. • Random Walk: – In 1D and in 2D (Square grid) – Plot of r.m.s. value of end to end distance as a function of time step – fitting and finding of exponent • Monte Carlo Integration	Student will able to perform analysis of probabilistic events with random numbers and simulate some simple experiments with Monte-Carlo.

3. Scaling and plots, exponents and parameters: Laws and distributions from Statistical Mechanics Some Problems • Maxwell-Boltzmann distribution • Bose-Einstein distribution • Fermi-Dirac distribution • Plot of specific Heat of Solids _ Dulong-Petit law _ Einstein distribution function _ Debye distribution function for high temperature and low temperature and compare them for these two cases	Student will able to perform analysis and represent various statistical laws.

Paper- CC XIII DIGITAL ELECTRONICS

1. Integrated Circuits Principle of Design of monolithic Chip. Advantages and drawbacks of ICs. Scale of integration: SSI, MSI, LSI and VLSI (basic idea and definitions only w.r.t. micron/submicron feature length).	1.Enable students to understand how to work with IC
2. Number System Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. Signed and unsigned number representation of binary system. Representation of negative number. 1's Complement and 2's Complement method of subtraction.	2. To understand and examine the structure of various number systems and its application in digital design.
3. Digital Circuits (a) Difference between Analog and Digital Circuits. Introduction of switching algebra, Huntington's postulates. Combinational logic, Truth table. Introduction of basic logic functions AND, OR and NOT. Implementation of OR, AND, NOT Gates (realization using Diodes and Transistor). De Morgan's Theorems. NAND and NOR Gates as Universal Gates. XOR and XNOR Gates and application as Parity Checkers. Circuit representation of gates (both Usual and IEEE symbols). Introduction to different logics like DTL, TTL, MOS and CMOS. MOS and CMOS inverter circuit. NAND/NOR circuit using MOS logic. (b) Product term and sum term in logical expression. Sum of Product and Product of Sum and mixed expression. Minterm and Maxterm in the expressions. Conversion between truth table and logical expression. Simplification of logical expression using Karnaugh Map.	3. Have a **thorough understanding of the fundamental concepts and techniques used** in digital electronics.
4. Implementation of different circuits Half and Full Adders. Subtractors, 4-bit binary adder/Subtractor. Combinational logic circuits using PAL/PLA, use of IC 7483 as adder and subtractor.	4. Educating the students about the circuit configuration of binary addition and subtraction

5. Data processing circuits Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders.	5.To impart clear idea of Arithmatic logic unit of Computer to the students.
6. Sequential Circuits: Introduction to Next state present state table, excitation table and truth table for Sequential circuits. SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race condition in SR and Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop, T type FF.	6. To build up clear concepts of memory circuit configurations of Computer.
7. Registers and Counters (a) 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). (b) Counters (4 bits): Asynchronous counters: ripple counter, Decade Counter. Synchronous Counter, Ring counter.	7. To develop the idea of design of registers and counters, which are essential part of learning computer hardware.
8. Computer Organization Input/Output Devices. Data storage (idea of RAM and ROM, EPROM). Computer memory. Memory organization & addressing. Memory Interfacing. Memory Map.	8.To develop concept of data storage in the students.
9. Data Conversion A/D (Ladder and weighted resistance) and D/A conversion circuit	9. Enable the students to know the circuit diagram and proper operation of data conversion.

