FYUG Odd Semester Exam., 2024

PHYSICS

(1st Semester)

Course No. : PHYDSC–102T

(Mechanics and Relativity)

Full Marks : 70

Pass Marks : 28

Time : 3 hours

The figures in the margin indicate full marks for the questions

UNIT—I

1. Answer any *two* from the following : 2×2=4

(a) Define linear momentum of a moving particle. How is it related to force?

(b) Three particles of masses 2 gm, 3 gm and 5 gm are located in space. Their position vectors are $\vec{r}_1 = 2\hat{i} + 2\hat{j} + 2\hat{k}$, $\vec{r}_2 = \hat{i} + \hat{j} + \hat{k}$ and $\vec{r}_3 = \hat{i} - \hat{k}$ respectively. Find the position vector of the centre of mass.

(c) Distinguish between elastic collision and inelastic collision.

2. *(a)* What do you mean by projectile? Show that the trajectory of a projectile fired at an angle with the horizontal direction is parabolic in nature. 1+5=6

(b) Find expressions for the *(i)* time of flight and *(ii)* horizontal range. 2+2=4

OR

3. *(a)* Define conservative force. Show that the central force is conservative in nature. Obtain the law of conservation of mechanical energy. 1+3+2=6

(b) State and prove work-energy theorem. 1+3=4

UNIT—II

4. Answer any *two* from the following : 2×2=4

(a) Define moment of inertia and radius of gyration of a body about an axis.

(b) The trajectory of a particle of unit mass is given by the radius vector $\vec{r} = \hat{i}\,a\cos\omega t + \hat{j}\,b\sin\omega t$, where a and b are constants. Calculate the angular momentum of the particle about the origin.

(c) State Hooke's law. What do you mean by modulus of elasticity?

5. *(a)* State the two theorems of moment of inertia. 3

(b) Calculate the moment of inertia of a solid cylinder about *(i)* its own axis and *(ii)* an axis passing through its centre of mass and perpendicular to its own axis. 2+5=7

OR

6. *(a)* Define Young's modulus (Y), bulk modulus (K), modulus of rigidity (η) and Poisson's ratio (σ). 4

(b) Show that—

(i) $Y = 3K(1-2\sigma)$;

(ii) $Y = 2\eta(1+\sigma)$. 3+3=6

UNIT—III

7. Answer any *two* from the following : 2×2=4

(a) Define central force. Give one example.

(b) State Kepler's laws of planetary motion.

(c) Explain weightlessness.

8. *(a)* State Newton's law of gravitation. Find the gravitational potential inside and outside of a spherical shell. 1+6=7

(b) The potentials within two homogeneous shells of same surface density are in the ratio 1:2. Calculate the ratio of their radii. 3

OR

9. (a) Define angular momentum of a particle. Show that when a particle moves under central force, angular momentum is a constant of motion. 1+2=3

(b) Write short notes on the following : 3½+3½=7

(i) Escape velocity

(ii) Global Positioning System (GPS)

UNIT—IV

10. Answer any *two* from the following : 2×2=4

(a) What are the characteristics of simple harmonic motion?

(b) Obtain the differential equation of simple harmonic motion.

(c) Distinguish between inertial and non-inertial frames.

11. (a) The displacement of a particle executing SHM is represented by

$$y = 10\sin\left(100\pi t + \frac{\pi}{6}\right) \text{m}$$

Find its (i) amplitude, (ii) angular frequency, (iii) frequency and (iv) time period. 4

(b) Obtain the expressions for average kinetic energy and average potential energy of a particle executing simple harmonic motion. 3+3=6

OR

12. (a) Obtain the expressions of fictitious forces appearing in a uniformly rotating frame of reference. 7

(b) Explain the effect of coriolis force on a freely falling body. 3

UNIT—V

13. Answer any *two* from the following : 2×2=4

(a) Write down Galilean transformation equations.

(b) State the postulates of special theory of relativity.

(c) What do you mean by length contraction?

14. (a) Derive Lorentz transformation equations. 7

(b) Show that

$$L = L_0\sqrt{1-\frac{v^2}{c^2}}$$

where the symbols have their usual meanings. 3

OR

15. *(a)* Obtain the expression of relativistic addition of velocities. 4

(b) Obtain Einstein's mass-energy relation. Show that the rest mass of photon is zero. 4+2=6

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