2022
B.A./B.Sc.
First Semester
CORE – 2
PHYSICS
Course Code: PHC 1.21
(Mechanics)

Total Mark: 70 *Pass Mark: 28*
Time: 3 hours

Answer five *questions, taking* one *from each unit.*

UNIT–I

1. (a) Determine whether length, velocity and acceleration are invariant under Galilean transformations. 6
   (b) Prove that the law of conservation of energy is invariant to Galilean transformation. 5
   (c) A moving particle has coordinates $(6t + 3)$, $8t$, 5 in frame S at any time t. The frame S' is moving relative to S with a velocity $(3\hat{i} + 4\hat{j})$ m/s. Find the coordinates and velocity of the particle in frame S'. 3

2. (a) State and prove the law of conservation of momentum of a one particle and two particle systems. 5
   (b) What is impulse? Prove that impulse is equal to the total change in momentum. 5
   (c) Prove that work done is equal to the product of the component of force along the displacement and the displacement. 4

UNIT–II

3. (a) Discuss perfectly elastic collision in one dimension in a laboratory frame. 6
   (b) Prove that angular momentum of a rigid body is the product of its moment of inertia and angular velocity. 4

(c) What is moment of inertia? Prove that the moment of inertia is twice the kinetic energy of rotation of a body when its angular velocity is unity. 4

4. (a) Find the moment of inertia of a rectangular lamina about 10
   (i) an axis through its centre and parallel to one side
   (ii) an axis through its centre and perpendicular to the plane
   (iii) an axis passing through the midpoint of one side and perpendicular to its plane
   (iv) an axis passing through one of its corners and perpendicular to its plane

   (b) Derive the expression of acceleration in case of a body rolling down an inclined plane. What is the acceleration in case of a cylinder? 4

UNIT–III

5. (a) Derive the expression of velocity and acceleration in a rotating frame of reference. 5
   (b) Obtain the components of acceleration in spherical polar coordinate system. 6
   (c) Write short note on Global Positioning System (GPS). 3

6. (a) Find the gravitational potential due to a spherical shell at a point outside and inside the spherical shell. 5
   (b) State and prove Kepler's law of planetary motion. 9

UNIT–IV

7. (a) Prove the relation $Y = 3K(1 - 2\sigma)$ where the symbols have their usual meaning. 5
   (b) Derive Poiseuille's equation for flow of liquid through capillary tube. 6
   (c) Calculate η and σ for silver. Given that $Y = 7.25 \times 10^{11}$ dynes/cm^2 and $K = 11 \times 10^{11}$ dynes/cm^2. 3

8. (a) Derive the general equation of motion of a simple harmonic oscillator and obtain its various solutions. 8

(b) The displacement of a moving particle at any time t is given by $y = a\cos\omega t + b\sin\omega t$. Show that the motion is simple harmonic. 3

(c) A particle performing SHM has a mass 2.5 gm and frequency of vibration 10 Hz. It is oscillating with an amplitude of 2 cm. Calculate the total energy of the particle. 3

UNIT–V

9. (a) Derive Lorentz transformation equations. Also write the inverse Lorentz transformation equations. 8

(b) What is proper length? Discuss length contraction. 4

(c) A particle with a proper lifetime of $1\,\mu s$ moves through the laboratory at $2.7\times10^{8}\ ms^{-1}$. What is its lifetime as measured by an observer in the laboratory? What will be the distance traversed by it before disintegrating? 2

10. (a) Derive the relativistic formula for the variation of mass with velocity. 8

(b) Obtain the relation between total energy and momentum in relativistic mechanics. 4

(c) Calculate the kinetic energy of an electron moving with a velocity of 0.98 c in the laboratory system. 2
