

2908

Name of Course : B.Sc. (Prog.)..__Core

Semester : I- Semester

Name of the Paper: Mechanics

Unique Paper Code : 42221101

Duration: 3 Hours

Maximum Marks: 75

Attempt five questions in all.

Question No. 1 is compulsory.

Attempt any four questions from the rest of the paper.

1. Attempt any five from the following:

(a) Show that the force $\vec{F} = yz\hat{i} + zx\hat{j} + xy\hat{k}$ is conservative force. (3)

(b) Determine the value of λ such that the vectors $\vec{a} = \hat{i} + \hat{j} + \hat{k}$, $\vec{b} = 2\hat{i} - 4\hat{k}$ and $\vec{c} = \hat{i} + \lambda\hat{j} + 3\hat{k}$ are coplanar. (3)

(c) Calculate the radius of gyration of a solid sphere rotating about its diameter if its radius is 5.0cm. (3)

(d) State the postulates of the special theory of relativity. (3)

(e) A rod has a length of 2m. Find its length, when carried in a rocket with a speed of $2.7 \times 10^8 \text{ m/sec}$. (3)

(f) Explain the concept of central force with suitable examples. (3)

2. (a) Prove that $(y^2 - z^2 + 3yz - 2x)\hat{i} + (3xz + 2xy)\hat{j} + (3xy - 2xz + 2z)\hat{k}$ is both solenoidal and irrotational vector. (5)

b) Solve the following second order homogenous and linear differential equation using constant coefficient method

$$\frac{d^2y}{dx^2} - 5\frac{dy}{dx} + 6y = 0 \quad (5)$$

(c) State and explain the work-energy theorem. Also, prove the conservation of energy using the work-energy principle. (5)

3. (a) State and explain the law of conservation of angular momentum with suitable examples. (5)
 (b) Derive an expression for the center of mass of a solid semi-circular disk having mass M and radius R . (5)
 (c) Show that the relative velocity between the particles after an elastic head-on collision is equal and opposite of the velocity before the collision. (5)
4. (a) A reference frame s' moves with a uniform velocity v with respect to the frame s . Derive expressions for Lorentz transformations that connect x', y', z', t' with x, y, z, t . (5)
 (b) State the relation showing total energy for a particle moving under a central force. Hence derive a relation between (i) r and t (ii) θ and t (5)
 (c) What is compound pendulum? How does it differ from the simple pendulum? (5)
5. (a) Derive expression for the displacement and velocity corresponding to the simple harmonic motion. Also, prove that velocity of simple harmonic motion at any time t leads the displacement by a phase angle of $\frac{\pi}{2}$ radian. (5)
 (b) State Kepler's laws of planetary motion with suitable diagrams. (5)
 (c) Show that a conservative force can be expressed as $\vec{F} = -\nabla U$, where U is potential energy (5)
6. (a) Calculate the moment of inertia of a thin rod of mass M and length l about an axis passing through its center and perpendicular to its length. (5)
 (b) If this rod rotates about the above axis with a constant angular speed ω , determine its angular momentum and kinetic energy. (5)
 (c) Calculate the mass of a body when its speed is 0.8 times the speed of light. Assume the rest mass of the body to be one gram. (5)