

2012

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) A set-up in which a particle collides with another particle at rest is called

(i) inertial frame of reference

(ii) laboratory frame of reference

(iii) accelerated frame of reference

(iv) centre of mass frame of reference

(b) An apple appears to fall towards the earth and the earth towards the apple. This is because

(i) acceleration of the apple produced by the earth is appreciable

(ii) acceleration of the earth produced by the apple is negligible

(iii) Both of the above are correct

(iv) None of (i) and (ii) explains the fact

(c) If the moment of inertia of a body is  $I = \frac{2}{5} MR^2$ , where  $M = 1$  kg and  $R = 1$  m, then

(i) the body is a sphere

(ii) the radius of gyration is  $\sqrt{\frac{2}{5}}R$  m

(iii) the axis is passing through the centre

(iv) All of the above are correct

(d) The value of Poisson's ratio ( $\sigma$ ) for a rubber tube is

(i)  $\sigma \geq -1$

(ii)  $\sigma \leq 0.5$

(iii)  $-1 \leq \sigma \leq 0.5$

(iv) None of the above are correct

(e) If a system of  $N$  particles there are  $K$  equations of constraints, the number of degrees of freedom is reduced to

(i)  $3N - K$

(ii)  $K - 3N$

(iii)  $3NK$

(iv)  $3N / K$

(f) The presence of Coriolis force

(i) can be demonstrated

(ii) can never be demonstrated

(iii) Both of the above are correct

(iv) None of the above are correct

(g) The fictitious force acting on a falling body of mass 5 kg with relative downward acceleration of  $2 \text{ m/s}^2$  is

(i) 10 N

(ii)  $-10 \text{ kg m/s}^2$

(iii) 49 N

(iv)  $-49 \text{ kg m/s}^2$

(h) The Foucault's pendulum is a device used to

(i) demonstrate the rotation of earth

(ii) determine the value of  $g$  at the pole

(iii) demonstrate that earth is an inertial frame of reference

(iv) None of the above are correct

(i) In the case of a musical string instrument, the vibration of the string and the sound wave it produces are in real sense

(i) 'transverse' and 'transverse'

(ii) 'transverse' and 'longitudinal'

(iii) both 'transverse and longitudinal' and 'longitudinal'

(iv) 'longitudinal' and 'longitudinal'

2. Write the answers of the following in brief :

(a) As for example consider the following to be the records of time periods of three planets with their average distances from the sun, as observed by an astronomer :

Planets	Time period ( $x$ )	Average distance ( $y$ )
$P_1$	4	8
$P_2$	5	2.32
$P_3$	6	2.62

Guess a relation from the data and write it in mathematical form and also name the law.

$$1+1=2$$

(b) The work done by a force in moving a particle from initial position to the final position in a forced field is zero. What would be the type of path and the name of the path?

$$1+1=2$$

- (c) Explain in brief the concept of 'scattering cross-section'. 2
- (d) Why is there no overflow of a liquid from a capillary tube of insufficient length when one end of it is dipped into the liquid? 2
- (e) What is 'degrees of freedom' of a mechanical system? 2
- (f) If the bending moment of a beam is  $\frac{Y}{R}ak^2$ , show that for a beam of rectangular cross-section it is  $\frac{Ybd^3}{12R}$ , where the symbols have their usual meaning. 2
- (g) Explain the fact in brief that during cyclone the air mass rotates in anti-clockwise direction in the northern hemisphere and is in clockwise direction in the southern hemisphere. 2
- (h) In what way the vibration of an electrically maintained tuning fork differs from an ordinary tuning fork? Write in brief. 2
- (i) Give one example of each of the following, that you always experience in your day-to-day life : 2
- (i) Resonance
  - (ii) Doppler's effect

3. (a) What do you mean by a two-body problem? Give one example of it. Reduce it into a one-body problem. Define reduced mass. What will be the reduced mass of a two-body system, comprising masses  $m_1$  and  $m_2$ , where  $m_1 \gg m_2$ ?

$$1+1+5+1+1=9$$

- (b) (i) Write Kepler's law of equal areas. Draw a neat diagram representing the law and mark there the positions of 'perihelion' and 'aphelion'.

$$1+1+\frac{1}{2}+\frac{1}{2}=3$$

- (ii) If the area swept out by a radius vector  $\vec{r}$  in time  $dt$  is represented by  $dA = \frac{1}{2} r (rd\theta)$ , show that the areal velocity of a planet of mass  $m$  and angular momentum  $L$  is constant. 3

- (iii) Find the force if the potential  $V = \frac{1}{2} kr^2$  and the potential if the

$$\text{force } \vec{F} = \frac{k}{r^3} \vec{r}.$$

$$1\frac{1}{2}+1\frac{1}{2}=3$$

4. (a) (i) Explain in brief why moment of inertia (MI) of a circular disc about a diameter differs from the MI of the same disc but about a tangent. 2

- (ii) Derive an expression for MI of a solid cylinder about an axis passing through its centre and perpendicular to its own axis of cylindrical

symmetry. Also find MI of the same cylinder about a diameter of one of its faces.

4+1=5

(iii) A thin ring has diameter 0.6 m and mass 1 kg. It rolls down an inclined plane from rest. If its linear velocity, when it touches the ground is 5 m/s, calculate its kinetic energy of rotation at that instant.

2

(b) (i) Consider a unit cube. Three pairs of forces  $(T_x, T_x)$ ,  $(T_y, T_y)$  and  $(T_z, T_z)$  respectively are acting perpendicularly to its three opposite faces. If  $\alpha$  and  $\beta$  be the extension per unit length per unit tension and contraction per unit length per unit tension, calculate the increase in volume of the cube.

4

(ii) If in the expression, derived in the above question no. (b) (i), pressure  $P$  is applied instead of tension  $T$ , show that bulk modulus

$$K = \frac{1}{3(\alpha - 2\beta)}$$

2

(iii) If the modulus of rigidity  $n = \frac{1}{2(\alpha + \beta)}$ ,

relate  $Y$ ,  $K$  and  $n$  by the relation

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

3

5. Discuss the molecular theory of surface tension. Why does a liquid surface tend to occupy minimum surface area?

3+1=4

6. What do you mean by virtual work? Establish the Lagrange's equation of motion for a conservative system using D'Alembert's principle. 2+7=9

Or

State Hamilton's principle and use it to prove that the shortest distance between two points in space is a straight line. 9

7. Write what you know about the following : 2½+2½=5

- (a) Deviation of freely falling bodies from the vertical  
 (b) Foucault pendulum

8. What is Doppler effect? Is this effect applicable to light? Find out the change in frequency in any two of the situations represented pictorially below : 1+1+(3½×2)=9

(a) 

(b) 

(c) 

Or

Explain—

- (a) whether a wave differ from an oscillation;  
 (b) why sound cannot travel through vacuum;  
 (c) a situation where Doppler effect becomes ineffective. 3×3=9