Mechanics and Relativity

Assam University
FYUG · Semester 1 · Credits 3
PHYDSC102T

OBJECTIVES

- To review fundamental concepts of mechanics from a more advanced perspective
- To develop a strong understanding of dynamics, gravitation and oscillatory motion
- To introduce the foundations of Special Theory of Relativity and its physical consequences

COURSE CONTENT

Unit 1: Fundamentals of Dynamics (10 Hours)

Force and linear momentum, Principle of conservation of momentum, 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, Impulse, Work–Energy theorem, Conservative and non-conservative forces, Elastic potential energy, Force as a gradient of potential energy, Law of conservation of mechanical energy, Elastic and inelastic collisions in one and two dimensions, Collisions in centre of mass and laboratory frames

Unit 2: Rotational Dynamics (8 Hours)

Angular momentum of a particle and system of particles, Torque, Principle of conservation of angular momentum, Moment of inertia, Calculation of moment of inertia for rectangular, cylindrical and spherical bodies, Elasticity, Hooke’s law, Poisson’s ratio and its limiting values, Relation connecting elastic constants, Twisting torque on a cylinder or wire

Unit 3: Gravitation and Central Force Motion (9 Hours)

Law of gravitation, Gravitational potential and potential energy, Potential and field due to spherical shell and solid sphere, Central force: definition and characteristics, Kepler’s laws with derivation, Deduction of Newton’s law of gravitation from Kepler’s law, Satellite in circular orbit, Orbital velocity, Escape velocity, Time period of satellite, Geosynchronous orbits, Weightlessness, Basic idea of global positioning system (GPS)

Unit 4: Oscillations and Non-Inertial Systems (9 Hours)

Simple harmonic oscillations, Differential equation of SHM and its solution, Kinetic energy, potential energy and total energy in SHM, Time-average values, Damped oscillations, Forced oscillations, Resonance and sharpness of resonance, Power dissipation, Quality factor, Inertial and non-inertial frames, Fictitious forces, Uniformly rotating frame, Laws of physics in rotating coordinate systems, Coriolis theorem, Centrifugal force, Coriolis force and its applications

Unit 5: Relativity (9 Hours)

Galilean transformations, Galilean invariance, Michelson–Morley experiment and its outcome, Postulates of Special Theory of Relativity, Lorentz transformations, Simultaneity and order of events, Lorentz contraction, Time dilation and its experimental verification, Twin paradox, Relativistic addition of velocities, Variation of mass with velocity, Massless particles, Mass–energy equivalence

LEARNING OUTCOMES

- Apply laws of dynamics to systems of particles and rotational motion
- Analyse gravitational motion and central force problems
- Understand oscillatory motion and non-inertial reference frames
- Explain the basic principles and consequences of Special Theory of Relativity

REFERENCES

- An Introduction to Mechanics – Daniel Kleppner and Robert J. Kolenkow
- Physics – Resnick, Halliday and Walker
- The Feynman Lectures on Physics, Vol. I – R. P. Feynman, R. B. Leighton, M. Sands
- Introduction to Special Relativity – Robert Resnick
- Analytical Mechanics – G. R. Fowles and G. L. Cassiday