2017
PHYSICS
PAPER : CC-2
MECHANICS

Full Marks : 60 **Time : 3 Hours**

The figures in the margin indicate full marks for the questions

1. Choose the correct answer from the given alternative: 1×5=5

(a) Michelson-Morley experimentwas conducted -

(i) To find the velocity of light in ether

(ii) To detect the relative motion between the earth and ether

(iii) To prove the transverse nature of light

(iv) To find the density of ether

(b) A capillary tube of length 'L' and radius 'r' is joined to another capillary tube of length L/4 and radius r/2 A liquid flows through this series combination. If the pressure difference between the ends of the first tube is P, that between the ends of the second tube is

(i) P (ii) 4P (iii) 8P (iv) 16P

(c) The relation between modulus of elasticity (Y), modulus of rigidity (η) and bulk modulus (B) is given as

(i) $Y = 9B\eta/(B + 3\eta)$ (ii) $Y = 3B\eta/(3B + \eta)$

(iii) $Y = 3B\eta/(9B + \eta)$ (iv) $Y = 9B\eta/(3B + \eta)$

(d) The physical quantity which is the cause of rotational motion is

(i) Torque (ii) Angular momentum

(iii) Moment of inertia (iv) All of the above

(e) Newton's laws of motion are not valid in

(i) Cartesian frame of reference

(ii) Inertial frame of reference

(iii) Non-inertial frame of reference

(iv) Absolute frame of reference

2. Answer the following: **2×5=10**

(a) Mention the factors on which the rate of flow of a liquid through a capillary tube depends.

(b) Show that the total relativistic energy of a particle is given by

$$E = c\sqrt{p^2 + m_0^2 c^2}\ .$$

(c) A wire of 2 mm diameter and length 2 m is twisted through 90°. If the modulus of rigidity is 5×10^{11} dynes/cm^2, what is the torsional couple?

(d) A satellite travels around a planet at maximum and minimum distances 2×10^7 m and 10^7 m respectively. If the speed of satellite at the farthest point be 2×10^3 m/sec, calculate the speed of satellite at the nearest point.

(e) Write down the equation of motion of a body of variable mass. Give one example of motion of a variable mass. 1+1

3. Answer any *five* questions: **5×5=25**

(a) Write down the equation of motion of the particle of mass m subjected to a restoring force proportional to the displacement and a resisting force proportional to its velocity. Obtain the condition for amplitude resonance in a forced vibration. 2+3

(b) What is meant by Galilean invariance? Show that the law of conservation of momentum is invariant to Galilean Transformation. 1+4

(c) What are laboratory and centre of mass frames of reference? Draw labelled diagrams showing the collision process as seen by the observers in the laboratory and centre of mass system. 2+3

(d) Two waves are represented by $y_1 = 5\sin(\omega t + \pi/2)$ and $y_2 = 5\cos \omega t$, then what is the phase difference between the waves? Show that the mean kinetic energy and potential energy of non-dissipative S.H.M. are equal. 1+4

(e) Show that for a system of particles, the total external torque is equal to the rate of change of angular momentum.

(f) Show that the effect of centrifugal force due to rotation of earth on the acceleration due to gravity is maximum at the equator.

(g) Show that the force acting on a particle of mass m confined to move in a plane such that $\vec{r} = A\sin\omega t\ \hat{i} + B\cos\omega t\ \hat{j}$ is conservative. Also, find the expressions for its potential energy. 3+2

4. Answer any *two* questions: **10×2=20**

(a) Calculate the moment of inertia of a solid cylinder of mass M, length *l* and radius R about an axis passing through its centre and perpendicular to its own axis of symmetry. Given a solid sphere and a hollow sphere of the same diameter and mass, describe a non-destructive experiment to determine which is solid and which is hollow? 7+3

(b) Reduce a two body problem to one body problem and obtain the equation of motion for the equivalent one body problem for two masses. Obtain the expression for gravitational potential at a point outside a thin spherical shell. 5+5

(c) State the basic postulates of Einstein's special theory of relativity. Obtain an expression for relativistic transformation of velocities and hence show that in no case the resultant velocity of a material particle be greater than c. An unstable particle has the mean proper lifetime of 2 μs. What will be its lifetime when it is travelling with a speed of 0.9 c. 2+5+1+2

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