DEPARTMENT OF PHYSICS

Debraj Roy College (Autonomous)

Programme Structure for M.Sc. in Physics (CBCS)

Total Credits: 88

Distribution of marks in Examination: 40% of the total marks allotted for the theory papers (Except mathematical physics) will be Problem/Application based.

Structure of the curriculum

Course category	**No of courses**	**Credits per course**	**Total Credits**
I. Core courses (Theory)	9	4	36
Core courses (Theory)	1	2	2
Core courses (Project)	2	(4+10)	14
Core courses (Practical)	2	4	8
Core courses (Practical)	2	2	4
II. Elective courses (Specialization)	4	4	16
III. Elective courses (Open)	2	4	8
Total credits			**88**

SEMESTER-WISE SCHEDULE

SEMESTER I

Course type	**Course title**	**L**	**P**	**CH**	**Credits**
Core	PHY1 C1: Mathematical Physics	4	0	4	4
	PHY1 C2: Electrodynamics	4	0	4	4
	PHY1 C3: Electronics (Analog and Digital)	4	0	4	4
	PHY1 C4: Classical Mechanics	4	0	4	4
	PHY1 C5: Computational and Numerical Lab-I	0	2	4	2
	PHY1 C6: Physics Lab-I	0	4	8	4
	Total				**22**

SEMESTER II

Course type	Course title	L	P	CH	Credits
Core	PHY2 C7: Statistical Mechanics	4	0	4	4
	PHY2 C8: Condensed Matter Physics (Gen)	4	0	4	4
	PHY2 C9: Quantum Mechanics	4	0	4	4
	PHY2 C10: Atomic and Molecular Physics	4	0	4	4
	PHY2 C12: Physics Lab-II	0	4	8	4
	Total				**20**

SEMESTER III

Course type	Course title	L	P	CH	Credits
Core	PHY3 C13: Minor Project	4	0	4	4
	PHY3 C14: Nuclear Physics	4	0	4	4
	PHY3 C15: Computational and Numerical Lab-II	0	2	4	2
Elective	PHY3 E1: Elective	4	0	4	4
	PHY3 E2: Elective	4	0	4	4
	PHY3 OE 1: Open Elective-I	4	0	4	4
	Total				**22**

SEMESTER IV

Course type	Course title	L	P	CH	Credits
Core	PHY4 C16: Major Project	0	10	20	10
Elective	PHY4 E3: Elective	4	0	4	4
	PHY4 E4: Elective	4	0	4	4
	PHY4 OE II: Open Elective-II	4	0	4	4
	Total				**22**

*L- Lecture, P - Practical, CH- Contact Hour

Course Code: PHY1 C1
Course Title: Mathematical Physics
Nature of the Course: Core
Total credits assigned: 04
Distribution of credits: Theory – 04

Recapitulation: Vector algebra and vector calculus. Linear algebra, matrices, Cayley-Hamilton Theorem. Eigenvalues and eigenvectors. Linear ordinary differential equations of first & second order.

Unit I: Linear Vector Spaces and Matrices (L 15, Marks 15)

Linear vector spaces - definition and examples, linear independence, basis and dimension, inner product, norm of a vector, orthonormal basis, Gram-Schmidt orthogonalization method, linear operators, matrix representation of linear operators.

Special types of matrices - symmetric and antisymmetric, orthogonal, Hermitian and anti-Hermitian, unitary, normal; eigenvalues and eigenvectors; change of basis, similarity transformation, orthogonal and unitary transformations, diagonalization of matrices; infinite dimensional vector spaces, Hilbert space.

Unit II: Complex analysis (L 10 Marks 10)

Complex variables: Complex algebra, graphical representation, Euler's formula, De Moivre's theorem, Roots of Complex Numbers, Analyticity and Cauchy-Riemann Conditions, Harmonic functions, complex integrations, Cauchy’s integral theorem, Cauchy's integral formula, Derivative of an analytical function.

The calculus of residues: singular point, definition of residue at a pole, residue theorem, evaluation of real definite integrals by contour integration.

Taylor & Laurent series: Laurent and Taylor’s expansion of a function.

Unit III: Special functions (L 15 Marks 15)

Legendre’s Differential Equation: The Power series Solution, Legendre Functions of the first and second kind, Generating Function, Rodrigues Formula, Orthogonal Properties, Recurrence Relations, Applications in Physics.

Bessel’s Differential Equation: Power series Solution, Bessel Functions of First and Second kind, Generating Function, Orthogonal Properties and Recurrence Relations, Applications in Physics.

Hermite Differential Equation: Power series Solution, Hermite polynomials, Generating Function, orthogonality and Recurrence relations, Rodrigues formula, Applications in Physics.

