Programme Specific Outcomes (PSO)

B.Sc. (Honours) Physics 2018-2019

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 how to become effective and ethical practitioners contributing to social and national development.**

Programme Outcome (PO)

B.Sc. (Honours) Physics 2018-2019

	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, di_erentiation. Plotting functions. Intuitive ideas of continuous, di_erentiable, etc. functions and plotting of curves. Approximation: Taylor and binomial series (statements only). (b) First Order and Second Order Di_erential equations: First Order Di_erential Equations and Integrating Factor. Homogeneous Equations with constant coe_cients. 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 di_erentials. 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 Di_erentiation: Scalar and Vector _elds. Directional derivatives and normal derivative. Gradient of a scalar _eld and its geometrical interpretation. Divergence and curl of a vector _eld. Del and Laplacian operators. Vector identities. (c) Vector Integration: Ordinary Integrals of Vectors. Multiple integrals, Jacobian. Notion of in_nitesimal line, surface and volume elements. Line, surface and volume integrals of Vector _elds. Flux of a vector _eld. 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 Di_erential 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 scienti_c computing (a) Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, under_ow&over_ow- emphasize the importance of making equations in terms of dimensionless variables, Iterative methods. 3. Errors and error Analysis. (a) Truncation and round o_ errors, Absolute and relative errors, Floating point computations. 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 _les, _tting data using gnuplot's _t function, polar and parametric plots, modifying the appearance of graphs, exporting plots. 5. Introduction to programming in python: (a) Introduction to programming, constants, variables and data types, dynamical typing, operators and expressions, modules, I/O statements, _le handling, iterables, compound statements, indentation in python, the if-elif-else block, for and while loops, nested compound statements. 6. Programs (a) Elementary calculations with di_erent 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, _nding the largest and lowest number from a list, swapping two data in a list, sorting of numbers in an array using bubble sort, insertion sort method. Calculation of term value in a series and	5.Through the course of practical student should know the elementary programming with python and gnuplot.

_nding the other terms with a seed (value of particular term) and calculation of di_erent quantities with series. Convergence and accuracy of series. Introduction of three dimensional array. Simple calculations of matrices e.g., addition, subtraction, multiplication.	

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 _elds in one, two and three dimensions using cartesian, cylindrical polar and spherical polar coordinate systems. 17 (b) Dynamics of systems of particles: Di_culty 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. (c) 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 _eld - concept of Potential Energy. Other equivalent de_nitions 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) Di_erential 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 _eld due to spherical shell and solid sphere.	
4. Non-Inertial Systems (a) Galilean transformations and Galilean invariance. (b) Non-inertial frames and idea of _ctitious 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 de_ning 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 _xed axis. 18 (d) Principal Axes transformation. Transformation to a body _xed frame. E.O.M for the rigid body with one point _xed (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
6. Elasticity (a) Relation between Elastic constants. Twisting torque on a Cylinder or Wire. Bending of a beam . Internal bending moment. Elastic potential energy.	6.Student know the engineering aspects materials.

7. Fluid Motion (a) Kinematics of Moving Fluids: Idea of compressible and incompressible _uids, Equation of continuity; streamline and turbulent _ow, Reynold's number. Euler's Equation. The special case of _uid 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.
2. To determine the Moment of Inertia of a Flywheel.
3. To determine Coe_cient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
4. Determination of Young's modulus of the material of a beam by the method of _exure.
5. To determine the elastic constants of a material by Searle's method.
6. To determine the value of g using Bar Pendulum.
7. To determine the height of a building using sextant.

<table>
<tr><th colspan="2">Semester – 2 Course Outcomes</th></tr>
<tr><th colspan="2">Paper-CCIII Electricity and Magnetism</th></tr>
<tr><td>Electrostatic Field
(a) Coulombs law and Principle of superposition leading to the de_nition
of Electrostatic Field. Field lines.
(b) Divergence of the Electrostatic _eld. Flux, Gauss's theorem of electrostatics.
Applications of Gauss theorem to _nd Electric _eld due to charge con_gurations 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 _eld from potential.
(d) Laplace's and Poisson equations. Uniqueness Theorems. Method
of Images and its application to: (1) Plane In_nite Sheet and (2)
Sphere.
(e) Conductors: Electric _eld and charge density inside and on the surface
of a conductor. Conductors in an electrostatic _eld. 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 _eld.</td><td>1.know basic models of magnetism and electrostatics</td></tr>
<tr><td>2. Dielectric properties of matter
(a) Electric potential and _eld 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</td><td>2. learn to solve electrostatic boundary value problems</td></tr>
</table>

