SEMESTER-II

PHYDSM151T

MATHEMATICAL PHYSICS, MECHANICS AND RELATIVITY

Contact Hours: 45

Full Marks = 100 [ESE (70) CCA(30)]

Course objective: *The emphasis of the course is on various tools required for solving problems of interest to physicists. The course will teach the students to model a physics problem mathematically. This course also aims to review few concepts of mechanics learnt earlier from a more advanced perspective and utilize those to build new concepts.*

Unit 1:

Vectors: Dot and Cross product of vectors and their properties. Scalar and vector triple products. Introduction to Gradient, divergent and curl and their significance. Line, surface and volume integrals of Vector fields, Gauss-divergence theorem and Stoke's theorem of vectors (statement only).

Ordinary Differential Equations: 1st order homogeneous differential equations. 2nd order homogeneous differential equations with constant coefficients. **(9 Lectures)**

Unit 2:

Momentum and Energy: Conservation of momentum, Conservation of energy. Work energy theorem, Centre of Mass and centre of gravity.

Rotational Motion: Angular velocity and angular momentum. Torque. Conservation of angular momentum. Moment of inertia and radius of gyration. Calculation of moment of inertia of rectangular bar, cylinder and shell. **(8 Lectures)**

Unit 3:

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. Satellite in circular orbit, orbital velocity, Geosynchronous orbits, Geostationary satellites and applications. Weightlessness. Basic idea of global positioning system (GPS). **(9 Lectures)**

Unit 4:

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, Torsional pendulum. Cantilever, bending of beams. **(9 Lectures)**

Unit 5:

Fluids: Surface Tension, Excess of pressure - Application to spherical and cylindrical drops and bubbles - variation of surface tension with temperature -. Viscosity: Rate flow of liquid in a capillary tube - Poiseuille's formula and Variations of viscosity of a liquid with temperature.

Special Theory of Relativity: Frames of reference, Galilean transformation, Postulates of Special Theory of Relativity. Lorentz Transformation (derivation), Length contraction & time dilation. **(10 Lectures)**

Expected learning outcomes: *After completing this course, the students will be able to understand the concepts of vector algebras and differential equations. Moreover, upon completion of this course, the students will be able to learn the concepts rotational dynamics, gravitation, elasticity, fluids and the Special Theory of Relativity including Lorentz transformations and its consequences.*

Reference Books:

i. University Physics. FW Sears, MW Zemansky and HD Young13/e, 1986. AddisonWesley.

ii. Mechanics Berkeley Physics course, v.1: Charles Kittel, et. Al. 2007, Tata McGraw-Hill.

iii. Physics – Resnick, Halliday & Walker 9/e, 2010, Wiley.

iv. Engineering Mechanics, Basudeb Bhattacharya, 2nd edn., 2015, Oxford University Press.

v. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.