Paper- CC XIII Digital ELECTRONICS (Practical)

1. To design OR & AND logic with diode and resistor. Basic logic gates with Transistors. To verify the logics by any type of universal gate NAND/NOR	Hands on experience on computer hardware
2. Construction of half adder and full adder	Hands on experience on circuitry performing addition etc.
3. Construction of SR, D, JK FF circuits using NAND gates.	Learning design concepts of memory circuit.
4. Construction of 4 bit shift registers (serial & parallel) using D type FF IC 7476.	To gain experience on hardware of ALU
5. Construction of 4×1 Multiplexer using basic gates and IC 74151.	To gain experience on hardware of ALU

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Semester – 6 Course Outcomes	
PHS-A-CC-6-14-TH: Solid State Physics	
PAPER	**COURSE OUTCOME**
1. Crystal Structure Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis; Central and Non-Central Elements. Unit Cell. Miller Indices. Reciprocal Lattice. Types of Lattices. Brillouin Zones. Diffraction of X-rays by Crystals. Laue and Bragg's Law and their equivalance. Atomic and Geometrical Structure Factor. Basic idea of crystal indexing: examples with SC, BCC, FCC structure.	Students will be able to identify different types of crystal structure and know their application, Miller indices, crystal planes. Students will be able to determine crystal structure by using different X-ray diffraction methods.
2. Elementary Lattice Dynamics Lattice Vibrations and Phonons: Linear Monatomic 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, T^3 law.	Students will learn the role of lattice vibrations and phonons in the electrical and thermal properties of materials. Students will be able to calculate specific heats of solids by different models and at diff temperatures.
3. Magnetic Properties of Matter Dia, Para, Ferri and Ferromagnetic Materials. Classical Langevin Theory of Dia and Paramagnetic Domains. Quantum Mechanical Treatment of Paramagnetism (using parition function). Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis and	Students will learn characteristic features of different types of magnetic materials and their practical use.
4. Dielectric Properties of Materials Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mosotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Cauchy and Sellmeir relations. Langevin-Debye equation. Complex Dielectric Constant.	Students will gain knowledge about the principles of different types of polarization in dielectric materials, normal and anomalous dispersion.
5. Drude's theory Free electron gas in metals, effective mass, drift current, mobility and conductivity, Hall effect in metals. Thermal conductivity. Lorentz number, limitation of Drude's theory.	Students will be able to describe electron motion in metal, mobility, transport of electrons through conductors in electric and magnetic fields.
6. Elementary Band theory Kronig Penny model. Band Gap. effective mass and effective mass tensor. Conductor, Semiconductor (P and N type) and insulator. Conductivity of Semiconductor, mobility, Hall Effect. Measurement of conductivity (4 probe method) & Hall coefficient.	Students will be able to explain the presence of energy bands and gaps in the energy structure of a solid. Can differentiate between an metal, semiconductor and insulator.
7. Superconductivity Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, London's Equation and Penetration Depth. Isotope effect.	Students will be able to describe the characteristic features of superconductors. Can explain type I and type II superconductivity and apply London theory.

Paper: PHS-A-CC-6-14-Practical	
1. To study BH hysteresis of ferromagnetic material 2. To determine dielectric constant of different materials (solid and liquid) using fixed frequency alternating source. 3. Measurement of variation of resistivity in a semiconductor and investigation of intrinsic band gap using linear four probe. 4. Measurement of hall voltage by four probe method. 5. To study temperature coefficient of a semiconductor (NTC	Students get the opportunity to perform experiments which enhances the ability to work both independently and in a group. Students learn to interpret results, error analysis, analyzing data.

thermistor) and construction of temperature controller with comperator and relay switch. 6. Measurement of magnetic susceptibility of solids	

