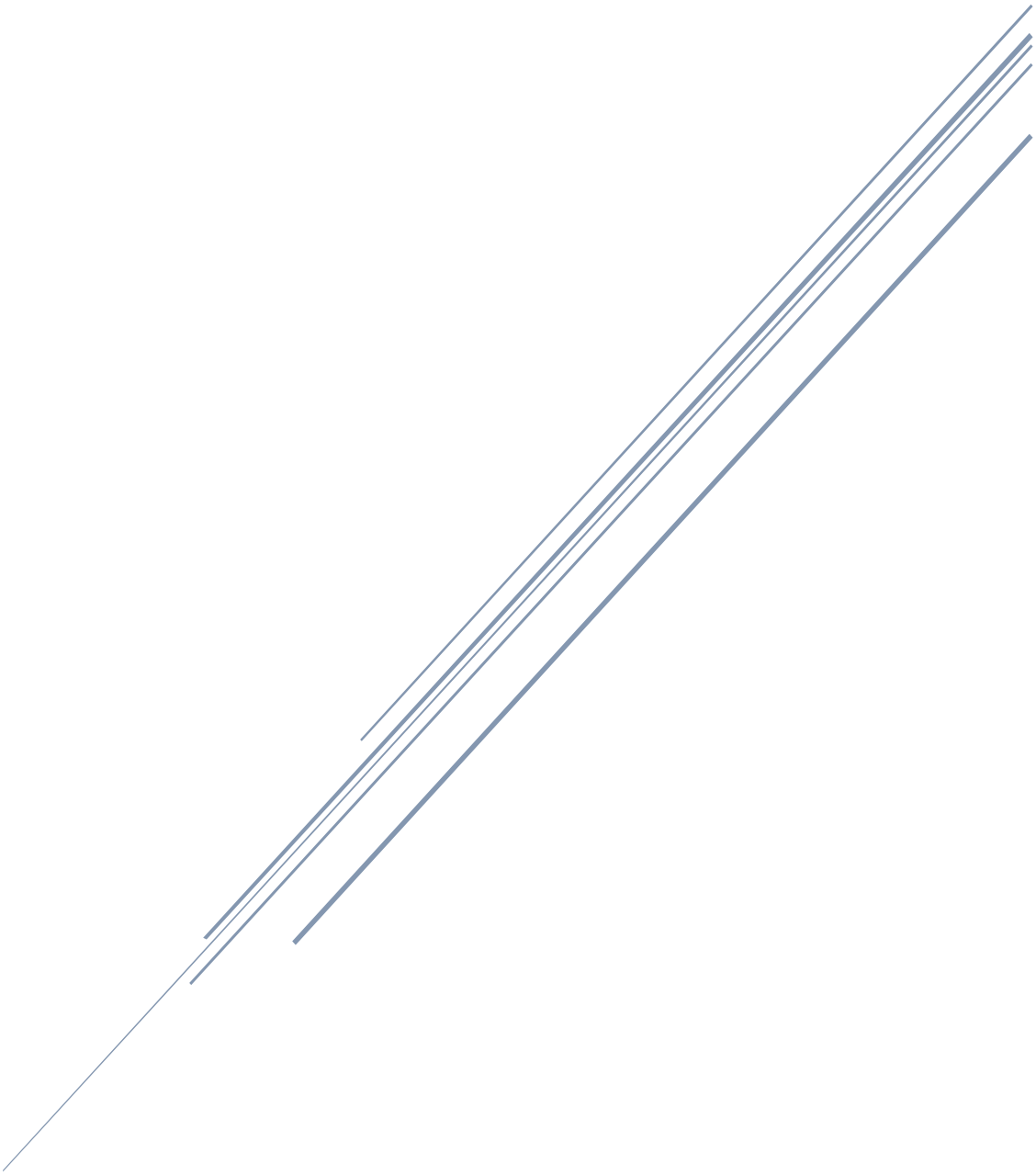
# BACHELOR OF SCIENCE (HONS) (PHYSICS)-ODL

## PROGRAMME PROJECT REPORT (PPR)



School of Sciences

PPR of B.Sc. in Physics approved by 39th Academic Council (vide memo no.: Reg/0322 dated 14.03.2023) for delivery of programme through Open Distance Learning mode.

## *i. Programme's mission and objectives:*

Netaji Subhas Open University established in the year 1997 following the State Act (W.B. Act (XIX) of 1997 and Recognised by U.G.C.). From its inception Universities mission was "to reached the unreached" and thus imparting education to the learners those who could not enter into the higher education due to their (i) distance from the higher education institution(s); (ii) poverty; (iii) other-wise engaged in jobs. Most people would probably agree that learning science with understanding is desirable for all the students. Keeping this in mind Netaji Subhas Open University launched its Physics course (EPH) at the Under-graduate level (BDP) from the session 2000-2001. The opening of the graduate course in Physics was the need and demand of the students as well as the study centres.

The main objectives for offering this program are: –

- ✓ To educate and trained individuals to be an effective managers and decision-makers.
- ✓ For the understanding that scientific knowledge is the product of a process engaged in by a community of scientists.
- ✓ To equip individuals with the necessary scientific skills and competencies to enable them to seek jobs and progress in their career.
- ✓ To enhance the capabilities of the existing workforce in the country and thus contribute to economic as well as scientific development.
- ✓ To give chances to the willing students those who could not entered into the conventional Universities due to their job and limitation of the seat in the respective subjects.
- ✓ Understand and apply theoretical and practical knowledge in the appropriate areas and enhance their living condition as well as to save the nature and its surroundings.
- ✓ Work collaboratively with others (within different sections of the society) in cross-functional teams, and to motivate, lead, and mentor others.

## *ii. Relevance of the program with HEI's Mission and Goals:*

The mission of the Higher Education Institution (University) is to bring more and more learners in the higher education and thus contribute to economic as well as scientific development. In other way, involvement of more learners in higher education will help the nation to reach its goal. Students completing this program will be able to have: (i) " hand on" knowledge of the Physics and provide insight for wise management decisions about how the planet's resources should be used; (ii) learners focus on "real world" relationships and dependencies among the phenomena and processes will give character to any location or place; (iii) summarizing a great deal of knowledge economically by incorporating it in a limited set of general principles; (iv) conduct spatial representation using visual, verbal, digital, and cognitive approaches; and (v) leading to specific, testable predictions.

## *iii. Nature of prospective target group of learners:*

For the programme, the students must have Physics in Higher Secondary level from any recognized board. They are considered as the target group of learners for the programme. In West Bengal, a lot of Learners pass higher secondary (10+2) examination with science background. But due to limitation of seats in the conventional Universities/ colleges in Physics (Honours), all of them could not get enrolled themselves in the subject of their choice (i.e., Physics). In recent years there are ample scope of higher studies as well as research in Physics, thus the Learners opt this subject by choice.

Besides, target group of learners are people from different age groups who wishes to pursue higher education and enhance their knowledge in the discipline to seek for a better career and lead a responsible life. The learners are from different socio-economic background and are located in different parts of the state of West Bengal and also from neighbouring other states. In compliance with the ultimate objective of distance education to reach the unreached, special care is taken to include learners from marginalised sections of the society, backward caste and tribes.

This makes for a very heterogeneous learner group.

### *iv. Appropriateness of programme to be conducted in Open and Distance Learning and/or Online mode to acquire specific skills and competence:*

In science "the term theory is used to describe an organized body of principles and assumptions that account for a set of phenomena along with the rules for its application". On the other hand, practical is a simplified, physical representation of a thing or process. The representation can take many forms, such as a diagram, a flow chart, a computer program, or a physical replica. NSOU provides all the pre-conditions of the science subjects while conducting both the Undergraduate course in Physics at the University. The following attributes amply speak for this.

i) Physics, as a discipline, in NSOU is its ability to integrate and apply knowledge across the interface of the natural world;

ii) In the course of Physics students work together to study fundamental and applied problems that are of compelling societal and scientific interest.

(iii) In Physics, we don't just learn in the classroom; we provide students with opportunities to learn relevant skills and apply their knowledge to real-world challenges.

(iv) The newer approach included by UGC in the curriculum is "virtual laboratory", for conducting practical classes. The University is on way to implement this new arena in the syllabi, thus imparting knowledge of this new arena of science to the students.

### *v. Instructional Design:*

The curriculum design and detailed syllabus for UG-CBCS Physics Learners is as follows.

