Four-year Undergraduate Programme

Subject: Physics
Semester: First
Course Name: Mathematical Physics and Mechanics
Existing Base Syllabus: HS Maths and Physics
Course Level: PHY101
Syllabus showing each unit against class number and marks

Unit no.	Unit content	No. of classes	Marks/Credit
Theory			
Part A: Mathematical Physics			
Unit I- Vector Calculus	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).	8	Credit - 1
Unit– II: Curvilinear coordinates	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.	5	
Unit-III: Dirac delta function	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.	2	
Part B – Mechanics			

Unit 1- Reference frames	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.	4	Credit - 2
Unit –II: Gravitation and central force motion	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.	7	
Unit –III: Conservation laws	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.	4	
Unit–IV: Dynamics of rigid bodies	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.	6	
Unit–V: Work and energy	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.	3	
Unit –VI: Oscillations	Oscillation - differential equation of simple harmonic motion and its solution. Total energy of oscillation.	2	
Unit –VII: Properties of matter	Relation between elastic constants. Twisting torque on a cylinder or wire. Cantilever. Kinematics of moving fluids: Poiseuille's equation for flow of a liquid through a capillary tube.	4	
Laboratory			
	<u>At least four from the following:</u> 1. To study the motion of spring and calculate (a) spring constant and (b) rigidity modulus. 2. To determine the moment of inertia of a cylinder about two different axes of symmetry by torsional oscillation method.		Credit-1

	3. To determine coefficient of viscosity of water by capillary flow method (Poiseuille's method). 4. To determine the Young's modulus of the material of a wire by Searle's apparatus. 5. To determine the modulus of rigidity of a wire (static method). 6. To determine the value of g using bar pendulum. 7. To determine the value of g using Kater's pendulum. 8. To determine the height of a building using a sextant. 9. To determine g and velocity for a freely falling body using digital timing technique.		

Reading list

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.

Graduate Attributes

i. Course Objective

This course introduces mathematical physics and mechanics. The basic objectives of the course are

- *to introduce essential primary concepts in mathematical physics such as calculus of vectors, curvilinear coordinates and Dirac delta function which are required for developing insight of the theories of physics,*
- *to introduce the concepts of dynamics of particles, energy, oscillation and basic properties of matter which will equip students with the tools required for applying the concepts of physics in practical problems and*
- *to train the students with concept visualisation through some laboratory practices.*

ii. Learning outcome

On successful completion of the course, students will be able to understand the calculus of vectors and concept of curved spaces which play central roles in developing insight of the theories of physics. They will learn the powerful method of computation through Dirac delta function which often appears in complex problems of physics. Students will be able to understand and apply the concepts of dynamics of particles, energy, oscillation and basic properties of matter in various problems of physics, technology and engineering. They will be trained in concept realisation through laboratory practices.

Theory Credit: 03 (Three)

Practical Credit: 01 (One)

No. of Required Classes: 45

No. of Contact Classes: 45

No. of Non-Contact Classes:

Particulars of Course Designer (Name, Institution, email id):

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