SEM-5 DSE-A
Laser and Fiber Optics.
Paper:PHA-A-DSE-A2-TH

1.Einstein coefficients and Rate equations : Historical background of laser, Einstein coefficients and stimulated light amplification: population inversion .Three level & four level lasers: Rate equation, condition for population inversion and threshold condition. Minimum amount of pump power	Students acquire knowledge about the theoretical and historical knowledge of Laser.
2. Basic properties of laser : Coherence, directionality, monochromaticity, brightness.	Students know about the basic properties of Laser.
3. Resonators : Optical resonators. Different configurations of optical resonators.stability condition (no derivation required)and stability diagram for optical resonators. Cavity lifetime. The Quality factor.	Students get knowledge about essential properties of resonators and their modes.
4. Transient effect: Transverse and Longitudinal mode selection. Principle of Q-switching and Mode locking. Different methods of Q-switching : electro-optic Q-switching, Pockels cell	Student can analyse transient behaviour of Laser.
5. Basic Laser Systems : (i) Gas Laser • He-Ne laser • CO2 Laser (ii) Solid state laser • Ruby Laser • Nd:YAG laser • Semiconductor laser (iii) Liquid laser: Dye laser	Students gather knowledge about gas Laser, solid state Laser and semiconductor Laser.
6. Practical properties and uses of laser : (a) The Line-shape function. Various Line broadening mechanisms: collisional broadening , Natural broadening, Doppler broadening. (b) Basic idea of Laser cooling and trapping	Students learn how to use Laser in practical purpose.
7. Fiber optics : Optical fiber, coherent bundle, Numerical aperture. Attenuation of optical fibers. Ray paths, Ray paths in a homogeneous medium, in square law media. Pulse dispersion in parabolic index medium and in planar step index waveguide. Modes of a planar waveguide: TE and TM modes. Physical understanding of modes, Optical fibers: Guided modes of step-index and graded index fibers. Applications of optical fibers in Communication and Sensing.	Recognise and classify the structure of opticalfiberanalyse various coupling losses and the application of optical fiber in communication and sensing.
8. Holography : Principle of Holography. Recording and Reconstruction Method. Theory of Holography between two plane waves. Point source holograms.	Acquire knowledge about Holography which involves transmission and reception of the wave patterns using an optical fiber.
9. Introductory Nonlinear Optics : Origin of nonlinearity, susceptibility tensor, phase matching, second harmonic generation, Sum frequency generation,Difference frequency generation, Sum and Difference Frequency generation, for second-order nonlinear optical medium. Nonlinear susceptibility of a classical anharmonic oscillator in case of noncentrosymmetric medium.	Students get an idea about nonlinear effects occur in optical fiber.

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DSE-B1 Nuclear and Particle Physics. Paper: PHS-A-DSE-A2-TH

1. Introduction :Recapitulation of general properties of nuclei, nuclear models and radioactivity	Acquire basic knowledgeof properties of nuclei ,nuclear models and radioactivity.

2. Nuclear Reactions : Types of Reactions, Conservation Laws, kinematics of reactions, Q value, reaction rate, reaction cross section,Concept of compound and direct Reaction, resonance reaction, Coulomb scattering (Rutherford scattering).	Students get knowledge about different types of reactions. Hence find Q value and reaction cross section.
3. Interaction of Nuclear Radiation with matter : Energy loss due to ionization (Bethe- Block formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter, photoelectric effect, Compton scattering, pair production, neutron's interaction with matter.	Students get idea about the interaction of gamma ray with matter eg photoelectric effect, Compton scattering and pair production.
4. 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 photomultiplier tube (PMT). Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility), neutron detector.	Students gather knowledge about the principle of nuclear detectors.
5. Particle Accelerators : Accelerator facility available in India, Different type of accelerators • Van-de Graaf generator (Tandem accelerator) • Linear accelerator • Cyclotron • Betatron • Synchrotrons	Students acquire knowledge about Particle accelerator, their limitations and use.
6. Particle Physics : Fundamental particles and their families. Fundamental particle-interactions and their basic features. GellmannNishijima formula. Quark structure of hadrons. Symmetries and Conservation Laws: energy and momentum,angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm. concept of quark model, color quantum number and gluons.	Students can recognize fundamental particles and their antiparticles. Study their basic characters.