Permittivity. Capacitor (parallel plate, spherical, cylindrical) _lled with dielectric.	
3. The Magnetostatic Field (a) Biot-Savart's law. Force on a moving point charge due to a magnetic _eld: Lorentz force law. Application of Biot-Savart's law to determine the magnetic _eld of a straight conductor, circular coil. Force between two straight current carrying wires. (b) Divergence of the magnetic _eld - its solenoidal nature. Magnetic vector potential. 21 (c) Curl of the magnetic _eld. Ampere's circuital law. Its application to (1) In_nite straight wire, (2) In_nite planar surface current, and (3) Solenoid.	3. learn the applications of Gauss' theorem
4. Magnetic properties of matter. (a) Potential and _eld due to a magnetic dipole. Magnetic dipole moment. Force and torque on a magnetic dipole in a uniform magnetic _eld. (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 de_nition 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.	5. Knowledge of various specialized fields and genres of journalism

(b) Energy stored in magnetic _eld.	
6. Electrical circuits (a) AC Circuits: Kirchho_'s laws for AC circuits. Complex Reactance and Impedance. Series LCR Circuit: (1) Resonance, (2) PowerDissipation 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.

Paper-CC IV Waves and Optics	
Oscillations (a) SHM: Simple Harmonic Oscillations. Di_erential 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. Di_erential 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. 24	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.	4. In this course student should learn the physics of vibration, oscillation and resonance
6. Wave optics (a) Electromagnetic nature of light. De_nition and properties of wave front. Huygens Principle. Temporal and Spatial Coherence. 7. Interference (a) Division of amplitude and wavefront. Young's double slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on re_ection: Stokes' treatment. Interference in Thin Films: parallel and wedgeshaped _lms. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: Measurement of wavelength and refractive index.	5. Learn physics of light and able to understand underlying magnificent phenomena of light. 6. Learn the mechanism of optical instruments.
8. Interferometers (a) Michelson Interferometer-(1) Idea of form of fringes (No theory required), (2) Determination ofWavelength, (3)WavelengthDi_erence, (4) Refractive Index, and (5) Visibility of Fringes. (b) Fabry-Perot interferometer.	7. Student should learn Modern optical instruments and their basic principles

9. Di_raction and Holography (a) Fraunhofer di_raction: Single slit. Circular aperture, Resolving Power of a telescope. Double slit. Multiple slits. Di_raction grating. Resolving power of grating. (b) Fresnel Di_raction: 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 di_raction 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. 3. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source. 4. To determine wavelength of sodium light using Fresnel Biprism. 5. To determine wavelength of sodium light using Newton's Rings? 6. To determine the thickness of a thin paper by measuring the width of the interference fringes produced by a wedge-shaped Film. 7. 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.

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 coe_cients. 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 In_nite Series. Term-by-Term di_erentiation and integration of Fourier Series. Parseval Identity.	1. tudent must know the method of expansion in eigenfunction.
2. Frobenius Method and Special Functions (a) Singular Points of Second Order Linear Di_erential Equations and their importance. Frobenius method and its applications to di_erential equations. Legendre, Bessel, Hermite and Laguerre Di_erential 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. 27	2. ust know the properties of special function.
3. Some Special Integrals	3.

(a) Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. Error Function (Probability Integral).	roperties of special function and their properties must be clear to them.
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. dvanced techniques like variational principle should be familiar to them.
5. Partial Di_erential Equations (a) Solutions to partial di_erential 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. Di_usion Equation.	5. tudent 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 di_erential equations. 2. Solution of Linear system of equations by 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) 4. Generation of Special functions using User de_ned functions (a) Generating and plotting Legendre Polynomials Generating and plotting Bessel function (Make use of generating function and recursion formula). 5. Root _nding: Bisection and Newton-Raphson method. 6. Interpolation by Lagranges method. 7. Numerical di_erentiation - forward and backward di_erence formulae. 8. Numerical integration - trapezoidal and simpsons rule. 9. Solution of ODE: First order Di_erential equation - Euler's method. 10. Basic 3D graph plotting - plotting functions and data _les, parametric plots, Surface and contour plots.	How to represent data and experimental results are also be the outcome of the course.

