PHYSICS

First Semester Unitwise Course Distribution

	PHY-HC-1016 Mathematical Physics I Total Lectures: 60	**PHY-HC-1026** Mechanics Total Lectures: 60	**PHY-HG-1016** Mechanics Total Lectures: 60	
NKD	Unit I: Vector Calculus (Lectures 25) Unit III: Orthogonal Curvilinear Coordinates (Lectures 06)	Unit IV: Rotational Dynamics (Lectures 12) Unit V: Elasticity (Lectures 03) Unit VI: Fluid Motion (Lectures 02) Unit VIII: Oscillations (Lectures 08)	Unit I : Vectors (Lectures 06)	Total Lectures: 62
HB	Unit II: First and Second order Differential Equations (Lectures 17) Unit IV: Dirac Delta function and its Properties (Lectures 02) Unit V: Introduction to Probability (Lectures 04) Unit VI: Theory of Errors (Lectures 06)	Unit VII: Gravitation and Central Force Motion (Lectures 08) Unit X: Special Theory of Relativity (Lectures 10)	Unit VII : Special Theory of Relativity (Lectures 07)	Total Lectures: 54
PB	------	Unit I: Fundamentals of Dynamics (Lectures 06) Unit II: Work and Energy (Lectures 04) Unit III: Collisions (Lectures 03) Unit IX: Non-Inertial Systems (Lectures 04)	Unit II : Laws of Motion (Lectures 10) Unit III : Momentum and Energy (Lectures 06) Unit IV : Rotational Motion (Lectures 05) Unit V : Gravitation (Lectures 07) Unit VI : Oscillations (Lectures 07) Unit VII : Elasticity (Lectures 08)	Total Lectures: 60

* Mathematical Physics lab for PHY-HC-1016 to be instructed entirely by HB
* Mechanics lab for PHY-HC-1026 and PHY-HG-1016 to be instructed jointly by NKD and PB

PHY-HC-1016

Mathematical Physics I

Total Lectures: 60 Credits: 6 (Theory: 04, Lab: 02)

Course Outcome: *Successful students should be able to understand vector and its applications in various fields, differential equations and its applications, different coordinate systems, concept of probability and error.*

Theory

Unit I: Vector Calculus (Lectures 25)

Revision: 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.

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).

Unit II: First and Second order Differential Equations (Lectures 17)

First Order and Second Order Differential equations: First Order Differential Equations and Integrating Factor. Homogeneous Equations with constant coefficients. Wronskian and general solution.

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

Unit III: Orthogonal Curvilinear Coordinates (Lectures 06)

Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems.

Unit IV: Dirac Delta function and its Properties (Lectures 02)

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

Unit V: Introduction to Probability (Lectures 04)

Independent random variables: Probability distribution functions; binomial, Gaussian and Poisson, with examples. Mean and variance.

Unit VI: Theory of Errors (Lectures 06)

Systematic and Random Errors. Propagation of Errors. Normal Law of Errors. Standard and Probable Error. Least-squares fit.

Lab

Aim

The aim of this Lab is not just to teach computer programming and numerical analysis but to emphasize its role in solving problems in Physics.

- Highlights the use of computational methods to solve physical problems
- The course will consist of lectures (both theory and practical) in the Lab
- Evaluation done not on the programming but on the basis of formulating the problem
- Aim at teaching students to construct the computational problem to be solved
- Students can use any one operating system Linux or Microsoft Windows

Introduction and Overview Computer architecture and organization, memory and Input/output devices

Basics of scientific computing Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow & overflow- emphasize the importance of making equations in terms of dimensionless variables, Iterative methods

Review of C & C++/Python/ Matlab/ Mathematica 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. Uncondi- tional and Conditional Looping. while Loop. do-while Loop. for Loop. breakand continueStatements. Nested Loops), Arrays (1D & 2D) and strings, user defined functions, Structures and Unions, Idea of classes and objects.

Programs Sum & average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending descending order, Binary search

Random number generation Area of circle, area of square, volume of sphere, value of pi (π)

Solution of Algebraic and Transcendental equations by Newton Raphson methods Solution of linear and quadratic equation, solving $\alpha = tan\alpha$, $I = I_O(sin\alpha/\alpha)^2$ in optics

Interpolation by Newton Gregory Forward and Backward difference formula Evaluation of trigonometric functions e.g. $\sin\theta$, $\cos\theta$, $\tan\theta$ etc.

Numerical Integration (Trapezoidal and Simpson rules), Monte Carlo method Given Position with equidistant time data to calculate velocity and acceleration and vice versa. Find the area of B-H Hysteresis loop

Solution of Ordinary Differential Equations (ODE) First order Differential equation Euler, modifted Euler and Runge-Kutta (RK) second and fourth order methods First order differential equation

(a) Radioactive decay (b) Newton's law of cooling.

PHY-HC-1026
Mechanics
Total Lectures: 60 Credits: 6 (Theory: 04, Lab: 02)

Course Outcome: *On successful completion of the course students should be able understand Inertial and non inertial reference frames, Newtonian motion, Galilean transformations, projectile motion, work and energy, Elastic and inelastic collisions, motion under central force, simple harmonic oscillations, special theory of relativity.*

Theory

Unit I: Fundamentals of Dynamics (Lectures 06)

Reference frames. Inertial frames; Review of Newton's Laws of Motion. Galilean transformations; Galilean invariance. Momentum of variable mass system: motion of rocket. Motion of a projectile in Uniform gravitational field Dynamics of a system of particles. Centre of Mass. Principle of conservation of momentum. Impulse.

