

2022

(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. (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 6.4×10^8 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

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- (c) Obtain the expression for total angular momentum of a system of particles in terms of angular momentum of the centre of mass. $2\frac{1}{2}$
6. (a) State and prove the theorem of parallel axes on moment of inertia for a plane laminar body. $1+2\frac{1}{2}=3\frac{1}{2}$
- (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. $1+6\frac{1}{2}=7\frac{1}{2}$
8. (a) Write the equation of continuity for fluids and explain its significance. $1+1\frac{1}{2}=2\frac{1}{2}$
- (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. $1+1\frac{1}{2}=2\frac{1}{2}$
- (b) Obtain an expression for the excess pressure inside an air bubble. 5

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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 $\frac{\pi}{2}$.
 $4\frac{1}{2}+1+1=6\frac{1}{2}$
11. (a) What are damped and forced oscillations? $1+1=2$
- (b) Calculate the average energy of a damped simple harmonic oscillator. $5\frac{1}{2}$
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. $2\frac{1}{2}+4=6\frac{1}{2}$
13. What are wave velocity and group velocity? Derive the relation between them. $1+1+5\frac{1}{2}=7\frac{1}{2}$
14. What are ultrasonic vibrations? Describe a method to detect them. Mention three applications of ultrasonic waves. $1+3\frac{1}{2}+3=7\frac{1}{2}$
15. Define reverberation time and hence obtain an expression for it. $1+6\frac{1}{2}=7\frac{1}{2}$
