Odd Semester, 2020

(Held in March, 2021)

PHYSICS

(Elective/Honours)

[Phy–01(T)]

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

Marks : 75

Time : 3 hours

The figures in the margin indicate full marks for the questions

Answer *any* **ten** questions

1. *(a)* State Gauss' divergence theorem and Stokes' theorem and explain their significance. 2½+2½=5

(b) Calculate the work done in moving a body along a vector $\vec{r} = 3\hat{i} - 6\hat{j} + 3\hat{k}$ through 1 m if the force applied is given by $\vec{F} = 2\hat{i} - \hat{j} + \hat{k}$. (Units of force and displacement are in SI.) 2½

2. *(a)* Solve : 3½

$$\frac{dy}{dx} + y\sec x = \tan x$$

(b) Find the solution of the following equation : 4

$$\frac{d^2y}{dx^2} + 4\frac{dy}{dx} + 5y = 0$$

3. Derive the expressions for tangential and normal components of acceleration of a particle moving along a curve. What is the magnitude and direction of acceleration when the particle moves in a circular path with a uniform velocity? 6+1½=7½

4. *(a)* What are geosynchronous satellites? Obtain the expression for velocity of a satellite in circular orbit at a height H above the surface of the earth. 1+3=4

(b) Show that the central forces are conservative in nature. 3½

5. *(a)* Distinguish between elastic and inelastic collisions. Obtain the expression for loss of kinetic energy in an inelastic collision in the laboratory system in one dimension. 2+4=6

(b) Two particles of masses 3 g and 5 g have position vectors $(2\hat{i} + \hat{j} - \hat{k})$ and $(\hat{i} + 2\hat{j} + 3\hat{k})$ respectively (in cm). Calculate the position vector of the centre of mass. 1½

6. State the theorems of parallel axës and perpendicular axes related to moment of inertia. Obtain an expression for the moment of inertia of a thin spherical shell rotating about any of its diameter. 3+4½=7½

7. *(a)* State Hooke's law. Deduce the relation

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

where the symbols have usual significance. ½+5½=6

(b) The Young's modulus and Poisson's ratio of a material are $7{\cdot}25\times10^{10}\ \mathrm{N/m^2}$ and 0·39 respectively. Calculate its Bulk modulus. 1½

8. State and prove Bernoulli's theorem. 1½+6=7½

9. What is surface tension? Derive the expression for the height to which a liquid may rise in a capillary tube. 1½+6=7½

10. Two mutually perpendicular simple harmonic vibrations of same frequency but different amplitude with constant phase difference ϕ are acting simultaneously on a particle. Show that the resultant motion is in general elliptic. What would be the nature of the resultant figure if the phase difference is $\pi/2$ and the two amplitudes are equal? 5½+2=7½

11. Write down the equation of damped simple harmonic motion and solve it for critical damping. 1½+6=7½

12. What is progressive wave? Show that the kinetic energy and potential energy densities in the plane progressive wave are equal. 1½+3+3=7½

13. *(a)* Deduce an expression for the speed of a transverse wave in a stretched string. 3½

(b) Explain how constructive interference and destructive interference of sound wave occur. 4

14. What are ultrasonic waves? Give a detailed description of any method for generating ultrasonic wave. 1½+6=7½

15. What are the requirements of a good auditorium? Obtain the equation for growth of sound intensity and decay of sound intensity in an auditorium. 3½+4=7½

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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 $\vec{V} \quad y\hat{x} \quad x\hat{y}$. 2

(c) Solve the differential equation

$$\frac{d^2y}{dx^2} \quad 3\frac{dy}{dx} \quad 2y \quad x^3 \quad x$$ 4

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

(b) Solve the equation

$$\cos x\frac{dy}{dx} \quad y\sin x \quad 1$$ 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 $6{\cdot}4 \times 10^8$ 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

(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

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 $\frac{}{2}$. 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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