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 di_erential 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-e_cient. (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 &e_ciency. Refrigerator &coe_cient 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. tudent 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. 30	
2. Thermodynamic Potentials (a) Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. Their De_nitions, 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 coe_cient for Ideal and Van der Waal Gases, (5) Energy equations, (6) Change of Temperature during Adiabatic Process.	2. ble 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 Veri_cation. 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). Speci_c heats of Gases. (b) Molecular Collisions: Mean Free Path. Collision Probability. Estimates	3. nderstand the nature of real gas, atmosphere and radiation

of Mean Free Path. Transport Phenomenon in Ideal Gases: (1) Viscosity, (2) Thermal Conductivity and (3) Di_usion. Brownian Motion and its Signi_cance.	
4. Conduction of Heat	4. The working principles of engines should be clear to them.
Paper- CC VII Digital Systems and Applications	
Integrated Circuits (a) Active & Passive components. Discrete components. Wafer. Chip. Advantages and drawbacks of ICs. Scale of integration: SSI, MSI, LSI and VLSI (basic idea and denitions only). Classication of ICs. Examples of Linear and Digital lCs. .	1. tudents should know how to work with IC
Digital Circuits (a) Dierence 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.	2. tudents should have clear idea of binary number system and their operations
Boolean algebra (a) De Morgan's Theorems. Boolean Laws. Simplication 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.	3. tudents should know the binary addition and subtraction
Data processing circuits (a) Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders.	4. asic idea of multiplexer and demultiplexer must be implemented
Circuits (a) Arithmetic Circuits: Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders. Half & Full Subtractors, 4-bit binary Adder/Subtractor	5. tudents should have the idea of filp flops and timer IC

Sequential Circuits: SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop.	6. tudents should have the idea of filp flops and timer IC
Timers (a) IC 555: block diagram and applications: Astablemultivibrator and Monostable multivibrator.	7. ounter and registers should be designed
Shift registers (a) Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in-Parallel-out Shift Registers (only up to 4 bits).	8. ounter and registers should be designed
Counters (4 bits) (a) Ring Counter. Asynchronous counters, Decade Counter. Synchronous Counter. Computer Organization (a) Input/Output Devices. Data storage (idea of RAM and ROM). Computer memory. Memory organization & addressing. Memory Interfacing. Memory Map	9. ounter and registers should be designed

(1+1+1System) Course Outcomes	
Paper- III	
Amplifier Voltage and current gain, principle of feedback, positive and negative feedback, advantages of negative feedback, multistage amplifier, frequency response of a two stage R-C coupled amplifier, gain and band width and their product, operating point of class A, amplifier, analysis of single tuned voltage amplifier, requirement of power amplifiers	1. students will know how to classify and apply amplifiers.
2. Oscillators Barkhausen criterion for sustained oscillation, L-C, Weinbridge and crystal oscillators, relaxation oscillators- monostable, bistable and astable multivibrators. *3. Operational amplifier* Properties of ideal OP-AMP, differential amplifiers, CMRR, inverting and non-inverting amplifiers, mathematical operations.	2.students will know how an oscillator work.
4. Combinational logic Half adder, full adder, digital comparator, decoder, encoder (ROM), multiplexure *5. Sequential logic* Flip-flops- RS, D, JK, JKMS flip-flops, edge triggering. Shift register, ripple counter(binary and decade).	3.students will know how to construct combinational logic gates.
6. Communication principles Modulation and demodulation – elementary theory of AM, FM and PM, demodulation of AM (diode detector) and FM (slope detector) waves.	4.Student should know about communication principles
Magnetic effect of steady current Lorentz force and concept of magnetic induction; force on linear current element; Biot-Savart's law. $\nabla . \mathbf{B}=0$; magnetic vector potential; calculation of vector potential and magnetic induction in simple cases – straight wire, magnetic field due to small current loop; magnetic dipole; field due to a dipole; magnetic shell; Ampere's theorem; Ampere's circuital law – simple illustrations; force between long parallel current carrying conductors; $\nabla \times \mathbf{B} = \mu \mathbf{J}$; comparison between static electric and magnetic fields. *2. Field and magnetic materials* Free current and bound current; surface and volume density of current distribution; magnetisation; nonuniform magnetisation of matter; $\mathbf{J}b = \nabla \times \mathbf{M}$; Ampere's law in terms of free current density and introduction of **H**; line integral of **H** in terms of free current; boundary conditions for **B** and **H**; permanently magnetized body; magnetic scalar potential;	5..The idea of magnetism and their effects.