Introduction: This programme is very popular and demanding since its stating in West Bengal. It is well designed and well structured following the UGC guidelines and the syllabus is also well framed following the major educational institutions in West Bengal and India. Each and every year a very good number of students enrolled in this programme and complete it successfully. This programme for Honours in Physics (HPH) at undergraduate level is well designed and well structured following the Choice Based Credit system in compliance with UGC guidelines and the syllabus is also well framed following the major educational institutions in West Bengal and India. The programme consists of fourteen (14) Core Courses (CC), four (04) Discipline Specific Elective [DSE] courses, two (02) Skill Enhancement Courses [SEC], two (02) Ability Enhancement Compulsory Courses [AECC] and four (04) Generic Elective Courses [GEC]. The fresher and existing employees can take the advantage of ODL system to enhance their skills and competency in this particular field without disturbing their work schedule.

The Department takes every care to prepare the Learning Materials in printed form popularly known as the Self-Learning Materials (SLM) with the approach of self-explanatory, self-contained, self-motivating and self-evacuating following the guidelines offered by the University Grants Commission through its notifications. The details of the Under graduate programme given below:

a. Course Structure: (Please see the detailed table below):

| SEM | | Course CODE | Name of Course | Credit | Study Hours | TE Full Marks | Assig. Full Marks | Total Marks |
|---|---|---|---|---|---|---|---|---|
| 1st Year | I | **CC-PH-01** | Lab -I | 6 | 180 | 70 | -- | 70 |
| | | **CC-PH-02** | Lab -II | 6 | 180 | 70 | -- | 70 |
| | | **GE-01:** # Refer Table below | | 6 | 180 | 50 | 20 | 70 |
| | | **AE-BG-11** | * Bengali | 2 | 60 | 50 | 20 | 70 |
| | | **AE-EG-12** | * English | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | II | **CC-PH-03** | Mechanics and General Physics | 6 | 180 | 50 | 20 | 70 |
| | | **CC-PH-04** | Mathematical Methods in Physics-I | 6 | 180 | 50 | 20 | 70 |
| | | **GE-02:** # Refer Table below | | 6 | 180 | 50 | 20 | 70 |
| | | **AE-ES-21** | Environmental Studies | 2 | 60 | 50 | 20 | 70 |
| 2nd Year | III | **CC-PH-05** | Lab -III | 6 | 180 | 70 | -- | 70 |
| | | **CC-PH-06** | Lab -IV | 6 | 180 | 70 | -- | 70 |
| | | **CC-PH-07** | Mathematical Methods in Physics-II | 6 | 180 | 50 | 20 | 70 |
| | | **GE-03:** # Refer Table below | | 6 | 180 | 50 | 20 | 70 |
| | | **SE-PH-11** | Electrical Circuits and Network Skills | 2 | 60 | 50 | 10 | 60 |
| | IV | **CC-PH-08** | Electricity and Magnetism | 6 | 180 | 50 | 20 | 70 |
| | | **CC-PH-09** | Waves and Optics | 6 | 180 | 50 | 20 | 70 |
| | | **CC-PH-10** | Mathematical Methods in Physics - III | 6 | 180 | 50 | 20 | 70 |
| | | **GE-04:** # Refer Table below | | 6 | 180 | 50 | 20 | 70 |
| | | **SE-PH-21** | Renewable Energy and Energy Harvesting | 2 | 60 | 50 | 10 | 60 |
| 3rd Year | V | **CC-PH-11** | Lab- V | 6 | 180 | 70 | -- | 70 |
| | | **CC-PH-12** | Thermodynamics and Statistical Mechanics | 6 | 180 | 50 | 20 | 70 |
| | | **DS-PH-11** | Physics of Devices and Communication | 6 | 180 | 50 | 20 | 70 |
| | | **DS-PH-21** | DSE Lab- I | 6 | 180 | 70 | -- | 70 |
| | VI | **CC-PH-13** | Quantum Physics | 6 | 180 | 50 | 20 | 70 |
| | | **CC-PH-14** | Electronics | 6 | 180 | 50 | 20 | 70 |
| | | **DS-PH-31** | Solid State Physics | 6 | 180 | 50 | 20 | 70 |
| | | **DS-PH-41** | Nuclear and Particle Physics | 6 | 180 | 50 | 20 | 70 |

GE combination list:

| Subject | SEM-I: GE-01 | SEM-II: GE-02 | SEM-III: GE-03 | SEM-IV: GE-04 |
|---|---|---|---|---|
| Mathematics | **GE-MT-11:** Statistical Techniques | **GE-MT-21:** Dynamical Systems | **GE-MT-31**: Applications of Algebra | **GE-MT-41:** Modelling and Simulation |
| Chemistry | **GE-CH-11:** Basic Physical Chemistry | **GE-CH-21:** Basic Inorganic Chemistry | **GE-CH-31:** Basic Organic Chemistry | **GE-CH-41:** Application Oriented Chemistry |
| | | | | **¥ GE-CH-42:** Approved MOOCs' |

* Learners have to choose any one from AE-BG-11: Bengali or AE-EG-12: English as Ability Enhancement Compulsory Course 1

# Learners have to choose any one course from each individual GE group of Semester I, II, III and IV.

Course Legend: CC – Core Courses, AECC – Ability Enhancement Compulsory Courses, GEC – Generic Elective Courses, SEC – Skill Enhancement Courses, DSEC – Discipline Specific Elective Courses

b. Detailed Syllabus: (Learners are advised to check the relevant Self Learning Materials (SLM's) for actual distribution of Modules and Units. All courses have been designed in keeping with UGC (Open and Distance Learning and Online Programmes) Regulations, 2020 regarding the minimum number of Units)

# Semester-I

## Course: CC-1(Lab-I) Credit-6 (Marks-70)

Unit 1: Extension of spring and to find out spring constant from vertical Oscillations.
Unit 2: To find out modulus of rigidity from torsional oscillation of a wire.
Unit 3: Determination of Moment of Inertia of a Fly-wheel.
Unit 4: Determination of refractive index of a liquid by travelling microscope.
Unit 5: To find Fourier coefficients of different periodic vibrations by graphical method
Unit 6: To determine the coefficient of Viscosity of water by capillary flow method.
Unit 7: Determination of g using a Bar pendulum/Kater's pendulum.

Unit 8: Determination of thermal conductivity of a bad conductor by Lee's and choltron's method.
Unit 9: To determine the surface tension of a liquid by Jagger's method.
Unit 10: To determine focal lengths of convex & concave lenses bydisplacement and
Combination methods.
Unit 11: To adjust a Spectrometer for parallel rays by Schuster's method and to find
out the angle of a prism.
Unit 12: To determine an unknown Low Resistance using Potentiometer.
Unit 13:Write a programme and verify to find out sum and average of given number
set (By using C/C++).
Unit 14:Write a programme and verify to find out largest number and its position in a
given number set.(By using C/C++).
Unit 15: Write a programme and verify to arrange a number in ascending/descending order for a given number set (By using C/C++).

## **Course:CC-2**(Lab-II) **Credit-6 (Marks-70)**

Unit 1: To draw the forward bias and reverse bias characteristics of ajunction diode and to find the value of $r_p$ in active region.
Unit 2: To draw the Zener Diode–characteristics in forward and reverse bias condition
and find the break down voltage and the break down current.
Unit 3: To verify Thevenin, Norton theorem, Maximum Power Transfer Theorem.
Unit 4: To determine the Y of a material by flexure method.
Unit 5: To draw the input-out-put characteristics of a common emitterTransistor.
Unit 6: To determine the band gap energy of a semiconductor by four probe method.
Unit 7: To determine H by Vibrational magnetometer.
Unit 8: To determine the self-inductance of a coil by Anderson's bridge.
Unit 9: To draw e - T of a thermocouple.
Unit 10: To determine the elastic Constants of the material a wire by Searle's method
Unit 11: To study the V-I curve of a solar cell and find the maximum power point and
efficiency.
Unit 12: To study the variation of mutual inductance of a given pair of coaxial coils by
using a ballistic galvanometer.
Unit 13: To find out temperature co-efficient of the material of a wire by
*Carey- Foster bridge*
Unit 14: To find leakage resistance by discharging a capacitor
Unit 15: To study Lissajous Figures

