1 SEM TDC PHY M 1

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(November)

PHYSICS

(Major)

Course : 101

(Mechanics and Properties of Matter)

Full Marks : 80

Pass Marks : 32

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. Choose the correct option from the following : $1 \times 8 = 8$

   (a) A straight line in a freely falling lift appears to be a

   (i) curve bending upward

   (ii) curve bending downward

   (iii) straight line

(**2**)

(b) If

$$F = -\mu\left[\frac{d^2r}{dt^2} - r\left(\frac{d\theta}{dt}\right)^2\right]$$

the reduced mass will be

(i) μ

(ii) $\mu\frac{d^2r}{dt^2}$

(iii) $\mu r\left(\frac{d\theta}{dt}\right)^2$

(c) A central force gives rise to

(i) infinite torque

(ii) no torque

(iii) None of the above

(d) The physical quantity which is conserved in perfectly elastic as well as perfectly inelastic collision is

(i) momentum

(ii) potential energy

(iii) kinetic energy

(e) Which of the following materials does not possess rigidity modulus?

(i) Solid

(ii) Liquid

(iii) Gas

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(*Continued*)

(f) Excess pressure inside a liquid drop

   (i) is an inherent property of liquid like surface tension

   (ii) occurs due to atmospheric pressure

   (iii) occurs due to surface tension

(g) If a system comprising N particles there are k equations of constraints, the number of degrees of freedom is reduced to

   (i) $\frac{3N}{k}$

   (ii) $k - 3N$

   (iii) $3N - k$

(h) If generalized coordinate has the dimension of momentum, the generalized velocity will have the dimension of

   (i) velocity

   (ii) acceleration

   (iii) force

   (iv) torque

2. (a) Rewrite the Lorentz transformation equations from the following Galilean transformation equations :

   (i) $x' = x - vt$ (ii) $y' = y$

   (iii) $z' = z$ (iv) $t' = t$

                    (*Turn Over*)

How fast should a rocketship more relative to an observer in order that one year on it may correspond to two years on the earth?

$(\frac{1}{2}\times4)+2=4$

(b) Define gravitational field intensity and gravitational potential. What is gravitational potential energy? What does the negative sign before the expression of gravitational potential mean?

$1\times4=4$

Or

Find F, if $V = \frac{1}{2}kr^2$ and find V, if $\vec{F} = \frac{k}{r^3}\vec{r}$.

$2+2=4$

(c) State and prove the theorem of parallel axis.

$1+3=4$

Or

Calculate the moment of inertia of a solid cylinder about an axis passing through its centre and perpendicular to its length. (Draw a neat diagram.)

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(d) Define the terms (i) virtual displacement, (ii) virtual work and (iii) constraints. Write the mathematical form of the principle of virtual work.

$1\times4=4$

3. (a) What do you mean by centre of mass of a system of particles? Show that, if no external force acts on the system, the velocity of the centre of mass remains constant. $1+8=9$

(b) (i) Write the expression for angular momentum $\vec{J}$. Show that the rate of change of $\vec{J}$ is the torque acting on a particle. $1+4=5$

(ii) What do you mean by a two-body problem? Give one example of it. Define reduced mass (μ). Write the expression for μ for a two-body system of masses m_1 and m_2, where $m_1 \gg m_2$. $2+1+1+1=5$

4. State Kepler's laws of planetary motion. Prove any one of the laws by drawing a neat diagram. $1\frac{1}{2}+\frac{1}{2}+2=4$

5. (a) Define bulk modulus (K) and Young's modulus (Y). Show that

$$K = \frac{Y}{3(1-2\sigma)}$$

where σ is the Poisson ratio. $2+5=7$

Or

Define Poisson ratio (σ) and modulus of rigidity (η). Show that the limiting values of σ are -1 and $+0 \cdot 5$. If

$$\eta = \frac{1}{2(\alpha + \beta)}$$

where α and β have their usual meanings, show that

$$\frac{9}{Y} = \frac{3}{\eta} + \frac{1}{K} \qquad\qquad 1+1+2+3=7$$

(b) What do you understand by surface tension? Show that the rise of liquid is inversely proportional to the radius of the capillary tube. What happens if the tube is of insufficient length? $2+4+1=7$

6. *(a)* For a simple pendulum, the Lagrangian is given by $L = \frac{1}{2}ml^2\dot{\theta}^2 - mgl(1-\cos\theta)$ subject to constraint $r = l$. Find the time period of the pendulum using the method of undetermined multipliers.   9

Or

What do you mean by Hamiltonian H? Give its physical significance. Calculate H for a simple pendulum. $2+2+5=9$

(*Continued*)

(b) Write short notes on any *four* of the following : 2½×4=10

(i) Coriolis force

(ii) Foucault's pendulum

(iii) Deviation of freely falling bodies

(iv) Generalized coordinates

(v) Simple harmonic oscillator

(vi) Fictitious force

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