application of Laplace's equation to the problem of a magnetic sphere in uniform magnetic field; hysteresis and energy loss in ferromagnetic material; magnetic circuit; energy stored in magnetic field. *3. Electromagnetic induction* Faraday's and Lenz's law; motional e.m.f.-simple problems; inductances in series and parallel; reciprocity theorem LR, CR and LCR circuits- transient and sinusoidal emf cases, calculation of self and mutual inductance in simple cases.	
Units and dimensions CGS, Gaussian and SI units; conversion between Gaussian and SI units; dimension of various quantities. **(SI system to be followed for the rest of the syllabus)** (2) 2. Gauss' law Coulomb's law of electrostatics, intensity and potential; Gauss' theorem – its application; Poisson and Laplace's equations; Superposition theorem (statement only). Application of Laplace's equation to simple cases of symmetric spherical charge distribution. 3.Multipole expansion Multipole expansion of scalar potential – monopole, dipole and quadrupole terms; potential and field due to a dipole; work done in deflecting a dipole; dipole-dipole interaction (for both electric and magnetic dipoles); force on dipole in a non-homogeneous field. 4. Dielectrics Polarisation, electric displacement vector (**D**); Gauss's theorem in dielectric media; boundary conditions; electrostatic field energy; computation of capacitance in simple cases (parallel plates); spherical and cylindrical capacitors containing dielectrics – uniform and non-uniform. 5. Electrical Images Solution of field problems in case of a point charge near a grounded conducting infinite plane. Boundary value problem : in uniform external field for (i) conducting spherical shell and (ii) dielectric sphere. (4)	6. he calculation of electric fields and charge distribution problems

<table>
<tr><th colspan="2">(1+1+1System) Course Outcomes</th></tr>
<tr><td>Paper- IVA</td><td rowspan="2">1.
tudents will know about basic concept of quantum physics</td></tr>
<tr><td>Basic quantum mechanics
de Broglie hypothesis. Electron double-slit experiment. Compton effect, Davisson-Germer experiment,
Heisenberg's uncertainty principle (statement) with illustrations. Concept of wave function as describing
the dynamical state of a single particle. Group and phase velocities, classical velocity of a particle and the
group velocity of the wave representing the particle. Principle of superposition. Schrodinger equation.
Probabilistic interpretation; equation of continuity, probability current density. Boundary conditions on
the wave function. (10)
3. Basic postulates of quantum mechanics
Dynamical variables as linear hermitian operators and eigenvalue equations, Momentum, energy and
angular momentum operators. Measurement of observables, expectation values. Commutation relations
between operators. Compatible observables and simultaneous</td></tr>
<tr><td>Basic Concepts
Microscopic and macroscopic points of view : thermodynamic variables of a system, State function, exact
and inexact differentials. (2)
2. First Law of Thermodynamics
Thermal equilibrium, Zeroth law and the concept of temperature. Thermodynamic equilibrium, internal
energy, external work, quasistatic process, first law of thermodynamics and applications including
magnetic systems, specific heats and their ratio, isothermal and adiabatic changes in perfect and real
gases. (5)
3. Second Law of Thermodynamics
Reversible and irreversible processes, indicator diagram. Carnot's cycles-efficiency, Carnot's theorem.
Kelvin's scale of temperature, relation to perfect gas scale, second law of thermodynamics – different
formulations and their equivalence, Clausius inequality, entropy, change of entropy in simple reversible
and irreversible processes, entropy and disorder; equilibrium and entropy principle, principle of
degradation of energy. (9)
4. Thermodynamic Functions</td><td>2. Student will learn about basic thermodynamic laws and their nature of action</td></tr>
<tr><td>Enthalpy, Helmholtz and Gibbs' free energies; Legendre transformations, Maxwell's relations and simple
deductions using these relations; thermodynamic equilibrium and free energies. (4)
5. Change of State</td><td>3. Student should learn about the thermodynamic potentials and state changes.</td></tr>
</table>