# Semester-II

## **Course: CC-3**(Mechanics and General Physics)
## **Credit-6 (Marks-70)**

**Laws of Motion:** Inertial and non-inertial frame, Galilean transformations; Galilean invariance. Dynamics of a system of particles. Concept of Centre of Mass,

determination of centre of mass for discrete and continuous bodies having cylindrical and spherical symmetry.
Application of Newton's law for variable mass system. Conveyer belt feeding raw material, Rocket motion in gravity and gravity free space.
Conservative and non-conservative forces, Force as a gradient of Potential Energy, stability and potential energy, conservation of momentum and energy.
Elastic and in-elastic collisions, in laboratory frame and centre of mass frame.
**Rotational Dynamics:** Angular velocity, Angular momentum, Torque, Conservation of angular momentum, Moment of Inertia, product of inertia, Parallel and perpendicular axes theorem, calculation of Moment of Inertia of discrete and continuous objects (1-D, 2-D and 3-D), Euler's equations; K.E of rotation involving both translation and rotation.
Rotating reference frame and the pseudo forces,non-inertial frames and idea of fictitious forces.Equation of motion with respect to a uniformly rotating frame - Centrifugal and Coriolisforces. Laws of Physics in a laboratory on the surface of the earth.
**Gravitation**: Gravitational potential and intensity, Gauss's law, applications of Gauss's law, Poisson's equation, Laplace's equation, gravitational self-energy, gravitational field and potential due to spherical bodies. Effect of Coriolis force on a falling body. Foucault pendulum.
**Central Force Motion:** Motion of a particle under a central force field. Two-body problem and its reduction to one-body problem and its solution. The energy equation and energy diagram.
Satellite motion: Kepler's laws and its deduction for elliptic orbit. Geo-synchronousorbits, Weightlessness. Basic idea of Global Positioning System (GPS).
**Elasticity:** Interrelationships between the various elastic constants for isotropic medium, Torsion of a cylinder and torsional rigidity, Bending of beams and cantilevers, flexural rigidity, geometrical moment of inertia, strain-energy relations.
**Viscosity and fluid dynamics**: Coefficient and Newton's law. Poiseullie's equation, Stoke's method and terminal velocity. Equation of continuity in differential form, Bernoulli's theorem and its applications,Toricelli's theorem.
**Special Theory of Relativity**: Discovery of constancy of speed of light from theoretical and experimental consequence, Postulates of Special Theory of Relativity, Lorentz Transformation, Length Contraction, Time Dilation, Examples. Lorentz Invariance; Velocity Addition Theorem, Doppler Effect,
Variation of Mass with Velocity, Energy-Mass Equivalence, Relativistic Energy and Momentum and their Transforms; Newton's Laws of Motion in Relativistically Covariant Form.

# CC-4: (Mathematical methods in Physics-I) Credit-6 (Marks-70)

**Calculus:**
Recapitulation: Limits, continuity, average and instantaneous quantities, differentiation. Intuitive ideas of continuous, differentiable, functions and plotting of curves.Approximation: Taylor and binomial series (statements only).

Second Order Differential equations: Homogeneous Equations with constant coefficients. Wronskian and general solution. Statement ofexistence and Uniqueness Theorem for Initial Value Problems. Particular Integral.
Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor with simple illustration. Constrained Maximization using Lagrange Multipliers.
**Vector Calculus**: Recapitulation of vectors: Properties of vectors under rotations. Scalar product and its invariance under rotations. Vector product, Scalar triple product and their interpretation in terms of area and volume respectively. Scalar and Vector fields.
Vector Differentiation: Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities, Gradient, divergence, curl and Laplacian in spherical and cylindrical coordinates.
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)
**Orthogonal Curvilinear Coordinates:**
Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl andLaplacian in Cartesian, Spherical and Cylindrical Coordinate Systems
**Dirac Delta function and its properties**:
Definition of Dirac delta function. Representation as limit of a Gaussian function and rectangular function. Properties of Dirac delta function.
**Matrices:** Addition and Multiplication; Transpose and conjugate transpose of a matrix; Adjoint and Inverse of a Matrix; rank of a matrix; Normal Forms; Characteristics equation of a square matrix and diagonalization; Trace of a Matrix; Inner Product.
Types of matrices – Null Matrices, Singular and non-singular matrices, Symmetric and Skew- symmetric Matrix, Hermitian and Skew-Hermitian Matrix, Orthogonal and unitary matrices and their properties.
Solution of systems of linear homogenous and non-homogeneous equations by matrix method; Cayley- Hamiltontheorem.
Eigen-values and Eigenvectors. Theorem. Diagonalization of Matrices. Solutions of Coupled Linear Ordinary Differential Equations, Functions of a Matrix.

**C & C$^{++}$ Programming fundamentals:**
Introduction to Programming, constants, variables and data types, operators and Expressions, I/O statements, scanf and printf, c in and c out, Manipulators for data formatting, Control statements (decision making and looping statements) (If-statement. If-else Statement. Nested if Structure. Else-if Statement. Ternary Operator.Goto Statement. Switch Statement. Unconditional and Conditional Looping. While Loop. Do-While Loop. FOR Loop. Break and Continue Statements. Nested Loops).

# Semester-III

## CC-5: (Lab-III) Credit-6 (Marks-70)

Unit 1: To find mutual inductance by Carey-Foster method

Unit 2: To measure the field strength B and its variation with distance by using a search coil.
Unit 3: To study the variation of refractive index(μ) of the material of a prism with wave length and to verify Cauchy's dispersion formula and to find the dispersive power of the material of the prism by spectrometer.
Unit 4: To draw the regulation characteristics of a bridge rectifier (i) without using any filter and (ii) using C filter. Determination of ripple factor in both cases by measuring the ripple voltage with the help of an A.C meter.
Unit 5: To find the optical rotation of a sugar solution by a Polarimeter.
Unit 6: To find wavelength of Na-light by Fresnel's bi-prism.
Unit 7: To draw $\delta-\lambda$, $\delta-1/\lambda^2$graphs and find an unknown wavelength by a prism Spectrometer
Unit 8: To draw: sin $\theta-\lambda$ graph with the help of a diffraction grating and find wavelengths.
Unit 9: To study response curve of a Series LCR circuit and determine its Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Band width.
Unit 10: To find the resistance of a Galvanometer by Half Deflection Method.
Unit 11: Measurement of charge and current sensitivity and CDR of Ballistic Galvanometer
Unit 12: To determine wavelength of sodium light using Newton's Rings.
Unit 13: To study the response curve of a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q.
Unit 14: To determine refractive index of the Material of a prism using sodium source.
Unit 15: To determine the Temperature Coefficient of Resistance by Platinum ResistanceThermometer (PRT).

## **CC-6:** (Lab-IV) **Credit-6 (Marks-70)**

Unit 1: To find the number of lines per centimetre of a transmission grating and to measure the wave length of an unknown spectral line.
Unit 2: To study photo current versus intensity and wave length of light; maximum of photo electrons versus frequency of light.
Unit 3: Determination of slit width by studying the single slit diffraction pattern.
Unit 4: Use of an OP-AMP as adder, Subtractor, inverting and non-inverting amplifier.
Unit 5: To test a Transistor using a Multimeter. To design a switch (NOTgate) using a Transistor and study its performance.
Unit 6: To verify and design AND, OR, NOT and XOR gates using NAND gates.
Unit 7: To design a combinational logic system for a specified Truth Table.
Unit-8: To design Half Adder, Full Adder and 4-bit binary Adder.
Unit 9: To design a Half Subtractor, Full Subtractor, Adder-Subtractor using Full Adder I.C.
Unit 10: To study the diffraction pattern of a crossed grating with the help of a LASER source.
Unit 11: To draw the characteristics of a JFET and hence to determine relevant parameters.
Unit 12: Determination of thickness of a thin film by Fresnel"s bi-prism.
Unit 13: To calibrate a thermocouple to measure temperature in a specified Range using
(i) Null Method, (ii) Direct measurement using Op- Amp difference amplifier and to determine Neutral Temperature.

Unit 14: To design Fourier spectrum of (i) Square (ii) triangular and (iii) half sinusoidal wave form by CRO.

## **CC-7:** (Mathematical Methods in Physics-II)
## **Credit-6 (Marks-70)**

**Fourier Series**: Periodic functions. Orthogonality of sine and cosine functions, DirichletConditions (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.

**Frobenius Method and Special Functions**: Singular Points of Second Order LinearDifferential Equations and their importance. Frobenius method and its applications todifferential equations. Legendre, Bessel, Hermite and Laguerre. Differential Equations. Properties of Legendre Polynomials: Rodrigues Formula, Generating Function, Orthogonality. Simple recurrence relations. Expansion of function in a series of Legendre Polynomials. Bessel Functions of the First Kind: Generating Function, simplerecurrence relations. Zeros of Bessel Functions and Orthogonality.

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

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

**Partial Differential Equations**: Solutions to partial differential equations, usingseparation of variables: Laplace's Equation in problems of rectangular, cylindrical andspherical symmetry. Wave equation and its solution for vibrational modes of a stretchedstring, rectangular membrane.

