2013

PHYSICS

(Major)

Paper : 10100

(Mechanics and Properties of Matter)

Full Marks : 90

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. Choose the correct option from the following : 1×9=9

(a) In physics when a collision takes place in between two particles, then

(i) it is always essential to strike one particle by another

(ii) it is not essential to strike one particle by another

(iii) the actual option is not mentioned

(iv) None of the above is correct

(b) The moment of inertia of an object of mass M_0 rotating in a circular path of radius R_0, about an axis may be equal to that of a ring of mass M_R and radius R_R, only when

(i) $M_0 = M_R$

(ii) $R_0 = R_R$

(iii) Both of the above are valid

(iv) All of the above are incorrect

(c) Which of the following options may be true to express Young modulus, bulk modulus and the modulus of rigidity as similar quantities?

(i) They have same dimensions in M, L and T

(ii) They have same unit

(iii) All are stresses divided by a dimensionless quantity

(iv) All of the above are correct

(d) In the case of mercury in a capillary tube

(i) cohesive force > adhesive force

(ii) cohesive force < adhesive force

(iii) cohesive force = adhesive force

(iv) None of the above is correct

(e) A particle is free to execute motion along any one axis (x or y or z) independently. The degrees of freedom of the particle will be

(i) one

(ii) two

(iii) three

(iv) None of the above is correct

(f) Constraints are the forces

(i) that act on the system

(ii) that are exerted by the system

(iii) Both of the above are correct

(iv) None of the above is correct

(g) The bob and the string of a simple pendulum should be

(i) weightless and inextensible

(ii) heavy and inextensible

(iii) light and extensible

(iv) heavy and extensible

(h) The equation of motion of a particle in a rotating coordinate system is

$$m\frac{\partial \vec{v}}{\partial t} = \vec{F} - 2m(\vec{\omega} \times \vec{v}) - m\vec{\omega} \times (\vec{\omega} \times \vec{r})$$

If the particle is at rest in the rotating coordinate system, the new form of the equation will be

(i) $0 = \vec{F} - 2m(\vec{\omega} \times \vec{v}) - m\vec{\omega} \times (\vec{\omega} \times \vec{r})$

(ii) $m\frac{\partial \vec{v}}{\partial t} = \vec{F} - m\vec{\omega} \times (\vec{\omega} \times \vec{r})$

(iii) $m\frac{\partial \vec{v}}{\partial t} = \vec{F} - 2m(\vec{\omega} \times \vec{v})$

(iv) $m\frac{\partial \vec{v}}{\partial t} = -2m(\vec{\omega} \times \vec{v}) - m\vec{\omega} \times (\vec{\omega} \times \vec{r})$

(i) Is Doppler effect observable in our day-to-day life?

(i) Yes

(ii) No, it is a theoretical concept only

(iii) No, it is observable in laboratory only

(iv) None of the above is correct

2. *(a)* The momenta of two particles before and after collision are $m_1u_1 + m_2u_2$ and $(m_1 + m_2)V$. where the symbols have their usual meaning. Find an expression for V. If $u_2 = 0$, show that kinetic energy after collision is less than the KE before collision.

[Hint : Find the ratio of KE after collision to the KE before collision]

½+2½=3

(b) The moment of inertia of a sphere about a diameter is $\frac{2}{5}MR^2$. Draw a neat diagram to show that its moment of inertia about a tangent will be $\frac{7}{5}MR^2$.

1+2=3

(c) A spherical body of mass M and radius R is rolling down an inclined plane through a distance S. If v be the velocity acquired by the body after traversing the distance S. then show that the total energy gained by the body is $\frac{7}{10}Mv^2$. 3

(d) Discuss the phenomenon of pressure difference across liquid surfaces of shape *(i)* plane, *(ii)* concave and *(iii)* convex.

1×3=3

(e) What do you mean by constraints? Write what you know about *(i)* holonomic and non-holonomic constraints or *(ii)* scleronomous and rheonomous constraints. 1+2=3

(f) What is Hamiltonian (H)? Give its physical significance. 1+2=3

(g) What do you mean by virtual work and virtual displacement? 1½+1½=3

(h) Discuss the phenomenon of deviation of freely-falling bodies from the vertical. 3

(i) If $y_1 = a\sin 2\pi(n-1)t$, $y_2 = a\sin 2\pi nt$, and $y_3 = a\sin 2\pi(n+1)t$ be the displacements due to three sound waves at a particular point in a medium, find out the resultant displacement as $y = a(1+2\cos 2\pi t)\sin 2\pi nt$. What will be the amplitude at that point? 2½+½=3

3. (a) Differentiate between conservative force and central force. Under what condition a law is said to be inverse-square law? Explain the terms *(i)* gravitational potential and *(ii)* gravitational field. 1+1+1+1+1=5

(b) Define bending moment. Find out an expression for depression of a cantilever fixed at one end and loaded uniformly. 1+4=5

(d) Derive equation of motion for a simple pendulum of length l and mass of the bob m by using Lagrange's equations. 5

(d) Discuss the Foucault's pendulum experiment and also mention why this experiment is famous in the history of physics. 4+1=5

Or

Find the equation of motion of a particle relative to the rotating earth. Discuss the fictitious forces. 5

(e) What are Lissajous figures? Deduce the resultant motion of a particle influenced by two mutually perpendicular simple harmonic motions having the same period but differing in phase by *(i)* $\pi/2$ and *(ii)* π. 1+4=5

Or

What are beats? If two waves having difference in frequency less than 10 Hz move in the same direction, show that the frequency of the resultant wave will be equal to half of the sum of the frequencies of the waves. Mention one application of beats. 1+3+1=5

4. *(a)* Derive the expression for moment of inertia of a spherical shell or a solid sphere about its diameter. 8

Or

Define surface tension and surface energy. Show that the excess pressure acting on the curved surface of a curved membrane is given by

$$P = 2T\left(\frac{1}{r_1} + \frac{1}{r_2}\right)$$

where r_1 and r_2 are radii of curvature and T, the surface tension of the liquid. 1+1+6=8

(b) State Hamilton's principle. Deduce the equation of motion of one-dimensional harmonic oscillator using Hamilton's principle. 2+6=8

Or

Deduce Hamilton's canonical equations of motion and explain the physical significance of Hamiltonian. 6+2=8

(c) Obtain an expression for velocity of longitudinal waves in gases. Mention two factors on which the velocity of longitudinal waves through gaseous medium depends. Why did Newton's formula fail to obtain the correct result for velocity of sound waves propagating through a gaseous medium? What change did Laplace forward to Newton's formula? 4+½+½+2+1=8

Or

What is Doppler effect? Under what condition *(i)* the apparent frequency heard by an observer will be maximum and *(ii)* there will be no change in the apparent frequency in spite of being the source and the observer in motion?

A tuning fork producing sound of frequency 440 Hz is approaching a fixed wall with a velocity 4 cm/s. How many beats per second can an observer detect if *(i)* the tuning fork is between the observer and the wall and *(ii)* the observer is between the fork and the wall? (velocity of sound = 332 m/s.)

2+1+1+1+1½+1½=8

5. Write short notes on any two of the following : 2½×2=5

(a) Capillarity

(b) Poisson's ratio

(c) Generalised coordinate

(d) Coriolis force

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