Unit II: Work and Energy (Lectures 04)

Work and Kinetic Energy Theorem. Conservative and non-conservative forces. Potential Energy. Energy diagram. Stable and unstable equilibrium. Elastic potential energy. Force as gradient of potential energy. Work & Potential energy. Work done by non-conservative forces. Law of conservation of Energy.

Unit III: Collisions (Lectures 03)

Elastic and inelastic collisions between particles. Centre of Mass and Laboratory frames.

Unit IV: Rotational Dynamics (Lectures 12)

Angular momentum of a particle and system of particles. Torque. Principle of conservation of angular momentum. Rotation about a fixed axis. Moment of Inertia. Calculation of moment of inertia for rectangular, cylindrical and spherical bodies. Kinetic energy of rotation. Motion involving both translation and rotation.

Unit V: Elasticity (Lectures 03)

Relation between Elastic constants. Twisting torque on a Cylinder or Wire. Cantilever.

Unit VI: Fluid Motion (Lectures 02)

Kinematics of Moving Fluids: Poiseuille's Equation for Flow of a Liquid through a Capillary Tube.

Unit VII: Gravitation and Central Force Motion (Lectures 08)

Law of gravitation. Gravitational potential energy. Inertial and gravitational mass. Potential and field due to spherical shell and solid sphere. Motion of a particle under a central force field. Two-body problem and its reduction to one-body problem and its solution. The energy equation and energy diagram. Kepler's Laws.

Unit VIII: Oscillations (Lectures 08)

SHM: Simple Harmonic Oscillations. Differential equation of SHM and its solution. Kinetic energy, potential energy, total energy and their time-average values. Damped oscillation. Forced oscillations: Transient and steady states; Resonance, sharpness of resonance; power dissipation and Quality Factor. Compound Pendulum.

Unit IX: Non-Inertial Systems (Lectures 04)

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

Unit X: Special Theory of Relativity (Lectures 10)

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

NKD
HB
PB

Lab

A minimum of seven experiments to be done.

1. Measurements of length (or diameter) using vernier caliper, screw gauge, Spherometer and travelling micro- scope.
2. To study the Motion of Spring and calculate (a) Spring constant and (b) Rigidity modulus.
3. To determine the Moment of Inertia of a cylinder about two different axes of symmetry by torsional oscillation method.
4. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
5. To determine the Young's Modulus of the material of a wire by Searle's apparatus.
6. To determine the Modulus of Rigidity of a Wire Static method.
7. To determine the value of g using Bar Pendulum.
8. To determine the value of g using Kater's Pendulum.
9. To determine the height of a building using a Sextant.
10. To determine g and velocity for a freely falling body using Digital Timing Technique.

PHY-HG-1016 (PHY-RC-1016)
Mechanics
Total Lectures: 60 Credits : 6 (Theory : 04, Lab :02)

Course outcome: *Upon completion of this course, students are expected to understand the role of vectors and coordinate systems in Physics, solve Ordinary Differential Equations, laws of motion and their application to various dynamical situations, Inertial reference frames their transformations, concept of conservation of energy, momentum, angular momentum and apply them to basic problems, phenomenon of simple harmonic motion, motion under central force, concept of time dilation, Length contraction using special teory of relativity. In the laboratory course, after acquiring knowledge of how to handle measuring instruments (like screw gauge, Vernier calipers, travelling microscope) student shall embark on verifying various principles and associated measurable parameters.*

Theory

Unit I : Vectors (Lectures 06)
Vector algebra. Scalar and vector products. Derivatives of a vector with respect to a parameter. Ordinary Differential Equations: 1st order homogeneous differential equations. 2nd order homogeneous differential equations with constant coeffcients.

Unit II : Laws of Motion (Lectures 10)
Frames of reference. Newton's Laws of motion. Dynamics of a system of particles. Centre of Mass.

Unit III : Momentum and Energy (Lectures 06)
Conservation of momentum. Work and energy. Conservation of energy. Motion of rockets.

Unit IV : Rotational Motion (Lectures 05)
Angular velocity and angular momentum. Torque. Conservation of angular momentum.

Unit V : Gravitation (Lectures 07)
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).

Unit VI : Oscillations (Lectures 07)
Simple harmonic motion. Differential equation of SHM and its solutions. Kinetic and Potential Energy, Total Energy and their time averages. Damped oscillations. Compound pendulum.

Unit VII : Elasticity (Lectures 08)
Hooke's law - Stress-strain diagram – Elastic moduli-Relation between elastic constants - Poisson's Ratio-Expression for Poisson's ratio in terms of elastic constants – Work done in stretching and work done in twisting a wire – Twisting couple on a cylinder – Determination of Rigidity modulus by static torsion - Torsional pendulum-Determination of Rigidity modulus and moment of inertia – q, η and σ by Searles method.

Unit VII : Special Theory of Relativity (Lectures 07)
Constancy of speed of light. Postulates of Special Theory of Relativity. Length contraction. Time dilation. Relativistic addition of velocities.

NKD
HB
PB

Lab

A minimum of five experiments to be done.

1. Measurements of length (or diameter) using vernier caliper, screw gauge and Spherometer.
2. To determine the Moment of Inertia of a Symmetrical body about an axis by torsional oscillation method.
3. To determine the Young's Modulus of the material of a wire by Searle's apparatus.
4. To determine the Modulus of Rigidity of a Wire Static method.
5. To determine the elastic Constants of a wire by Searle's method.
6. To determine the value of g using Bar Pendulum.
7. To determine the value of g using Kater's Pendulum.
8. To study the Motion of Spring and calculate (a) Spring constant and (b) value of g.