**Advance Mechanics**

Constraints, Generalized co-ordinates, Virtual displacement and virtual work done; D'Alembert's principle and derivation of Euler-Lagrange equations; Lagrange’s equations for velocity-dependent potential; Application to Lagrange's equation to some simple cases(one-dimensional Simple Harmonic Oscillations and falling body in uniform gravity). Cyclic coordinates Isotropy and Homogeneity of space, Lagrangian formulation of conservation laws of linear momentum, angular momentum and energy.

Hamilton formalism: Variational principles; Hamilton's principle; Derivation of Lagrange's equation from Hamilton's principle.

Hamilton's equation of motions; Hamiltonian; Applications of Hamilton's equation of motion to some simple cases(Hamiltonian for a harmonic oscillator, solution of Hamilton’s equation for Simple Harmonic Oscillations; particle in a central force field- conservation of angular momentum and energy).

# Semester-IV

## **CC-8:** (Electricity and Magnetism)
## **Credit-6 (Marks-70)**

**Electric Field and Electric Potential:**

Conservative nature of Electrostatic Field,Gauss' Law and its applications with spherical, cylindrical and planar symmetry of charge distribution, Laplace's and Poisson equations, the Uniqueness Theorem.Electrostatic energy of a system of charges. Electrostatic energy of a charged sphere. Conductors in an electrostatic Field. Surface charge and force on a conductor. Capacitance of a system of charged conductors. Parallel-plate capacitor. Capacitance of an isolated conductor. Method of Images and its application to: (1) Plane Infinite Sheet and (2) Sphere.

**Dielectric Properties of Matter:**
Electric Field in a medium, Dielectric Polarization, Electrical Susceptibility and Dielectric Constant. Displacement vector **D**. Relations between **E**, **P** and **D**. Gauss' Law in dielectrics.Linear dielectrics, boundary conditions at the dielectric surface, energy density in electrostatic field, microscopic theory of dielectric polarizability, Clausius-Mossotti relation, atomic radius from dielectric constant, polar molecules and Langevin-Debye (formula only).

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

**Magnetic Properties of Matter:** Magnetization vector (**M),**Magnetic Intensity(**H),**Magnetic Susceptibility and permeability. Relation between **B, H, M**. Ferromagnetism, B-H curve and hysteresis loss.

**Electromagnetic Induction:** Faraday's Law, Lenz's Law. Self-Inductance, Mutual Inductance, Energy stored in a Magnetic Field.

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

**Network theorems:** Ideal Constant-voltage and Constant-current Sources.
Network Theorems: Thevenin's theorem, Norton's theorem, Superposition theorem, Maximum power theorem, Reciprocity theoremand their applications.

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

**Ballistic Galvanometer:** Torque on a current Loop. Ballistic Galvanometer: Current and Charge Sensitivity. Electromagnetic damping. Logarithmic damping, CDR. Conversion of ballistic to dead beat Galvanometer.

# **CC-9:**(Waves and Optics) **Credit-6 (Marks-70)**

**Recapitulation of SHM**: Setting up of differential eqn. and to find out general soln. Calculation of energy of SHM.

**Damped harmonic motion**: Setting up of differential eqn. and to find out general soln. study of the effect of damping factor on motion.

**Forced oscillations**: Transient and steady state solution, Resonance, band width, sharpness of resonance; powerdissipation and Quality Factor.Pendulum with

length comparable with the radius of earth. Compound pendulum with corrections, centre of percussion, Kater's Pendulum.

**Superposition of Harmonic Oscillations:** Superposition Principle. Superposition of two collinear oscillations with equal an un equal frequencies and their uses. Superposition of two perpendicular SHMs, Lissajous figs.

**Wave motion:**(a) Plane and Spherical Waves. Longitudinal and Transverse Waves.Plane Progressive Waves. Wave Equation. Particle and Wave Velocities. Differential Equation of a wave. Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave.(b) Water Waves: Ripple.

**Velocity of Waves**:(a) Velocity of Transverse Vibrations of Stretched Strings.(b) Velocity of Longitudinal Waves in a Fluid in a Pipe. Newton's Formulafor Velocity of Sound. Laplace's Correction.

**Superposition of Harmonic Waves:**(a) Standing (Stationary) Waves in a String: Fixed and Free Ends. AnalyticalTreatment. Changes with respect to Position and Time. Energyof Vibrating String. Transfer of Energy. Normal Modes ofStretched Strings. Plucked and Struck Strings. Melde's Experiment.(b) Longitudinal Standing Waves and Normal Modes. Open and ClosedPipes.(c) Superposition of N Harmonic Waves. Phase and Group Velocities.

**Wave optics:** (a) Electromagnetic nature of light. Definition and properties of wavefront. Huygens Principle, Temporal and Spatial coherence.

**Interference :**(a) Division of amplitude and wavefront. Young's double slit experiment.Lloyd's Mirror and Fresnel's Bi-prism.Stokes' treatment. Interference in Thin Films: parallel and wedgeshapedfilms. Fringes of equal inclination (Haidinger Fringes); Fringesof equal thickness (Fizeau Fringes). Newton's Rings: Measurementof wavelength and refractive index.

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

**Diffraction and Holography:**

(a) Fraunhofer diffraction: Single slit. Circular aperture, Resolving Powerof a telescope. Double slit. Multiple slits. Diffraction grating. Resolvingpower of grating. (b) Fresnel Diffraction: Fresnel's Assumptions. Fresnel's Half-PeriodZones for Plane Wave. Explanation of Rectilinear Propagation ofLight. Theory of a Zone Plate: Multiple Foci of a Zone Plate. Fresnel'sIntegral, Fresnel diffraction pattern of a straight edge, a slit anda wire.

**LASER**: Characteristics, Spontaneous and stimulated emission, meta-stable states, population inversion. Three level, four level LASERs, optical resonator, Ruby Laser, He-Ni Laser.

**Holography**: Principle of Holography. Recording and ReconstructionMethod. Theory of Holography as Interference between two PlaneWaves. Point source holograms.

**Polarization of Light:** Description of Linear, Circular and Elliptical Polarization. Propagation of E.M. Waves in Anisotropic Media. Fresnel's Formula. Uniaxial and Biaxial Crystals. Light Propagation in Uni-axial Crystal. Double Refraction. Polarization by Double Refraction. Nicol Prism. Ordinary & extraordinary refractive indices. Production & detection of Plane, Circularly and Elliptically Polarized Light. Phase Retardation Plates: Quarter-Wave and Half-Wave Plates. Babinet Compensator and its Uses. Optical Rotation. Biot's Laws for Rotatory Polarization. Fresnel's Theory of optical rotation. Specific rotation. Laurent's half-shade Polarimeter.

**Optical Fibres: -**Propagation of light in fibre, Numerical Aperture. Step and Graded Indices (Definitions Only). Single and Multiple Mode Fibres (Concept and Definition Only).

# CC-10:(Mathematical methods in Physics-III)
# Credit-6 (Marks-70)

**Complex Analysis**: Brief Revision of Complex Numbers and their Graphical Representation. Euler's formula, De Moivre's theorem, Roots of Complex Numbers. Functions of Complex Variables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions. Singular functions: poles 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.
**Integrals Transforms**: Fourier Transforms: Fourier Integral theorem. Fourier Transform. Examples. Fourier transform of trigonometric, Gaussian, finite wave train & other functions. Representation of Diracelta function as a Fourier Integral. Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem. Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.). Three dimensional Fourier transforms withexamples. Application of Fourier Transforms to differential equations: One dimensionalWave and Diffusion/Heat Flow Equations.

**Laplace Transforms**: Laplace Transform (LT) of Elementary functions. Properties of
LTs: Change of Scale Theorem, Shifting Theorem. LTs of 1st and 2nd order Derivativesand Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function,Dirac Delta function, Periodic Functions. Convolution Theorem. Inverse LT.Application of Laplace Transforms to 2nd order Differential Equations: DampedHarmonic Oscillator, Simple Electrical Circuits, Coupled differential equations of $1^{st}$order. Solution of heat flow along infinite bar using Laplace transform.
**Tensors**: Tensors as multilinear transformations (functionals) on vectors. Examples: Moment of Inertia, dielectric susceptibility. Components of a tensor in basis. Symmetric and antisymmetric tensors. The completely antisymmetric tensor. Non-orthonormal and reciprocal bases. Summation convention. Inner product of vectors and the metric tensor.

Coordinate systems and coordinate basis vectors. Reciprocal coordinate basis.Components of metric in a coordinate basis and association with infinitesimal distance.
Change of basis: relation between coordinate basis vectors. Change of tensorcomponents under change of coordinate system. Example: Inertial coordinates & bases in Minkowski space, Lorentz transformations as coordinate transformations,
Elelctro-magnetic tensor and change in its components under Lorentz transformations.