Laguerre Differential Equation: Laguerre Polynomials, Orthogonality and Orthogonal Polynomials, Generating Function, Rodrigues Formula, Associated Laguerre Polynomials, Applications in Physics.

Some Special Integrals: Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions.

Unit IV: Integrals Transforms: (L 20 Marks 20)

Fourier Transforms: Fourier transform of trigonometric, Gaussian, finite wave train & other functions. Representation of Dirac delta function as a Fourier Integral. Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem. Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.). Three dimensional Fourier transforms with examples. Application of Fourier Transforms to differential equations: One dimensional Wave and Diffusion/Heat Flow Equations.

Laplace Transforms: Laplace Transform (LT) of Elementary functions, LTs of 1st and 2nd order Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. Convolution Theorem. Inverse LT. Application of Laplace Transforms to 2nd order Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits, Coupled differential equations of 1st order. Solution of heat flow along infinite bar using Laplace transform.

Text Books and References:

1. A.W.Joshi, Matrices and Tensors in Physics, 3rd Edition, New Age Int. (2005)

2. M.L.Boas, Mathematical Methods in Physical Sciences, John Wiley & Sons (2005)

3. G.B.Arfken, H.J.Weber and F.E. Harris, Mathematical Methods for Physicists, Seventh Edition, Academic Press(2012).

4. Mathematical Methods for Physics, J. Mathews and R. L. Walker, Pearson Addison-Wesley; 2 edition (1 January 1971).

Course Code: PHY1 C2
Course Title: Electrodynamics
Nature of the Course: Core
Total credits assigned: 04
Distribution of credits: Theory-04

Recapitulation: Gauss' Law, Ampere's law, Faraday's Law

Unit 1: L 6, Marks-6

Maxwell's equations, Gauge transformations, Poynting's theorem, Maxwell's stress tensor, Energy and momentum conservations, angular momentum and its conservation

Unit 2: L 15, Marks-15

Electromagnetic waves in dielectric medium; reflection, refraction, total internal reflection, Fresnel's equations, Brewster's angle; Electromagnetic waves in conducting medium, skin depth, reflection at conducting surface.

Waves between parallel conductors, TE and TM waves, rectangular and cylindrical waveguides, resonant cavities, dielectric waveguide

Unit 3: L 5, Marks-5

Electromagnetic radiation from moving charges and dipoles, retarded potentials.

Unit 4: L 15, Marks-15

Scattering of radiation by a free charge and bound charge, radiation damping Frequency dependence of permittivity, complex dielectric constant, Normal and anomalous dispersion, Cauchy's formula, Dispersion in solid, liquid and gaseous medium (including the media containing free electrons

Unit 5: L 10, Marks-10

Definition and properties of plasma, quasineutrality, Debye length, Behaviour of plasma in electric and magnetic fields, Plasma as a conducting fluid, magnetic confinement, plasma frequency, reflection of electromagnetic waves from plasma

Unit 6: L 9, Marks-9

Four vectors, relativistic electrodynamics, magnetism as relativistic phenomenon, field tensor, energy-momentum tensor, transformation of electromagnetic fields under Lorentz transformation, invariance of Maxwell's equations

Suggested Textbooks

1. Introduction to Electrodynamics by D. J. Griffiths, Prentice-Hall of India
2. Electromagnetics by B. B. Laud, New Age International (P) Limited
3. Classical Electromagnetism by H C Verma (Bharati Bhawan)

Course Code: PHY1 C3
Course Title: Electronics (Analog and Digital)
Nature of the Course: Core
Total credits assigned: 04
Distribution of credits: Theory-04

Analog Electronics: ***Review of junction diode and transistor characteristics.***

Unit-I: L 15, Marks: 15

P and N type semiconductors, conductivity and mobility, concept of drift velocity, Principal and structure of LEDs, photodiodes and Solar Cell.

NPN and PNP Transistors, BJT amplifier, Emitter follower. Bootstrapped and Darlington amplifier.

Field effect transistors: JFET and MOSFET, structure, working, derivation of the equations of IV characteristics under different conditions, JFET as amplifiers and switch-MOSFET, E- MOSFET, introduction to CMOS technology.

Silicon Controlled Rectifier, Liquid Crystal Display, OLED.

Unit-II: L 20, Marks: 25

Operational amplifier: Review of Differential amplifiers, ideal OP-AMP, IC741, OP AMP parameters and corrections. Open-loop and Closed-loop Gain. Frequency Response. CMRR. Slew Rate and concept of Virtual ground.

Op Amp linear applications: Inverting and non-inverting amplifiers, Adder, Subtractor, Differentiator, Integrator, Current to Voltage Converter, Voltage to Current Converter.