Equilibrium between phases, triple point : Gibbs' phase rule (statement only) and simple applications. First and higher order phase transitions, Ehrenfest	4.Change of state and phase transition will be learned.
1. Unit 1 (a) Blackbody Radiation, Planck's quantum, Planck's constant. Photoelectric eect 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	1.students will have the basic idea of quantum theory to explain different physical phenomenon
2. Unit 2 (a) Postulates of Quantum Mechanics: States as normalized vectors (normalized wave functions). Dynamical variables as linear Hermitian operators. Predictions of quantum mechanics from solving the eigenvalue equation for the observables. Illustration using two and three level systems. Expectation values of observables. (b) Time evolution: Schrodinger equation for non-relativistic particles. Stationary states. Solution of Schrodinger's equation using expansion in stationary states. Time evolution of expectation values. (c) Application to one dimensional systems. Particle moving in one dimension: Position, Momentum and Energy operators. Probability and probability current densities in one dimension. Boundary conditions on wave functions. Ehrenfest theorem. Particle in a one dimensional innitely rigid box: energy eigenvalues and eigenfunctions, normalization. Quantum dot. Quantum mechanical scattering and tunneling in one dimension across a step potential & rectangular potential barrier. (d) Simultaneous measurements: Compatible and incompatible observables and their relation to commutativity. Heisenberg's uncertainty relation for a pair of incompatible observables. Complete and incomplete measurements - degeneracy. Ilustration of the ideas using the Angular momentum operators	2.wave particle duality and basic postulates of quantum mechanics will help them to formulate Schrodinger equation
3. Unit 3 (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	3.the idea of basic nuclear physics will be implemented

mass formula and binding energy. Nuclear Shell Model. Magic numbers.	
4. Unit 4 (a) 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. 39 (b) Fission and fusion: mass decit, 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) (c) Lasers: Einstein's A and B coe-cients. Metastable states. Spontaneous and Stimulated emissions. Optical Pumping and Population Inversion. Three-Level and Four-Level Lasers. Ruby Laser and HeNe Laser. Basic lasing	4.They can understand how LASER works

Paper- V(1+1+1 system)	
1. Central force problem Motion under central force; Nature of orbits in an attractive inverse square field; Kepler's laws of planetary motion. Rutherford scattering as an example of repulsive potential.	1. Central force problems will help students to solve planetary motion
2. Mechanics of Ideal Fluids Streamlines and flowlines; Equation of continuity; Euler's equation of motion; Streamline motion - Bernoulli's equation and its applications. Definition of Newtonian and non-Newtonian fluids.	2.Fluid dynamics will help them to understand the motion of a dynamic fluid
Lagrangian and Hamiltonian formulation of Classical Mechanics Generalised coordinates, constraints and degrees of freedom; D'Alembart's principle; Lagrange's equation for conservative systems (from D'Alembert's principle; variational principle not required) and	3.From Lagrangian and Hamiltoninan, students will learn a new approach apart from Newtonian mechanics
SPECIAL THEORY OF RELATIVITY 1. Introduction Galilean transformation and invariance of Newton's laws of motion, non-invariance of Maxwell's equations. Michelson-Morley experiment and explanation of the null result. 2. Special Theory of Relativity Concept of inertial frame. Postulates of special theory; simultaneity; Lorentz transformation along one of the axes – length contraction, time dilatation and velocity addition theorem, Fizeau's experiment. Four vectors. Relativistic dynamics : variation of mass with velocity; energy momentum relationship.	4.Special theory of relativity will help students to understand the physics of high velocity particles.
Vectors and 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 any one convention --- diag(-1,1,1,1) or diag(1,-1,-1,-1).) Example of common four-vectors: position, momentum, derivative, current density, four-velocity.	5.Covariant formulation of relativity will help students to understand the physics of tensors.