# Semester-V

# CC-11:(Lab-V) Credit-6(Marks-70)

Unit 1: To design d.c power supply with a specified output following the steps and to measure its
a) ripple factor
b) study its input and output by CRO
c) draw load and line regulation.

a) Half wave rectifier
   i) With L/C type filter
   ii) With pi filter
b) Full wave rectifier
   i) With L/C typefilter
   ii) With pi filter
c) Use a Zener diode to stabilize the output
d) Use IC to stabilize the output

Unit 2. To design an amplifier (Transistor/ OPAMP/FET) of a specified out-put andstudy its input and output signal by CRO.
Unit 3. To design an inverter with specified input and output resistance.
Unit 4. To design a 4-bit ripple counter using IC gates and study its performance.
Unit 5. To design a circuit to check water level of a water tank/reservoir and automate the filling motor.
Unit 6: To design a circuit by using LDR to check pollution level.
Unit 7: To design a fan speed electronic regulator using SCR.
Unit 8: To design a Wein's Bridge oscillator of given frequency.
Unit 9: To design PWM, PPM, PAM and Pulse code modulation using ICs.

# **CC-12:**( Thermodynamics and Statistical mechanics)

## Credit-6 (Marks-70)

**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, First Law of Thermodynamics and its differential form, Internal Energy, First Law & various processes, Applications ofFirst Law: General Relation between $C_P$ and $C_v$, Work Done during Isothermal andAdiabatic Processes, Compressibility and Expansion Co-efficient.

**Second Law of Thermodynamics**: Reversible and Irreversible process with examples.Conversion of Work into Heat and Heat into Work. Heat Engines. Carnot's Cycle,Carnot engine & efficiency. Refrigerator & coefficient of performance, 2nd Law ofThermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence.

Carnot's Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale

**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 Processes.Principle of Increase of Entropy. Temperature–Entropy diagrams for Carnot's Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero.

**Thermodynamic Potentials:** Extensive and Intensive Thermodynamic Variables.

Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. Their Definitions, Properties and simple applications. First and second order Phase Transitions with examples, Clausius-Clapeyron Equation and Ehrenfest equations.
Maxwell's Thermodynamic Relations: Derivations and applications of Maxwell's Relations, Maxwell's Relations:(1) Clausius-Clapeyron equation, (2) Values of $C_P$ - $C_V$, (3) TdS Equations, (4) Joule-Kelvin coefficient for Ideal and Vander Waal Gases, (5) Energy equations, (6) Change of Temperature during Adiabatic Process.
**Kinetic theory of Gases:** Derivation of Maxwell's law of distribution of velocities and its experimental verification, Mean free path (Zeroth Order), Transport Phenomena: Viscosity, Conduction and Diffusion (for vertical case), Law of equipartition of energy (no derivation) and its applications to specific heat of gases; mono-atomic and diatomic gases.

**Statistical Mechanics:** Phase space, Macro-states and Microstate, Entropy and Thermodynamic probability, Maxwell-Boltzmann lawand distribution of velocity.
**Bose-Einstein Statistics:** B-E distribution law, Thermodynamic functions of a strongly Degenerate Bose Gas, Bose Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and Thermodynamic functions of photon gas. Bose derivation of Planck's law.
**Fermi-Dirac Statistics:** Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely and strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals, Relativistic Fermi gas, White Dwarf Stars, Chandrasekhar Mass Limit.

# Semester-VI

## CC-13:(Quantum Physics) Credit-6 (Marks-70)

**Foundation:** Blackbody radiation, Spectral distribution, Concept of Energy Density, Derivation of Planck's law, Deduction of Wien's distribution law, Rayleigh-Jeans Law, Stefan Boltzmann Law and Wien's displacement law from Planck's law.Planck's quantum hypothesis, Planck's constant and light as a collection of photons.
**Quantum theory of Light**: Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. Wave description of particles by wave packets. Group and Phase velocities and relation between them.
Uncertainty Principle and its Consequences. [Estimating minimum energy of a confined particle using uncertainty principle]
**Atoms in Electric & Magnetic Fields**: Electron angular momentum. Space quantization. Electron Spin and Spin Angular Momentum. Larmor's Theorem. Spin Magnetic Moment. Stern-Gerlach Experiment. Normal and Anomalous Zeeman Effect, Electron Magnetic Moment and Magnetic Energy, Gyromagnetic Ratio and Bohr Magneton.
**Many electron atoms**: Pauli's Exclusion Principle. Symmetric & Antisymmetric Wave Functions. Periodic table. Fine structure. Spin orbit coupling. Spectral Notations for Atomic States. Total angular momentum. Vector Model. Spin-orbit coupling in atoms- L-S and J-J couplings. Hund's Rule. Term symbols. Spectra of Hydrogen and Alkali Atoms (Na etc.).
**X-ray**: production, Continuous and characteristic spectra, Moseley's law.
**Schrodinger Equation**: Time Dependent and Time Independent Schrodinger Equation in One Dimension, Statistical Interpretation of Wave Function, Probability Current Density and Continuity Equation, Normalization of Wave Functions, Wave

Function in Momentum Space; Observables and Operators, Linear Momentum, Orbital Angular Momentum, Commutation Relations, Expectation Values.
**Applications of Quantum Mechanics**: One Dimensional Rectangular Potential Barrier, Tunnelling, Parity Operator and its Eigenvalues; One Dimensional Potential Well, Particle in a Box, Free Particle, Simple Harmonic Oscillator (Energy Eigenvalues only); Quantum Numbers and Constants of Motion; Spin Angular Momentum: theMagnetic Moment of Electron, Stern-Gerlach Experiment, the Total Angular Momentum Vector, Space Quantization; Optical Spectra of Hydrogenic Atoms.

# **CC-14:**(Electronics) **Credit-6(Marks-70)**

**Diodes**: Principle and structure of Junction diode, Zener diode, LED,Photodiode, Solar Cell.Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, (2) Zener Diode as Voltage Regulation.
**Bipolar Junction transistors:** Transistor characteristics; CB, CEand CC Configurations. α and β and their relationship. Load Lineanalysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current flow. Active, Cut-off and Saturation Regions.
**Amplifiers:** Transistor Biasing and Stabilization Circuits. Fixed Bias and VoltageDivider Bias. Transistor as 2-port Network. h-parameter Equivalent Circuit. Analysis ofa single-stage CE amplifier using Hybrid Model. Input and Output Impedance, Current,Voltage and Power Gains. Classification of Class A, B & C Amplifiers.
**Coupled Amplifier:** RC-coupled amplifier and its frequency response.
**Feedback in Amplifiers:** Effects of Positive and Negative Feedback on InputImpedance, Output Impedance, Gain, Stability, Distortion and Noise.
**Sinusoidal Oscillators:** Barkhausen's Criterion for self-sustained oscillations. RC Phaseshift oscillator, determination of Frequency and condition of oscillation. Hartley &Colpitts oscillators.
**Digital Circuits:** Difference between Analog and Digital Circuits. Binary Numbers.Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimalnumbers. AND, OR and NOT Gates (realization using Diodes and Transistor). NANDand NOR Gates as Universal Gates. XOR and XNOR Gates and application as ParityCheckers
**Boolean algebra**: De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuitusing Boolean algebra. Fundamental Products. Idea of Minterms and Maxterms. Conversionof a Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2)Karnaugh Map.
Data processing circuits: Basic idea of Multiplexers, De-multiplexers, Decoders,Encoders.Circuits: Arithmetic Circuits: Binary Addition. Binary Subtraction using 2's Complement.Half and Full Adders. Half & Full Subtractors, 4-bit binary Adder/Subtractor.

**Sequential Circuits:** SR, D, and JK Flip-Flops. Clocked (Level and EdgeTriggered) Flip-Flops. Pre-set and Clear operations. Race-around conditionsin JK Flip-Flop. M/S JK Flip-Flop.
**Timers:** (a) IC 555: block diagram and applications: Astablemultivibrator andMonostablemultivibrator.
**A/D and D/A converter:** Weighted and R-2R latter DAC, Successive approximation method ADC.

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

# Discipline Specific Elective

1. PHYSICS OF DEVICES AND INSTRUMENTS
2. Physics Practical: DSE LAB
3. SOLID STATE PHYSICS
4. NUCLEAR and PARTICLE PHYSICS

## Semester-V

## DSE-1:(Physics of Devices And Communication)

## Credit-6 (Marks-70)

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

**Applications of Op-Amps:** (1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Log amplifier, (7) Zero crossing detector (8) Wein bridge oscillator.

**FET**: JFET, MOSFET& UJT, Structure and Characteristics. Small signal equivalent circuits of UJT and JFET. Metal semiconductor Junction. MOSFET– their frequency limits. Enhancement and Depletion Mode MOSFETS and their characteristics, CMOS. Charge coupled devices. Tunnel diode.

