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3 (Sem- 1/CBCS) PHY HC 2

2020

(Held in 2021)

PHYSICS

(Honours)

Paper : PHY-HC-1026

(Mechanics)

Full Marks : 60

Time : Three hours

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

1. Choose the correct option of **any seven** of the following: $1 \times 7 = 7$

(a) A rocket is based on the principle of conservation of :

(i) Linear momentum

(ii) Angular momentum

(iii) Energy

(iv) Mass

Contd.

(b) The displacement of a particle is represented by the equation $y = A\sin\omega t + B\cos\omega t$. The motion of particle is :

- (i) Simple harmonic motion with amplitude A
- (ii) Oscillatory but not simple harmonic
- (iii) Simple harmonic motion with amplitude $A + B$
- (iv) Simple harmonic motion with amplitude $\sqrt{A^2 + B^2}$

(c) Which one of the following is not a unit of Young's modulus ?

- (i) Nm^{-1}
- (ii) Nm^{-2}
- (iii) *dyne cm⁻²*
- (iv) *megapascal*

(d) If the moment of inertia of a solid sphere of mass M and radius R about its diameter is $\frac{2}{5}MR^2$, its moment of inertia about a tangent is given by :

- (i) $\frac{5}{7}MR^2$
- (ii) $\frac{2}{3}MR^2$
- (iii) $\frac{7}{5}MR^2$
- (iv) $\frac{3}{5}MR^2$

(e) Which of the following relation between gravitational force \vec{F} and potential V is correct ?

(i) $\vec{F} = -grad V$

(ii) $\vec{F} = -div V$

(iii) $\vec{F} = -curl V$

(iv) $\vec{F} = -\int V dx$

(f) Mathematical formulation $E = pc$ applies for :

(i) Electron

(ii) Photon

(iii) A massless particle moving fast

(iv) A particle moving with speed of light

(g) A particle is at rest in a rotating frame. The pseudo force acting on the particle in the rotating frame is :

(i) Zero

(ii) Only the centrifugal force

(iii) Only the coriolis force

(iv) The combination of both centrifugal and coriolis force

- (h) The velocity profile of a liquid flowing in a capillary tube of uniform cross-section is :
- (i) Circular
 - (ii) Elliptical
 - (iii) Parabolic
 - (iv) Hyperbolic

2. Answer **any four** of the following : $2 \times 4 = 8$

- (a) A loop of mass 2 kg and radius 20 cm rolls along the ground at the rate of 10 ms^{-1} . Calculate its kinetic energy.
- (b) In one-dimensional motion of a mass of 10 gm , it is acted by a restoring force of 10 dyne cm^{-1} , and a resisting force of magnitude $2 \text{ dynes-sec cm}^{-1}$. Find the value of resisting force which will make the motion critically damped.
- (c) At what velocity will a $10,000 \text{ kg}$ truck have the same momentum as a 4000 kg car at 30 ms^{-1} ?
- (d) In case of a damped harmonic oscillator, calculate the time in which its amplitude falls to e^{-1} of its undamped value.
(Given, $k = \frac{1}{2\tau} = 0.02$).

- (e) Find out whether the following force is conservative or not.

$$\vec{F} = (2xy + z^2) \hat{i} + x^2 \hat{j} + 2xz \hat{k}$$

3. Answer **any three** of the following :

- (a) Prove that in a conservative field force is negative gradient of potential. 5
- (b) What is Coriolis force ? Obtain an expression for the horizontal displacement of an object falling freely under the action of gravity in latitude ϕ . 1+4=5
- (c) Define centre of mass in terms of linear momentum of a system. Show that Newton's second law of motion remains invariant under Galilean transformation. 1+4=5
- (d) What is a central force ? Prove that the path of a particle under a central force lie in a plane. 1+4=5
- (e) What do you mean by laboratory frame of reference ? Show that, in the center-of-mass frame of reference, the magnitude of the velocities of the particles remain unaltered in an elastic collision. 1+4=5

4. Answer **any three** of the following :

(a) What are transient and steady states of a forced harmonic oscillator ? Establish the differential equation for a forced harmonic oscillator and find its steady state solution. $3+3+4=10$

(b) Find the moment of inertia of a rectangular plate with sides 'a' and 'b' about a side. Derive an expression for the acceleration of a body rolling down an inclined plane. $5+5=10$

(c) Obtain an expression for gravitational potential at a point outside a hollow spherical shell. Draw a diagram to represent the variation of gravitational potential of a spherical shell against distance (r) from its centre. The radius of the earth is $6.37 \times 10^8 \text{ cm}$, its mean density, 5.5 gm cm^{-3} and the gravitational constant, 6.66×10^{-8} CGS units. Calculate the earth's surface potential. $5+2+3=10$

(d) A uniform beam is clamped at one end and loaded at the other. Obtain the relation between the load and depression at the loaded end when the weight of the beam can be neglected. Young's modulus of a substance is equal to $7 \times 10^{11} \text{ dynes cm}^{-2}$, and the rigidity modulus for the same substance is equal to $3 \times 10^{11} \text{ dynes cm}^{-2}$. Calculate the bulk modulus of elasticity and Poisson's ratio for the substance. 6+4=10

(e) On the basis of Lorentz transformation, discuss (i) length contraction and (ii) simultaneity of two events. How fast a spacecraft need to travel relative to the earth for each day on the spacecraft to correspond to two days on the earth? 3+3+4=10
