PAR/CCM-63/13

2014

# PHYSICS

## FIRST PAPER

*Full Marks* : 200

*Time* : 3 hours

*The figures in the margin indicate full marks
for the questions*

Answer **all** questions

### GROUP—A

1. (a) Define angular momentum and torque. Establish the fundamental equations of rotational motion. 2+3=5

   (b) Show that the principle of conservation of linear momentum is invariant under Galilean transformation. 5

   (c) Define moment of inertia of a body about an axis. Establish the parallel axes theorem for a 3-D body. Evaluate the moment of inertia of a uniform circular disc about a diameter. 1+5+4=10

14T—200/137

*Or*

Define the radius of gyration of a body about an axis. The moment of inertia of a uniform lamina of mass $M$ and radius $a$ about an axis through its centre and perpendicular to its plane is $\frac{1}{2}Ma^2$. Calculate the moment of inertia of the circular lamina about a tangent parallel to any diameter of the lamina. Find the new length of a day if the radius of the earth is reduced to half of its present value without any change in its mass.　　10

2. *(a)* Find the equation of motion and time period for a particle executing SHM. Show that a system executing SHM is a self-conservative system.　　3+2+5=10

*Or*

Define Young's modulus, bulk modulus and modulus of rigidity. If $Y$, $K$ and $\eta$ represent these moduli respectively, prove the relation

$$Y = \frac{9\eta K}{(3K + \eta)}$$　　3+7=10

*(b)* In what way is a compound pendulum better than a simple pendulum for determining $g$ at a place? Give the theory and method for the accurate determination of $g$ using Kater's pendulum.　　3+7=10

　　( *Continued* )

3. (a) Define escape velocity. Find the expression for the escape velocity of a body projected from the surface of the earth. Show that the escape velocity from the surface of the earth is $\sqrt{2}$ times the velocity of projection of an artificial satellite orbiting close around the earth. 2+6+2=10

(b) State Hooke's law. A wire is stretched by a load applied along the length of the wire. Show that the work done per unit volume is

$$\frac{1}{2} \text{ load} \times \text{elongation}$$

Two wires of same radius and material have their lengths in the ratio 1 : 2. If these are stretched by the same force, find the ratio of the strain produced in the two wires. 1+5+4=10

4. (a) Define neutral axis and bending moment for a beam loaded at its free end. Obtain an expression for the depression of the loaded end for a cantilever (neglect the weight of the cantilever). 2+2+6=10

(b) According to Poiseuille, the rate of flow of liquid through a capillary is given by

$$Q = \frac{\pi P r^4}{8 \eta l}$$

where the symbols have their usual meanings. Deduce this relation stating the condition under which it holds. 10

*Or*

Explain the molecular origin of surface tension. Describe the relation between surface tension and surface energy.

3+7=10

5. (a) What is diffusion? Describe the principle, construction and working of a diffusion pump.

2+8=10

(b) Show that the excess pressure in case of bubble in air is $p = \frac{4T}{r}$, where $T$ is the surface tension of the material of the bubble and $r$ is the radius of the bubble. If two soap bubbles of radii $r_1$ and $r_2$ $(r_2 > r_1)$ are in contact, find the radius of their common interface. 5+5=10

*Or*

Describe the experimental arrangement for determining the rigidity modulus $\eta$ using a torsional pendulum. 5+5=10

*( Continued )*

GROUP—B

6. (a) What is spherical aberration? Can this be minimized in case of two thin lenses of same medium when placed at a distance apart from each other? 4+6=10

Or

Give the theory of interference of light. 10

(b) Derive the van der Waals' equation of state for real gases. Mention some of the defects of this equation. 7+3=10

7. (a) Give the construction and theory of Huygens eyepiece and show that it is free from spherical aberration. 10

(b) Describe Fresnel's biprism method for the determination of wavelength of light. 10

8. (a) State the basic postulates of kinetic theory of gases. Show how this theory explains Avogadro's hypothesis. 6+4=10

Or

What is Brownian motion? How can it be explained on the basis of kinetic theory? 3+7=10

(b) What do you understand by Joule-Thomson effect? Deduce the expression for Joule-Thomson cooling. 4+6=10

9. (a) What is a heat engine? Prove Carnot's theorem. 2+8=10

*Or*

Which particles do obey Fermi-Dirac statistics? Derive the distribution law according to Fermi-Dirac statistics. 1+9=10

(b) Explain Planck's hypothesis of quantum theory of radiation. Obtain Planck's radiation formula. 3+7=10

10. Write short notes on any *two* of the following : 10×2=20

(a) Solar energy and its applications

(b) Newton's rings arrangement

(c) Gibbs phase rule

(d) Liquefaction of gases

(e) Ramsden eyepiece

★ ★ ★