**Power supply and Filters**: Block Diagram of a Power Supply, Qualitative idea of C and L Filters. Line and load regulation, Short circuit protection Active and Passive Filters, Low Pass, High Pass, Band Pass and band Reject Filters.

**Multivibrators**: Astable and MonostableMultivibrators using transistors.Phase Locked Loop(PLL): Basic Principles, Phase detector(XOR & edge triggered), Voltage Controlled Oscillator (Basics, varactor). Loop Filter– Function, Loop Filter Circuits, transient response, lock and capture. Basic idea of PLL IC (565 or 4046).

**Processing of Devices:** Basic process flow for IC fabrication, Electronic grade silicon. Crystal plane and orientation. Defects in the lattice. Oxide layer. Oxidation Technique for Si. Metallization technique. Positive and Negative Masks. Optical lithography. Electron lithography. Feature size control and wet anisotropic etching. Lift off Technique. Diffusion and implantation.

**1**. **Electronic communication**

(a) Introduction to communication: means and modes. Need for modulation.Block diagram of an electronic communication system. Briefidea of frequency allocation for radio communication system in India. (TRAI). Electromagnetic communication spectrum, band designationsand usage. Channels and base-band signals. Concept of Noise,signal-to-noise (S/N) ratio.

2. Analog Modulation: (a) Amplitude Modulation, modulation index and frequency spectrum, power of carrier and side bands, Generation of AM (Emitter Modulation), Amplitude Demodulation(diode detector), Concept of Single side band generation and detection.
Frequency Modulation (FM) and Phase Modulation (PM), modulation index and frequency spectrum, equivalence between FM and PM, Generation of FM using VCO, FM detector (slope detector), Qualitative idea of Super Heterodyne Receiver.
3. Analog Pulse Modulation
(a) Channel capacity, Sampling theorem, Basic Principles- PAM, PWM,
PPM, modulation and detection technique for PAM only, Multiplexing.
**Digital Pulse Modulation**: Need for digital transmission, Pulse Code Modulation, Digital Carrier Modulation Techniques, Sampling, Quantization and Encoding. Concept of Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK), and Binary Phase Shift Keying (BPSK).
**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.
**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)

## **DSE-2:**(DSE Lab) **Credit-6 (Marks-70)**

1. To design the active Low pass and High pass filters of given specification.
2. To design the active filter (wide band pass and band reject) of given specification.
3. To study the output and transfer characteristics of a JFET.
4. To measure the Dielectric Constant of a dielectric Materials with frequency.
5. To study the output characteristics of a MOSFET.
6. To study the characteristics of a UJT and design a simple Relaxation oscillator.
7. Design and Verification of op-amp as integrator and differentiator
8. To design an Amplitude Modulator using Transistor.
10. To design an Astable-multivibrator of given specifications using transistor.
11. To study envelope detector for demodulation of AM signal.
12. Study of ASK and FSK modulator.
13. Design clocked SR and JK Flip-Flop`s using NAND Gates
14. Design 4-bit asynchronous counter using Flip-Flop ICs
15. Measurement of susceptibility of paramagnetic solution (Quinck`s Tube Method)
16. To determine the Hall coefficient of a semiconductor sample.

# Semester-VI

## **DSE-3:**(Solid State Physics)**Credit-6 (Marks-70)**

**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. Bragg's Law. Atomic and Geometrical Factor.

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

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

**Dielectric Properties of Materials:**
Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Cauchy and Sellmeir relations. Langevin-Debye equation. Complex Dielectric Constant. Optical Phenomena. Piezo-electric effect

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

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

# **DSE-4:**(Nuclear and Particle Physics)
# **Credit-6 (Marks-70)**

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

**Nuclear Models**: Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, two nucleon separation energies, Evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model, concept of mean field, residual interaction, concept of nuclear force.

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

**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).

**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 interaction with matter.

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

**Particle Accelerators:** Accelerator facility available in India: Linear accelerator, Cyclotron, Synchrotrons.

**Particle physics:** Particle interactions; basic features, types of particles and its families. Symmetries and Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm, concept of quark model, colour quantum number and gluons.

# Semester-I

**Paper- GE1: Mechanics** **Credit:6 (Marks-70)**

Vectors: Vector algebra. Scalar and vector products. Derivatives of a vector withrespect to a parameter.

Ordinary Differential Equations: 1st order homogeneous differential equations. 2$^{nd}$order homogeneous differential equations with constant coefficients.

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

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

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

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

Fluids: Surface Tension: Synclastic and anticlastic surface - Excess of pressure -Application to spherical and cylindrical drops and bubbles - variation of surfacetension with temperature - Jaegar's method. Viscosity - Rate flow of liquid in acapillary tube - Poiseuille's formula - Determination of coefficient of viscosity of a
liquid - Variations of viscosity of liquid with temperature- lubrication.

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

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

# Semester-II

**Paper- GE 2: Thermal Physics** **Credit:6**
**(Marks-70)**

Laws of Thermodynamics: Thermodynamic Description of system: Zeroth Law of thermodynamics and temperature. First law and internal energy, conversion of heat into work, Various Thermodynamical Processes, Applications of First Law: General Relation between CP and CV, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Coefficient, Reversible and irreversible processes, Second law and Entropy, Carnot's cycle & theorem, Entropy changes in reversible & irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Unattainability of absolute zero.
Thermodynamical Potentials: Enthalpy, Gibbs, Helmholtz and Internal Energy functions, Maxwell's relations and applications - Joule-Thompson Effect, Clausius- Clapeyron Equation, Expression for (CP – CV), CP/CV, TdS equations.
Kinetic Theory of Gases: Derivation of Maxwell's law of distribution of velocities and its experimental verification, Mean free path (Zeroth Order), Transport Phenomena: Viscosity, Conduction and Diffusion (for vertical case), Law of equipartition of energy (no derivation) and its applications to specific heat of gases; mono-atomic and diatomic gases.
Theory of Radiation: Blackbody radiation, Spectral distribution, Concept of Energy Density, Derivation of Planck's law, Deduction of Wien's distribution law, Rayleigh- Jeans Law, Stefan Boltzmann Law and Wien's displacement law from Planck's law.
Statistical Mechanics: Phase space, Macrostate and Microstate, Entropy and Thermodynamic probability, Maxwell-Boltzmann law - distribution of velocity –
Quantum statistics - Fermi-Dirac distribution law - electron gas - Bose-Einstein distribution law - photon gas - comparison of three statistics.

# Semester-III

**Paper- GE 3: Waves and Optics** **Credit:6**
**(Marks-70)**

Superposition of Two Collinear Harmonic oscillations: Linearity & Superposition Principle. (1) Oscillations having equal frequencies and (2) Oscillations having different frequencies (Beats).
Superposition of Two Perpendicular Harmonic Oscillations: Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses.
Waves Motion- General: Transverse waves on a string. Travelling and standing waves on a string. Normal Modes of a string. Group velocity, Phase velocity. Plane waves. Spherical waves, Wave intensity.
Sound: Simple harmonic motion - forced vibrations and resonance - Fourier's Theorem - Application to saw tooth wave and square wave - Intensity and loudness of sound - Decibels - Intensity levels - musical notes - musical scale. Acoustics of buildings: Reverberation and time of reverberation - Absorption coefficient - Sabine's formula - measurement of reverberation time - Acoustic aspects of halls and auditoria.
Wave Optics: Electromagnetic nature of light. Definition and Properties of wave front. Huygens Principle.
Interference: Interference: Division of amplitude and division of wavefront. Young's Double Slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: measurement of wavelength and refractive index.

Michelson's Interferometer: Idea of form of fringes (no theory needed), Determination of wavelength, Wavelength difference, Refractive index, and Visibility of fringes.
Diffraction: Fraunhofer diffraction- Single slit; Double Slit. Multiple slits and Diffraction grating. Fresnel Diffraction: Half-period zones. Zone plate. Fresnel Diffraction pattern of a straight edge, a slit and a wire using half-period zone analysis.
Polarization: Transverse nature of light waves. Plane polarized light – production and analysis. Circular and elliptical polarization.

# Semester-IV

**Paper- GE 4: Elements of Modern Physics** **Credit:6**

**(Marks-70)**

Planck's quantum, Planck's constant and light as a collection of photons; Photoelectriceffect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment.
Problems with Rutherford model- instability of atoms and observation of discrete atomic spectra; Bohr's quantization rule and atomic stability; calculation of energy levels for hydrogen like atoms and their spectra.
Position measurement- gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle- impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle.
Two slit interference experiment with photons, atoms & particles; linear superpositionprinciple as a consequence; Matter waves and wave amplitude; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of wavefunction, probabilities and normalization; Probability and probability current densities in one dimension.
One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization; Quantum dot as an example; Quantum mechanical scattering and tunnelling in one dimension - across a step potential and across a rectangular potential barrier.

