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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

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- ☐ 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

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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

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