Op Amp non-linear applications: Log amplifier, Voltage limiters, comparators, zero detector, Schmitt trigger, voltage to frequency and frequency to voltage converter, small-signal diodes, sample-and-hold circuits and signal generators: oscillators-square-wave, Wien bridge, phase shift.

Frequency response of an op-amp and active filter: Gain and phase shift vs. frequency, Bode plots, compensated frequency response, slew rate, active filter, first and second order low pass and high pass, Butterworth filter, band reject filter.

Unit III: L 15, Marks: 15

Digital electronics: Review of number systems, logic gates, De Morgan's Theorems. Boolean algebra, logic Families, Binary Arithmetic Circuits.

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

Data processing circuits: Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders, parity-generator/checker, comparator.

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. Shift Registers, Ring Counter. Asynchronous counters, Decade Counter. Synchronous Counter.

Unit-IV: L 10, Marks: 5

555 Timer: internal circuitry, astable, monostable and bistable operations, voltage regulators (IC 78xx, 79xx), A/D and D/A conversion.

Suggested Text Books:

1. Electronic Principles A.P. Malvino Tata McGraw Hill
2. D. P. Leach, A. P. Malvino and G. Saha, Digital Principles and Applications, Tata McGraw Hill.
3. R. A. Gayakwad, Op-Amps and Linear Integrated Circuits, PHI learning Private Limited-New Delhi
4. J. Millman and C C Halkias, Integrated electronics Analog and Digital Circuits and system, Tata McGraw Hill Education Pvt Ltd.
5. The Art of Electronics P. Horowitz and W. Hill Cambridge University Press

Course Code: PHY1 C4
Course Title: Classical Mechanics
Nature of the Course: Core
Total credits assigned: 04
Distribution of credits: Theory – 04

Unit I: Lagrangian and Hamiltonian Formulations (L 20, Marks 20)

Variational principle and Lagrange equation: Generalized coordinates, principle of virtual work, D'Alembert's principle, Lagrangian formulation and simple applications,Variational principle.

Hamiltonian formulation: Legendre transformations, Hamilton's equations, symmetries and conser-vation laws in Hamiltonian picture, Hamilton's principle, canonical transformations, Poisson brackets, Hamilton Jacobi theory, action-angle variables.

Unit II: Central force problem (L 15, Marks 15)

Central force problem: Two body problem in central force, Equations of motion, effective potential energy, nature of orbits, Virial theorem, Kepler's problem, condition for closure of orbits, scattering in a central force field, centre of mass and laboratory frame.

Unit III: Dynamics of rigid bodies (L 15, Marks 15)

Rigid Body Dynamics, Definition of Rigid body, The Eulerian Angles, Euler's theorem, Angular momentum and kinetic energy, Moment of inertia tensor, Euler's equation of motion, Symmetrical top, stability conditions,

Unit IV: (L 10, Marks 10)

Small-oscillations: Eigenvalue problem, frequencies of free vibrations and normal modes, forced vibrations, dissipation

Text Books and References:

1. H. Goldstein, C. P. Poole and J. Safko, Classical Mechanics, 3 rd Edition, Pearson (2012).

2. N. C. Rana and P. S. Joag, Classical Mechanics, Tata Mcgraw Hill (2001).

2. L. Landau and E. Lifshitz, Mechanics, Oxford (1981).

Course Code: PHY1 C5
Course Title: Computation Lab
Nature of the Course: Core (Practical)
Total credits assigned: 02
Distribution of credits: Practical – 02

1. Solution of algebraic and transcendental equation by Bisection/Newton Raphson/Secant method
2. Interpolation by Newton Gregory Forward and Backward difference formula
3. Error estimation of linear interpolation
4. Numerical differentiation (Forward and backward interpolation formula)
5. Numerical Integration (Trapezoidal and Simpson rules)
6. Monte Carlo method

Course Code: PHY1 C6
Course Title: Physics Lab I
Nature of the Course: Core (Practical)
Total credits assigned: 04

1. Determination of the boiling point of a liquid by platinum resistance thermometer and metre bridge.
2. Determine the moment of inertia of a flywheel.
3. To determine the energy band gap of a semiconductor using a p-n junction diode.
4. To design and fabricate a phase shift oscillator for the given frequency and to study the output using Op-Amp. 741/ 324 / 325.
5. To draw the frequency response curve of a CE transistor amplifier and also to find the input impedance of the amplifier.
6. To design astable and monostable multivibrator using 555 IC.
7. To design and study OPAMP as a differentiator and integrator.
8. To draw the frequency response curve of an RC coupled amplifier with and without negative feedback and compare the bandwidth.
9. To design and construct basic flip-flops R-S, J-K, J-K Master slave flip-flops using gates and verify their truth tables.
10. To study the characteristic curves of JFET and MOSFET.