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

Radioactivity: stability of nucleus; Law of radioactive decay; Mean life and half-life; α- decay; β-decay - energy released, spectrum and Pauli's prediction of neutrino; Y-ray emission.
Fission and fusion - mass deficit, relativity and generation of energy; Fission – natureof fragments and emission of neutrons. Nuclear reactor: slow neutrons interactingwith Uranium 235; Fusion and thermonuclear reactions.

# Semester-III

**Paper- SEC 1: ELECTRICAL CIRCUITS AND NETWORK SKILLS Credit:02**
**(Marks-60)**

**Basic Electricity Principles**: Voltage, Current, Resistance, and Power. Ohm's law. Series, parallel, and series-parallel combinations. AC Electricity and DC Electricity. Familiarization with multimeter, voltmeter and ammeter.
**Understanding Electrical Circuits**: Main electric circuit elements and their combination. Rules to analyse DC sourced electrical circuits. Current and voltage drop across the DC circuit elements. Single-phase and three-phase alternating current sources. Rules to analyse AC sourced electrical circuits. Real, imaginary and complex power
components of AC source. Power factor. Saving energy and money.
**Electrical Drawing and Symbols**: Drawing symbols. Blueprints. Reading Schematics. Ladder diagrams. Electrical Schematics. Power circuits. Control circuits. Reading of circuit schematics. Tracking the connections of elements and identify current flow and voltage drop.
**Generators and Transformers**: DC Power sources. AC/DC generators. Inductance, capacitance, and impedance. Operation of transformers.
**Electric Motors**: Single-phase, three-phase & DC motors. Basic design. Interfacing DC or AC sources to control heaters & motors. Speed & power of ac motor.
**Solid-State Devices**: Resistors, inductors and capacitors. Diode and rectifiers. Components in Series or in shunt. Response of inductors and capacitors with DC or AC sources
**Electrical Protection**: Relays. Fuses and disconnect switches. Circuit breakers. Overload devices. Ground-fault protection. Grounding and isolating. Phase reversal. Surge protection. Interfacing DC or AC sources to control elements (relay protection device)
**Electrical Wiring**: Different types of conductors and cables. Basics of wiring-Star and delta connection. Voltage drop and losses across cables and conductors. Instruments to measure current, voltage, power in DC and AC circuits. Insulation. Solid and stranded cable. Conduit. Cable trays. Splices: wirenuts, crimps, terminal blocks, split bolts, and solder. Preparation of extension board.

# Semester-IV

## SEC 2: Renewable Energy and Energy Harvesting
## Credits: 02 (Marks 60)

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

**Solar energy**: Solar energy, its importance, storage of solar energy, solar pond, non-convective solar pond, applications of solar pond and solar energy, solar water heater, flat plate collector, solar distillation, solar cooker, solar green houses, solar cell, absorption air conditioning. Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems.
**Wind Energy harvesting**: Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies.
**Ocean Energy**: Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices.

Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass.

**Geothermal Energy**: Geothermal Resources, Geothermal Technologies.

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

**Piezoelectric Energy harvesting**: Introduction, Physics and characteristics of piezoelectric effect, materials and mathematical description of piezoelectricity.

Piezoelectric parameters and modelling piezoelectric generators, Piezoelectric energy harvesting applications, Human power.

**Electromagnetic Energy Harvesting**: Linear generators, physics mathematical models, recent applications.

Carbon captured technologies, cell, batteries, power consumption. Environmental issues and Renewable sources of energy, sustainability.

c. Duration of the programme:

The minimum duration of the Programme is 3 (three) years from the date of registration. The registration is valid for a period of maximum 6 (six) years.

d. Faculty & Support Staff requirement:

| Sl. No. | Faculty | Name of the Faculty | Work at (HQ/RC) | Number |
|---|---|---|---|---|
| 1 | Associate Professor | Dr. Gahul Amin | RC - 1 | 1 |
| 2 | Associate Professor | Dr. Gautam Kumar Mallik | RC - 1 | 1 |
| 3 | Assistant Professor | Dr. Pabitra Mandal | RC - 1 | 1 |

e. Support Staff:

| Sl. No. | Office Staff (Designation) | Work at (HQ/RC) | Number |
|---|---|---|---|
| 1 | Junior Assistant | RC - 1 | 1 |
| 2 | Junior Assistant Cum Typist | HQ - 1 | 1 |

f. Instructional Delivery Mechanisms:

The NSOU follows a modern ICT enabled approach for instruction. The methodology of instruction in NSOU is different from that of the conventional/regular programs. Our ODL system is more learner-oriented and the learner is an active participant in the teaching-learning process. Most of the instruction is imparted through distance, rather than face-to-face communication. NSOU academic delivery system comprises:

Print Material: The printed material (Self Learning Material; SLM) of the programme is supplied to the students in batches ofblocks to each study centres following their enrolment during admission.

Audio-Visual Material Aids: The learning package contains audio and video programmeswhich have been produced by the NSOU. A video programme is normally of 45 minute to one hour duration.

Counselling session: Normally, counselling sessions are held as per a schedule drawn beforeby the Study Centre Coordinator for BDP Physics. They are held on weekends, i.e., Saturday and Sunday. The mandatory laboratory counselling cum evaluation session (LCES) is held for 12 days, out of which 11 days for learning cum continuous evaluation and on 12th day it is examination. Normally it is held during Puja Vacation at different centre throughout the West Bengal so that all the students can attend the course. LCES effective for paper IV and VIII and XII. In order to facilitate this LCES classes a Laboratory has already been developed at our own campus at Kalyani.

Online/Virtual Classes: Additionally, NSOU is developing conducts live/virtual classes usingtechnology.

| Mode of Delivery/ Types | Delivery Mechanisms | Provided (Yes/No) | Detailed Information (Please Mention the Activity Hour) |
|---|---|---|---|
| Face to Face Mode | PCP | Yes | Provided at LSC. For 6 Credits Theory Courses 9 counselling sessions of 2 hours each (Total 18 hrs); for 2 Credits Ability/Skill Courses 3 counselling sessions of 2 hours each (Total 6 hrs) |
| | Tutorials/ Special Classes/ Remedial Classes/ PCP | Yes | Provided online by NSOU faculty @ 6 hrs for each 6 Credits Course; Offline remedial classes once every semester at RC's (6 hrs for each 6 Credits Course) |
| | Seminar/ Research Colloquium | Yes | Learners participates in the seminar/workshops conducted by the University as per prior notice |
| | Laboratory based Practical | Yes | 96 hour Practical session per Core Courses and Discipline Specific Courses |
| Self-Learning | SLMs | Yes | All Courses are designed within the range of Units specified by relevant regulations. 20 hours of self- study time is envisaged for each SLM |
| | Reference Books | Yes | All Units have suggested reading lists. Additionally, faculty at LSC (during PCP) & NSOU faculty (at online sessions) guide learners regarding Reference Books |
| ICT/ Digital Wellness of students | Online (Web driven/Mobile App ) | Yes | Learners have access to institutional Learning Management System (LMS) |
| | Offline DVD/SD Card/USB Drive | Yes | USB drive used |
| | Telecommunications | Yes | Supports are given as per need. Communication Support is provided to the learners through University technical team as per requirement |
| Blended | Smart Classrooms | Yes | Arrangements are available both at RC's and at LSC's |
| | Flipped Learning | No | Will come into effect in a phased manner from the upcoming session with the development of NSOU MOOC |

## *vi. Procedure for admissions, curriculum transaction and evaluation:*

University frames its policy related to admission entry criteria, method of admission, conduction of admission through the Admission Committee (statutory body) following the guideline of the UGC (Open and Distance Learning and Online Programmes) Regulations, 2020 and Department of Higher Education, Govt. of West Bengal. Admissions are conducted entirely through Online mode centrally by the University.

### *Information Circulation Policy:*

All information related to the programme like admission policy, eligibility, fee structure, course curriculum, medium of instruction, method of instruction, evaluation method, SLMs etc. are transacted through prospectus, brochure, official notification etc.

### *Learner Support Services:*

Learner support services are provided by the University at three level of functioning of the Open University architecture i.e. Learner Support Centre (LSC), Regional Centre and Head Quarter.

Following the UGC (Open and Distance Learning and Online Programmes) Regulations, 2020 LSCs are provide various learner support services in order to facilitate the acquisition of teaching-learning experience for its enrolled learners throughout at various phases of learners' study life cycle. LSC also main contact points for access by the learners, responsive and facilitating information centres, arranging contact sessions and other operations like processing of assignments etc.

