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(February)

PHYSICS

(Elective/Honours)

(Mathematical Physics—I, Mechanics, Waves and Acoustics)

[PHY–01 (T)]

Marks : 75

Time : 3 hours

The figures in the margin indicate full marks for the questions

Answer *any* **ten** questions

1. *(a)* What is the physical significance of 'divergence of a vector'? 1½

 (b) Calculate the curl of the function $\vec{V} = y\hat{x} - x\hat{y}$. 2

 (c) Solve the differential equation

 $$\frac{d^2y}{dx^2} - 3\frac{dy}{dx} + 2y = x^3 + x$$ 4

(**2**)

2. *(a)* State the Stokes' theorem and explain its significance. 3½

 (b) Solve the equation

 $$\cos x \frac{dy}{dx} + y\sin x = 1$$ 4

3. *(a)* What are non-inertial frames? 1

 (b) Derive the equation for the forces on a moving particle in a uniformly rotating frame of reference. Mention the fictitious forces. 5½+1=6½

4. *(a)* What is universal gravitational constant? Write its dimension and SI unit. 1+1+1=3

 (b) What are the forces that keep a satellite in its orbit? Show that the orbit of a geostationary satellite is at a height of 36000 km above the surface of the earth. [Radius of the earth = $6\cdot4 \times 10^8$ m.] 1+3½=4½

5. *(a)* Write the expressions for velocity and acceleration of the centre of mass of a system of particles. 1+1=2

 (b) Derive the equation of motion of the centre of mass of a system of moving particles. 3

(3)

(c) Obtain the expression for total angular momentum of a system of particles in terms of angular momentum of the centre of mass.   2½

6. *(a)* State and prove the theorem of parallel axes on moment of inertia for a plane laminar body.   1+2½=3½

(b) Calculate the moment of inertia of a disc about an axis through its centre and perpendicular to its plane.   4

7. What is bending moment? Obtain the expression for the depression due to a load attached to the free end of a rectangular cantilever.   1+6½=7½

8. *(a)* Write the equation of continuity for fluids and explain its significance.   1+1½=2½

(b) Derive the Poiseuille's equation for the streamline flow of liquid through a capillary tube.   5

9. *(a)* Explain surface tension and surface energy of a liquid.   1+1½=2½

(b) Obtain an expression for the excess pressure inside an air bubble.   5

(4)

10. *(a)* What are Lissajous figures?   1

(b) Discuss the resultant motion of two mutually perpendicular simple harmonic motions having different amplitudes and phases but frequencies in the ratio of 1 : 2. Show the resultant patterns for phase differences 0 and $\frac{\pi}{2}$.   4½+1+1=6½

11. *(a)* What are damped and forced oscillations?   1+1=2

(b) Calculate the average energy of a damped simple harmonic oscillator.   5½

12. *(a)* What is a plane progressive wave?   1

(b) Establish the differential equation of a plane progressive harmonic wave and obtain its general solution.   2½+4=6½

13. What are wave velocity and group velocity? Derive the relation between them.   1+1+5½=7½

14. What are ultrasonic vibrations? Describe a method to detect them. Mention three applications of ultrasonic waves.   1+3½+3=7½

15. Define reverberation time and hence obtain an expression for it.   1+6½=7½

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