FYUG Odd Semester Exam., 2023

(Held in 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

SECTION—A

Answer *ten* questions, selecting *two* from each Unit : 2×10=20

UNIT—I

1. State with examples the principle of conservation of linear momentum.

2. What are conservative and non-conservative forces? Give examples.

3. Explain why a cricket player lowers his hands while catching a cricket ball.

UNIT—II

4. Show that torque is given by the time rate of change of angular momentum.

5. Explain elasticity and reason of elasticity.

6. What do you mean by restoring torque?

UNIT—III

7. Define gravitational potential and gravitational potential energy.

8. What is the difference between inertial mass and gravitational mass?

9. Describe in brief global positioning system (GPS).

UNIT—IV

10. What are fictitious and Coriolis forces?

11. Define resonance and sharpness of resonance.

12. Find an expression of kinetic energy of a body executing SHM.

UNIT—V

13. What do you mean by mass-energy equivalence?

14. What do you mean by massless particle? Find the velocity of such particle.

15. What is the aim of Michelson-Morley experiment?

SECTION—B

Answer *five* questions, selecting *one* from each Unit : 10×5=50

UNIT—I

16. *(a)* Define centre of mass of a system. Calculate the position, velocity and acceleration of centre of mass of two particles. 1+4=5

(b) State work-energy theorem with examples. Show that force is gradient of potential energy. 2+3=5

17. *(a)* Explain what is meant by elastic potential energy of a spring. Obtain an expression for it and discuss the nature of its variation. 2+3=5

(b) Define coefficient of restitution. Show that in an elastic one-dimensional collision, when a body collides with another body of same mass at rest, they just interchange their velocities after collision. 1+4=5

UNIT—II

18. *(a)* Define angular momentum of a particle. Show that time rate of change of angular momentum of a particle is equal to the torque acting on it. 1+4=5

(b) Define moment of inertia. What is its physical significance? Calculate the moment of inertia of a uniform circular disc about a diameter of the disc. 1+1+3=5

19. *(a)* Connecting the three elastic constants, derive the following relation :

$$\frac{9}{Y}=\frac{3}{\eta}+\frac{1}{K}$$

Here the symbols have their usual meanings. 5

(b) A cylinder of length l and of radius a is clamped at one end and a torque is applied at the other end. Establish the restoring torque that comes to play during the twisting of the cylinder is given by

$$\tau=\frac{\pi\eta Q^4}{2l}\phi$$

where η is the modulus of rigidity and ϕ is the angle of twist. 5

UNIT—III

20. *(a)* Obtain an expression for gravitational potential due to a solid sphere at a point outside the sphere. What will be the potential when the point lies on the surface of the sphere? 4+1=5

(b) Write the characteristic of the motion of a particle in a central force field. State Kepler's laws of planetary motion. 2+3=5

21. *(a)* Explain in brief how a satellite may be placed in its orbit round the earth, and find an expression for its orbital velocity and time period. 5

(b) Given

the radius of the earth is

$$R = 6{\cdot}37 \times 10^{8} \text{ cm}$$

mean density of the earth = $5{\cdot}53 \text{ g/cm}^3$

gravitational constant

$$= 6{\cdot}66 \times 10^{-8} \text{ CGS units}$$

Using the above data, calculate the gravitational potential on the surface of the earth. Explain geosynchronous orbit and weightlessness. 2+3=5

UNIT—IV

22. (a) What are the important characteristics of SHM? Show that the time period of simple harmonic oscillator is given by

$$T = 2\pi\sqrt{\frac{\text{displacement}}{\text{acceleration}}}$$ 2+3=5

(b) Explain briefly forced and damped oscillations. Write down the differential equation of damped oscillation and solve it to find the general equation of displacement. 2+3=5

23. (a) Write the differences between inertial and non-inertial frames of references. Show that a rotating frame is a non-inertial frame of reference. 2+3=5

(Continued)

(b) What are the important characteristics of SHM? Set up the differential equation of motion of a body executing simple harmonic motion. 2+3=5

UNIT—V

24. (a) On the basis of Lorentz transformation equation, discuss the phenomenon of time dilation. 5

(b) Describe Michelson-Morley experiment. 5

25. (a) State the fundamental postulates of the theory of special theory of relativity. Explain in brief, what you mean by length contraction. 2½+2½=5

(b) Explain reference frames and Galilean transformations. Prove that when v is much smaller than the velocity of light, Lorentz transformations reduce to Galilean transformations. 3+2=5

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