DSE A2 Nano Materials and Applications

1. 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 connement: Applications of Schrodinger equation: Infinite potential well, potential step, potential box, quantum confinnement of carriers in 3D, 2D, 1D nanostructures and its consequences.	1. Students will know about the theoretical background of nanostructure, its requirements and change in properties from bulk materials

2. Synthesis of Nanostructure Materials, Top down and Bottom up approach, Photolithography. Ball milling. Gas phase condensation. (b) Vacuum deposition • Physical vapor deposition (PVD) • Thermal evaporation – Electron beam evaporation – Pulsed Laser deposition • Chemical vapor deposition (CVD) • MBE growth of quantum dots Chemical Synthesis • Chemical bath deposition • Electro deposition • Spray pyrolysis • Hydrothermal synthesis • Sol-Gel synthesis • Preparation through colloidal methods	1. Students will know about different types of synthesis methods that they can apply at their research process 2. Students will learn the difference between physical and chemical synthesis
3. Characterization (a) X-Ray Diffraction. Optical Microscopy. Scanning Electron Microscopy (SEM). Transmission Electron Microscopy (TEM). Atomic Force Microscopy (AFM). Scanning Tunneling Microscopy (STM).	1. Students will learn about various standard characterization techniques for nanomaterials charaterization, their basic principle and applications
2. 4. Optical Properties 3. (a) Coulomb interaction in nanostructures. Concept of dielectric constant for nanostructures and charging of nanostructure. Quasi-particles and excitons. Excitons in direct and indirect band gap semiconductor nanocrystals. Quantitative treatment of quasi-particles and excitons, charging effects. Radiative processes: General formalization, absorption, emission and luminescence. Optical properties of heterostructures and nanostructures.	1. Students will learn about different optical properties and band gap tuning for various nanomaterials.
4. 5. Electron Transport 5. (a) Carrier transport in nanostrucutures. Coulomb blockade effect, thermionic emission, tunneling and hoping conductivity. Defects and impurities: Deep level and surface defects.	1. Students will learn about the electron transport and electrical properties for various nanomaterials
6. 6. Applications . (a) Applications of nanoparticles, quantum dots, nanowires and thin films for photonic devices (LED, solar cells). Single electron transfers 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).	1. Students will learn the applications of different types of nanomaterials such as zero, one or two dimensional nanostructures
DSE B2 Communication Electronics	
8. 1. Electronic communication . Lectures Introduction to communication means and modes. Need for modulation. Block diagram of an electronic communication system. Brief idea of frequency allocation for radio communication system in India (TRAI). Electromagnetic communication spectrum, band designations and usage. Channels and base-band signals. Concept of Noise, signal-to-noise (S/N) ratio	1. Students will learn about the flow chart of communication system 2. Students will have a brief idea about TRAI
10. 2. Analog Modulation 11. (a) Amplitude Modulation, mathematical analysis for modulation index, frequency spectrum and power in AM Generation of AM (Emitter Modulation), Diode/square law modulator, Amplitude Demodulation (diode detector), Balanced modulator for DSB, Concept of Single side band generation and detection, concept of vestigial side band. (b) Frequency Modulation (FM) and Phase	1. Students will learn about the working principles of analog modulations like, AM, FM, PM etc

