2024

Four Year Under Graduate Programme (FYUGP)

1st Semester Examination (Under NEP)
(New Session 2024-25)

PHYSICS (Major)

Paper Code : PHSMJ DC-101

(Mechanics)

Full Marks : 30 Time : Two Hours

The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable.

1. Answer any *six* questions : 1×6=6

(a) What do you mean by a central force?

(b) State the Hooke's law of elasticity.

(c) Define radius of gyration of a rotating body about its axis of rotation.

(d) What do you mean by Inertial frame of reference?

(e) State the principle of conservation of energy.

(f) What is the time period or revolution of a geostationary satellite?

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(g) Which conservation principle does the Kepler's second law of planetary motion indicate?

(h) A solid cube of side 10 cm is subjected to a uniform pressure of 10^7 N/m^2. If the bulk modulus of the material is 2×10^{11} N/m^2, calculate the change in volume of the cube.

2. Answer any *three* questions : 3×3=9

(a) A bomb in flight explodes into two fragments when its velocity is $\left(10\hat{i}+2\hat{j}\right)$ m/s. If the smaller mass M flies with velocity $\left(20\hat{i}+50\hat{j}\right)$ m/s, obtain the velocity of the larger mass $3M$. Also, deduce the velocities of both the fragments in the centre of mass reference frame. 1+1+1

(b) Examine whether the force, $\vec{F}=\left(y^2-x^2\right)\hat{i}+2xy\,\hat{j}$ is a conservative force field or not.

(c) What are gravitational potential and field, and how are they related?

(d) A circular disc of mass M and radius r is set rolling on a table. If ω be the angular velocity, then show that its total energy E is given by $\frac{3}{4}Mr^2\omega^2$.

(e) Prove that the motion of a particle moving under a central force field is confined to a plane.

3. Answer any *three* questions : 5×3=15

(a) Deduce an expression for the couple required to twist a uniform solid cylinder by an angle θ.

(b) Show that the kinetic energy of a system of particles is the sum of the kinetic energy of the total mass placed at the centre of mass (and moving with it) and the kinetic energy of the particles about the centre of mass.

(c) A particle of mass m moves in a force field defined by $\vec{F} = \frac{k}{r^3}\hat{r}$. If it starts on the positive x-axis at a distance a away from the origin and moves with a speed of v_0 in the direction making an angle a with the positive x-axis. Then prove that the differential equation for the radial position r of the particle at any time t is $\frac{d^2r}{dt^2} = \frac{k - ma^2v_0^2\sin^2\alpha}{mr^3}$.

(d) Show that, $L^2 = 2EI$, where J, E and I are the angular momentum, rotational kinetic energy and moment of inertia, respectively.

(e) Two bodies of masses M_1 and M_2 are placed at a distance 'd' apart. Show that, at the position where the gravitational field due to them is zero, the potential is given by $-\frac{G}{d}\left(M_1 + M_2 + 2\sqrt{M_1M_2}\right)$, where G is the universal gravitational constant.
