Four Year Undergraduate Course in Physics
Semester - I
Paper Name: Mathematical Physics & Mechanics
Paper Code= PHY010104
Total number of lectures= 45
Total credits = 4 (Theory 3 +Laboratory 1) (Total Marks Internal-25+External-75)

Part A
Mathematical Physics (Theory)
Credit = 1

Course outcome: *This course introduces vector calculus, curvilinear coordinates and Dirac delta function. On successful completion of the course, students will be able to understand how to compute in the calculus of vectors which plays a central role in laws of physics. They will be able to apply vector calculus in curved spaces which play major role in relativity. They will also be able to learn the powerful method of computation through Dirac delta function which often appears in complex problems of physics. In general, the students will be able to apply the mathematical methods on the problems of physics and engineering.*

Unit - I: Vector calculus (Lectures - 8)

Scalar and vector fields. Derivatives of vector functions (physical examples - velocity, centripetal acceleration of a point in circular motion). Directional derivative. Gradient of a scalar field (example of Newton's gravitational force as gradient of a scalar potential). Gradient as normal vector to a surface. Divergence and curl of a vector field- solenoidal and irrotational vector fields. Laplacian operator (physical problems –Laplacian of gravitational potential, divergence of central force). Vector identities.

Vector integration- Line integral (physical example- work done by a force, path dependence/independence and concept of conservative force). Surface and volume integrals. Concept of vector flux. Gauss's divergence theorem and Stokes's theorem (statement only)

Unit - II: Curvilinear coordinates (Lectures - 5)

Introduction to curvilinear coordinates. Orthogonal curvilinear coordinates. Examples of spherical, cylindrical and plane polar coordinates. Line element- transformation from Cartesian to curvilinear coordinates (spherical and cylindrical). Gradient, divergence and curl in spherical and cylindrical coordinates.

Unit - III: Dirac delta function (Lectures - 2)

Definition and properties of Dirac delta function. Representation of delta function by Gaussian function, rectangular function and Laplacian of 1/r . 3 Dimensional delta function.

Part B

Mechanics (Theory)

Credits = 2

Course outcome: *On successful completion of this course students should be able understand inertial and non-inertial reference frames, Newtonian motion, projectile motion, work and energy, elastic and inelastic collisions, motion under central force, simple harmonic oscillations. They will be able to apply foundational principles of physics in higher studies of physics, technology and engineering.*

Unit – I: Reference frames (Lectures - 4)

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

Unit – II: Gravitation and central force motion (Lectures - 7)

Motion under central force. Two-body problem and its reduction to one body problem. Kepler's laws, Gravitational potential and fields due to spherical body. Gauss's law and Poisson's equation for gravitational field.

Unit – III: Conservation laws (Lectures - 4)

Dynamics of a system of particles. Centre of mass. Principle of conservation of momentum. Torque. Impulse.

Elastic and inelastic collisions between particles. Centre of mass and laboratory frames.

Unit – IV: Dynamics of rigid bodies (Lectures - 6)

Rigid body motion. Rotational motion. Moment of inertia of rectangular lamina, disc, cylindrical and spherical bodies. Kinetic energy of rotation. Motion involving both translation and rotation.

Unit – V: Work and energy (Lectures - 3)

Work and kinetic energy theorem. Conservative and non-conservative forces. Potential energy. Force as gradient of potential energy. Work and potential energy. Work done by non-conservative forces.

Unit – VI: Oscillations (Lectures - 2)

Oscillation - differential equation of simple harmonic motion and its solution. Total energy of oscillation.

Unit – VII: Properties of matter (Lectures - 4)

Relation between elastic constants. Twisting torque on a cylinder or wire. Beam bending moment, Cantilever. Kinematics of moving fluids: Poiseuille's equation for flow of a liquid through a capillary tube.

Part C
Laboratory
Credit =1

Course outcome: *After the successful completion of this course, students will be able to determine various physical quantities of mechanics that will help them understand important principles related to the subject.*

The students are required to perform at least four experiments from the following list of experiments.

1. Measurements of length (or diameter) using Vernier calliper, screw gauge, spherometer and travelling microscope
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.

Reference books:

[1] Essential Mathematical Methods for the Physical Sciences; K.F. Riley and M.P. Hobson, Cambridge University Press.

[2] Advanced Engineering Mathematics; E. Kreyszic, John Wiley & Sons (New York).

[3] Mathematical Methods for Physicists; G. B. Arfken, H. J. Weber and F.E. Harris, Elsevier.

[4] Mathematical Physics-I, K. K Pathak and S. Parasher, Vishal Publication, Jalandhar (Delhi).

[5] Theoretical Mechanics, M. R. Spiegel, Tata McGraw Hill.

[6] Mechanics; D. S. Mathur, S. Chand & Company Limited.

[7] An Introduction to Mechanics, D. Kleppner and R. J. Kolenkow, Tata McGraw-Hill.

[8] Mechanics, Berkeley Physics, vol.1, C. Kittel, W. Knight, et.al., Tata McGraw-Hill.

[9] Physics, R. Resnick, D. Halliday and J. Walker, John Wiley & Sons.

[10] Analytical Mechanics, G. R. Fowles and G. L. Cassiday, Cengage Learning.

[11] Feynman Lectures, Vol. I, R. P. Feynman, R. B. Leighton and M. Sands, Pearson Education.

University Physics, F. W. Sears, M. W. Zemansky and H.D Young, Addison Wesley.

[12] Physics for Scientists and Engineers with Modern Phys., J. W. Jewett and R. A. Serway, Cengage Learning.
[13] Mechanics, D. Sarma and K. K Pathak, Vishal Publications, Jalandhar (Delhi).