Modulation (PM), modulation index and frequency spectrum, Transistor/FET reactance modulator, equivalence between FM and PM, Generation of FM using VCO, FM detector : slope detector, Balanced slope detector, Idea of Phase discriminator and ratio detector, Qualitative idea of IF and Super heterodyne receiver.	
12. 3. Analog Pulse Modulation 3. Channel capacity, Sampling theorem, Basic Principles- PAM, PWM, PPM, modulation and detection technique for PAM only, Multiplexing – FDM and TDM and its application in communication.	1. Students will learn about the advanced analog pulsed modulation techniques and their applications
2. 4. Digital Pulse Modulation 3. Need for digital transmission, Sampling and Shanon's criteria, Quantization and Encoding, Quantisation error, non-uniform quantisation, Impulse sampling, Natural sampling and flat top sampling, Pulse Code Modulation (PCM), Differential PCM , Digital Carrier Modulation Techniques, Concept of Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK). (b) Idea of 8-PSK, QPSK, BPSK, use of Constellation diagram (idea only), Delta modulation. Concept of companding- A law and μ law. Line Coder: Unipolar and bipolar RZ & NRZ, Manchester format.	1. Students will learn about the modern day digital pulsed modulation techniques and their applications
5. Introduction to Communication and Navigation systems: (a) Satellite Communication: Introduction, need, Geosynchronous satellite orbits geostationary satellite advantages of geostationary satellites. Satellite visibility, transponders (C - Band), path loss, ground station, simplified block diagram of earth station. Uplink and downlink. (b) Mobile Telephony System _ Basic concept of mobile communication, frequency bands used in mobile communication, concept of cell sectoring and cell splitting, SIM number, IMEI number, need for data encryption, architecture (block diagram) of mobile communication network, idea of GSM, CDMA, TDMA and FDMA technologies, simplified block diagram of mobile phone handset, 2G, 3G and 4G concepts (qualitative only). GPS navigation system (qualitative idea only).	1. Students will learn about the GPS, navigation systems, mobile and internet technologies and their applications

THE BHAWANIPUR EDUCATION SOCIETY COLLEGE

A MINORITY RUN COLLEGE. AFFILIATED TO UNIVERSITY OF CALCUTTA
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CO-PO MAPPING
B.Sc. (Honours) Physics 2018-2019

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1.1	√				√	√		
CO 1.2	√					√		
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CO 2.1	√	√	√			√		
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CO 2.5	√		√		√	√		
CO 2.6	√	√	√	√		√		
CO 2.7	√		√			√		√
CO 3.1	√		√			√		√
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CO 3.4	√		√			√		
CO 3.5	√		√			√		√
CO 3.6	√		√			√		
CO 3.7	√		√			√		√
CO 4.1	√	√	√	√		√	√	
CO 4.2	√		√			√		√
CO 4.3	√	√	√	√		√	√	
CO 4.4	√		√		√	√		
CO 4.5	√	√	√	√		√	√	
CO 4.6	√		√			√		√
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CO 4.8	√		√		√	√		
CO 5.1	√	√	√	√		√	√	
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CO 5.5	√		√		√	√		
CO 6.1	√	√	√		√	√		
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CO 7.1	√		√		√	√		
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CO 7.9	√		√		√	√		
CO 8.1	√		√			√		
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CO 9.1	√	√	√	√		√	√	
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CO 11.1	√		√		√	√		
CO 11.2	√	√			√	√		
CO 11.3	√				√	√		
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CO 11.6	√				√	√		
CO 11.7	√				√	√		
CO 11.8	√				√	√		
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CO 11.10	√					√		√
CO 11.11						√		√
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CO 11.13	√		√			√		
CO 12.1	√					√		√
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CO 12.6	√					√		√
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CO 12.9	√					√		√
CO 12.10	√		√			√		
CO 13.1	√					√		√
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CO 13.3	√					√		√
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CO 13.6	√					√		√
CO 14.1	√	√	√	√		√	√	
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CO 14.5	√					√		√
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CO 14.7	√	√	√	√		√	√	
CO 15.1	√					√		√
CO 15.2	√		√			√		
CO 15.3	√					√		√
CO 15.4	√		√			√		
CO 15.5	√					√		√
CO 15.6	√		√			√		

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CO 16.1	√	√	√	√		√	√	
CO 16.2	√					√		√
CO 16.3	√					√		√
CO 16.4	√	√	√	√		√	√	
CO 16.5	√					√		√
CO 17.1	√					√		√
CO 17.2	√	√	√	√		√	√	
CO 17.3	√					√		√
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CO 18.1	√					√		√
CO 18.2	√					√		√
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CO 18.4	√					√		√
CO 19.1	√		√		√	√		
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CO 20. 1	√					√		√
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