QUANTUM MECHANICS II 1. Time dependent and time independent Schrodinger equation Eigenstates, normalization and orthonormality.	6.Students will have the basic idea of quantum equations and the properties of states.
2. Simple applications of Quantum Mechanics One dimensional potential well and barrier, boundary conditions, bound and unbound states. Reflection and transmission coefficients for a rectangular barrier in one dimension – explanation of alpha decay. Free particle in one dimensional box, box normalization, momentum eigenfunctions of a free particle. Linear harmonic oscillator, energy eigenvalues from Hermite differential equation, wave function for ground state, parity of wave function. 3. Schrodinger equation in spherical polar coordinates	7. Students will have the basic idea of quantum theory to explain different physical phenomenon
Angular momentum operators and their commutation relations; eigenvalues and eigenfunctions of L2 and Lz; theorem of addition of angular momenta [statement with examples]. The hydrogen atom problem – stationary state wavefunctions as simultaneous eigenfunctions of H, L2, and Lz; radial Schrodinger equation and energy eigenvalues [Laguerre polynomial solutions to be assumed]; degeneracy of the energy eigenvalues.	8. Students will have the basic idea of quantum theory of angular momentum and theory of H atom
ATOMIC PHYSICS 1. Atomic Spectrum Good quantum numbers, and selection rules. Stern-Gerlach experiment and spin as an intrinsic quantum number. Incompatibility of spin with classical ideas. Bohr-Sommerfeld model. Fine structure. Study of fine structure by Michelson interferometer. 2. Vector atom model	9.Student will learn physics of atoms and models of atoms
Magnetic moment of the electron, Lande g factor. Vector model – space quantization. Zeeman effect. Explanation from vector atom model.	10.Student will learn physics of magnetic effect on atoms
3. Many electron model Pauli exclusion principle, shell structure. Hund's rule, spectroscopic terms of many electron atoms in the ground state.	11.Student will learn physics of many electrons
4. Molecular spectroscopy Diatomic molecules – rotational and vibrational energy levels. Basic ideas about molecular spectra. Raman effect and its application to molecular spectroscopy (qualitative discussion only).	12.Student will learn physics of molecules
5. Laser Physics Population inversion, Einstein's A and B coefficients; feedback of energy on a resonator; 3-level and 4-level systems.	13. Applications of LASER will be introduced

Paper- VI(I+I+I system)	
Paper VI **NUCLEAR & PARTICLE PHYSICS I** 1.Bulk properties of nuclei Nuclear mass, charge, size, binding energy, spin and magnetic moment. Isobars, isotopes and isotones; mass spectrometer (Bainbridge).	1.Student will know the basic properties of nucleus.
2. Nuclear structure Nature of forces between nucleons, nuclear stability and nuclear binding, the liquid drop model (descriptive) and the Bethe-Weizsacker mass formula, application to stability considerations, extreme single particle shell model (qualitative discussion with emphasis on phenomenology with examples).	2.Student will learn about mass model and other models of nucleus
3. Unstable nuclei (a) Alpha decay : alpha particle spectra – velocity and energy of alpha particles. Geiger-Nuttal law. (b) Beta decay : nature of beta ray spectra, the neutrino, energy levels and decay schemes, positron emission and electron capture, selection rules, beta absorption and range of beta particles, Kurie plot. (c)Gamma decay : gamma ray spectra and nuclear energy levels, isomeric states. Gamma absorption in matter – photoelectric process, Compton scattering, pair production (qualitative).	3.Student will learn about different nuclear radiation.
NUCLEAR & PARTICLE PHYSICS II 1.Nuclear reactions Conservation principles in nuclear reactions. Q-values and thresholds, nuclear reaction cross-sections, examples of different types of reactions and their characteristics. Bohr's postulate of compound nuclear reaction, Ghoshal's experiment.	
	4.Student will learn about nuclear fission and fusion
2. Nuclear fission and fusion Discovery and characteristics, explanation in terms of liquid drop model, fission products and energy release, spontaneous and induced fission, transuranic elements. Chain reaction and basic principle of nuclear reactors. Nuclear fusion: energetics in terms of liquid drop model.	