University has constituted Learner's Facilitation Centre (LFC) at each Regional Centres to provide various support services. Beside that University has also provided learners support services through web based platform/ telephone/ email/ instant messaging services.

***Transaction of Curriculum and Academic Planner:***

The whole curriculum of the programme is well structured and well designed with the updated syllabus structure. The curriculum transaction involves the face to face PCP sessions through chalk and talk method, use of Power Point presentations, web-based lessons, animated videos, etc. The PCP sessions would be such that the learner should participate actively in the discussion. Apart from this ICT enables online supports are provided for better understanding of the subject.

For practical courses exclusive study materials containing the requirements, procedure for the experiments are issued to the learners. In the laboratory, instruction would be given for the experiments followed by demonstration and finally the learners have to do the experiments individually.

Curriculum transaction is through Online and or Offline modes as detailed above and all academic activities are conducted following the programme is following the below mentioned activity planner during the academic session:

| Name of the Activity | Tentative months schedule (specify months) during Year | | | |
|---|---|---|---|---|
| | From (Month) | To (Month) | From (Month) | To (Month) |
| Admission | Jun | Jul | NA | NA |
| Distribution of SLM | Jul | Aug | NA | NA |
| Contact Programmes (counselling, Practical, etc.) | Aug | Oct | Jan | Mar |
| Assignment Submission | Oct | Nov | Mar | Apr |
| Evaluation of Assignment | Nov | Nov | Apr | Apr |
| Examination | Nov | Dec | May | Jun |
| Declaration of Result | Dec | Dec | Jun | Jun |
| Renewal/ Re–registration | NA | NA | Jun | Jul |

***Evaluation:***

Evaluation is on a 2-tier basis, divided into Assignment submission (online mode) and Term End Examinations (Offline mode). The weightage is as follows:
Assignment – 20 marks
Term End Examination – 50 marks
Total marks for each course – 70
A**ssignment / Internal Assessment/ Continuous Assessment / Formative Assessment:** Assignment submission is the first interaction between the learner and the teacher. It has a very important role to play in the teaching-learning process in distance education. So, submission of Assignment is mandatory for all learners. The assignment responses reflect what the learners have understood and learnt. The assignment answer scripts are returned to the learners so that the assignment answers serve the purpose of providing feedback to the learners and inform them their strengths and weaknesses. Learners will be required to submit assignment for each course and the marks obtained on evaluation of those assignment courses will be entered into his/her individual record of performance. This will constitute 30% (maximum) of the Full marks in the course as per University

Grants Commission (Open and Distance Learning Programmes and Online Programmes) regulations, 2020. All the Marks secured by the learners will be progressively entered into the result card. Every learner is required to submit the assignment courses before each Term-End Examination. In practical course of Science stream, there is no assignment.

**Term-End Examinations:** Minimum 70% of the total credit points of the course (except practical course where it is 100%) would be reserved for Term-End Examination as per University Grants Commission (Open and Distance Learning Programmes and Online Programmes) Regulations, 2020. Minimum qualifying marks in each course is 30% (Term End Examination Marks + Assignment Marks).

**Practical Examination / Laboratory Counselling-cum-Evaluation Sessions (LCES) for Lab based subjects:** Practical Sessions or Laboratory Counselling-cum-Evaluation Session (LCES), for Core and Discipline Specific Elective courses of Science stream, are arranged by the University for the learners who have enrolled for the particular programme. Centre for practical work (LCES) will be allotted by the University. For UG, a length of 12 days' practical session is held during Puja vacation at different study centres. First 11 days during the total session, the learners gain hands on experiences with the help of counsellors. Marks have been allotted on each day's work and awarded on the basis of the actual performance of the Learners. The sum of normalized marks awarded by Counsellors in continuous assessment contribute 70% to the final marks. On 12th day of the programme a Practical Examination which is unguided have been conducted and evaluated jointly by an external and internal examiner and 30% marks from this examination is reflected to the final marks. Examination is held in the examination centres in presence of both the internal and external examiners appointed by the Controller of Examination of the University. Attendance in the Lab Counselling Evaluation Session (LCES) is mandatory.

***Waive of Programme Fee:***

University waive of full course fee for transgender learners.

### *vii. Requirement of the laboratory support and Library Resources:*

Laboratory: To educate the students in more scientific way, a rhythmic practical class programme has been introduced. NSOU provides the necessary laboratory facilities to the students in their respective study centres. For BDP level, a period of 12 days (eight hours per day) has been allotted for the students during the Puja vacation. The College and University teachers have been appointed to take classes which show a beautiful sharing of resource persons among the conventional and distance institutions. The students of different study centres have been clubbed into a nearby study centres for practical classes. Due to the increased number of enrolments, the number of study centres for practical classes have been enhanced accordingly.

Library facility is one of important services in any higher educational institution. In addition to the Self Learning Materials (SLMs) and other learning resources the University provides library facility to all of its registered learners. The Library Department, Netaji Subhas Open University is located at Kalyani Campus.

Further, to cater to the needs of huge number of registered students, the University needs unlimited libraries to provide educational support to everyone. To cope with the situation, the University has initiated the process of setting up a strategic partnership with the existing network of Public Libraries that are available in the State of West Bengal to offer educational support to our learners all over the State. This initiative taken by NSOU is the first of its kind in the country.

### *viii. Cost estimate of the programme and the provisions:*

Total course fee is Rs. 15,600/- (Excluding Examination and Studentship Renewal Fees). An approximate distribution of expenditure is given below to get prior view:

| Assigned Head | Sub Head | % of Expenditure |
|---|---|---|

| | | |
|---|---|---|
| Development | SLM Preparation and Development Cost | 7 |
| | SLM Printing | 44 |
| Maintenance & Programme Delivery | Maintenances Grant | 15 |
| | Counselling/ PCP/ Lab Counselling | 15 |
| | Delivery Charges | 4 |
| | Other Overhead Expenses | 8 |
| ICT Support | Admission Processing | 1 |
| | ICT Support Services | 5 |
| | Computer Training | 1 |

## *ix. Quality assurance mechanism and expected programme outcomes:*

Quality assurance mechanisms have a set of processes and practices that help ensure that the program is of high quality and meets the needs of Learners and stakeholders. Some common quality assurance mechanisms include:

- ✓ Curriculum review and development: Faculty members are continuously engaged in developing quality Self Learning Materials (SLMs) in print under Choice Based Credit System (CBCS) system. The curriculum is reviewed regularly to ensure that it is up-to-date and relevant to the needs of learners.
- ✓ Learners assessment and evaluation: Learners performance is assessed and evaluated through a variety of methods, including exams, assignments. This helps to ensure that Learners are meeting the learning outcomes of the course and provides feedback on their progress.
- ✓ Faculty Development programme: Faculty members take part in faculty development programme in a regular basis to ensure that they are meeting the standards of the program and are providing high-quality instruction to Learners.
- ✓ Stakeholder feedback: Input from stakeholders, such as Learners, alumni, employers, and community members, is gathered through surveys, focus groups, and other methods to ensure that the program is meeting the needs of the community and to identify areas for improvement.
- ✓ Centre for Internal Quality Assurance: Centre for Internal Quality Assurance (CIQA) as per UGC (Open and Distance Learning) Regulations, 2017 to ensure the delivery of high quality programmes to its learners.

**Board of Studies (BOS):** Board of Studies ensure quality of the Curriculum of Bachelor's Degree Programme in Physics as per University norms. BOS plays a vital role as the following

- ✓ Curriculum review and development of quality Self Learning Materials (SLMs) in print under Choice Based Credit System (CBCS) system. The curriculum is reviewed regularly to ensure that it is up-to-date and relevant to the needs of learners.
- ✓ Learner's assessment and evaluation process through a variety of methods, including exams, assignments. This helps to ensure that Learners are meeting the learning outcomes of the Programme.

### *Expected Programme outcomes:*

For the understanding that scientific knowledge is the product of a process engaged in by a community of scientists.

- ✓ To equip individuals with the necessary scientific skills and competencies to enable them to seek jobs and progress in their career.
- ✓ To enhance the capabilities of the existing workforce in the country and thus contribute to economic as well as scientific development.
- ✓ To give chances to the willing students those who could not entered into the conventional Universities due to their job and limitation of the seat in the respective subjects.

- ✓ Understand and apply theoretical and practical knowledge in the appropriate areas and enhance their living condition as well as to save the nature and its surroundings.
- ✓ Work collaboratively with others (within different sections of the society) in cross-functional teams, and to motivate, lead, and mentor others.