3. Elementary particles (a) Four basic interactions in nature and their relative strengths, examples of different types of interactions. Quantum numbers – mass, charge, spin, isotopic spin, intrinsic parity, hypercharge. Charge conjugation. Conservation laws. (b) Classifications of elementary particles – hadrons and leptons, baryons and mesons, elementary ideas about quark structure of hadrons – octet and decuplet families.	5.Student wii learn about elementary particle a d the fundamental interactions
4. Particle Accelerator and Detector Cyclotron – basic theory, synchrotron, GM counter 5. Nuclear Astrophysics Primordial nucleosynthesis, energy production in stars, pp chain, CNO cycle. Production of elements (qualitative discussion)	6.Student will learn about nuclear instrumentations.
SOLID STATE PHYSICS I 1. Crystal Structure Crystalline and amorphous solids, translational symmetry. Elementary ideas about crystal structure, lattice and bases, unit cell, reciprocal lattice, fundamental types of lattices, Miller indices, lattice planes, simple cubic, f.c.c. and b.c.c. lattices. Laue and Bragg equations. Determination of crystal structure with X-rays. 2. Structure of solids Different types of bonding- ionic, covalent, metallic, van der Waals and hydrogen. Band theory of solids, Periodic potential and Bloch theorem, Kronig-Penny model, energy band structure. Band structure in conductors, direct and indirect semiconductors and insulators (qualitative discussions); free electron theory of metals, effective mass, drift current, mobility and conductivity, Wiedemann-Franz law. Hall effect in metals : Phenomenology and implication.	7.Students will learn about crystalline properties and their manifestation of it.
SOLID STATE PHYSICS II 1. Dielectric properties of materials Electronic, ionic and dipolar polarizability, local fields, induced and oriented polarization – molecular field in a dielectric; Clausius-Mosotti relation. 2. Magnetic properties of materials Dia, para and ferro-magnetic properties of solids. Langevin's theory of diamagnetism and paramagnetism. Quantum theory of paramagnetism, Curie's law. Ferromagnetism : spontaneous magnetization and domain structure; temperature dependence of spontaneous magnetisation; Curie-Weiss law, explanation of hysteresis.	8.Student will learn the electric and magnetic properties of solids.

3 Lattice vibrations Elastic and atomic force constants; Dynamics of a chain of similar atoms and chain of two types of atoms; optical and acoustic modes; interaction of light with ionic crystals. Einstein's and Debye's theories of specific heats of solids.	9.Student will know about thermal properties of solids
4. Superconductivity Introduction (Kamerlingh-Onnes experiment), effect of magnetic field, Type-I and type-II superconductors, Isotope effect. Meissner effect. Heat capacity. Energy gap. Ideas about High-Tc superconductors.	10.Student will know about superconducting state of matter.

Paper VIIA **STATISTICAL MECHANICS** 1.Microstates and macrostates Classical description in terms of phase space and quantum description in terms of wave functions. Hypothesis of equal a priori probability for microstates of an isolated system in equilibrium. Interactions between two systems – thermal, mechanical and diffusive. Statistical definition of temperature, pressure, entropy and chemical potential. Partition function of a system in thermal equilibrium with a heat bath. 2. Classical statistical mechanics Maxwell-Boltzmann distribution law. Calculation of thermodynamic quantities for ideal monoatomic gases. 3. Motivations for quantum statistics Gibbs' paradox. Identical particle and symmetry requirement. Derivation of MB, FD and BE statistics as the most probable distributions (micro-canonical ensemble). Classical limit of quantum statistics.	1.Student will learn about statistical nature of matter.
4. Quantum statistical mechanics Bose-Einstein statistics: Application to radiation – Planck's law. Rayleigh Jeans and Wien laws as limiting cases, Stefan's law. Fermi-Dirac statistics: Fermi distribution at zero and non-zero temperatures. Fermi energy and its expression in terms of particle density. Degenerate and non-degenerate Fermi gas. Electron specific heat of metals at low temperature. Saha equation for thermal ionization and its application to astrophysics.	2.Student will learn about quantum statistical nature of matter.
ELECTROMAGNETIC THEORY 1. Generalization of Ampere's Law Displacement Current, Maxwell's Field Equations, Wave equation for electromagnetic (EM) field and its solution – plane wave and spherical wave solutions, transverse nature of field, relation between E and B; energy density of field, Poynting vector and Poynting's theorem, boundary conditions.	3.Student will learn Maxwell's equations.

2. EM Waves in an isotropic dielectric Wave equation, reflection and refraction at plane boundary, reflection and transmission coefficients, Fresnel's formula, change of phase on reflection, polarization on reflection and Brewster's law, total internal reflection. 3. EM waves in conducting medium Wave equation in conducting medium, reflection and transmission at metallic surface – skin effect and skin depth, propagation of E-M waves between parallel and conducting plates – wave guides (rectangular only). 4. Dispersion Equation of motion of an electron in a radiation field : Lorentz theory of dispersion – normal and anomalous; Sellmeier's and Cauchy's formulae, absorptive and dispersive mode, half power frequency, band width.	4.Student will know about theory of radiation.
5. Scattering of radiation by a bound charge, Rayleigh's scattering (qualitative ideas), blue of the sky, absorption.	5.Student will know about optical scattering.

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

CO-PO MAPPING
B.Sc. (Honours) Physics 2018-2019

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