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Class: 11
Subject: Physics
No. of Questions: 27 (OASK1511SA101)
Duration : 3 hours
Maximum Marks = 100

Q1. A substance weighing 5.74 g occupies a volume of 1.2 cm^3. Calculate its density with due regard to significant digits

Sol. $\rho = \frac{M}{V} = \frac{5.74}{1.2} = 4.78\frac{g}{cc}$ = rounded off to have two significant digits.

Q2. Explain that a body can have zero average velocity but not zero average speed.

Sol. Average velocity = displacement / (total time taken)

and average speed = total distance travelled /(total time taken) . If an object completes a circular path of radius r in time t, then its displacement is zero but distance travelled by body is 2π r. Therefore, the average of body = zero but average speed of body = 2πr /t.

Q3. Is the acceleration of a car greater when the accelerator is pushed to the floor or when brake pedal is pushed hard?

Sol. Acceleration of a car is greater when brake pedal is pushed hard, because car suddenly comes to rest, i.e.,, the rate of change of velocity of car is large.

Q4. A bucket of water is rotated in a vertical circle so that the surface of water is at a distance r from the axis of rotation. What is the minimum angular velocity so that the water does not spill out?

Sol. i.e. , r ω^2 = mg ; $\omega = \sqrt{g/r}$

Q5. Can a body have energy without momentum?

Sol. yes, when P = 0, K = $\frac{p^2}{2m} = 0$

Q6. Is torque a scalar or vector? If it is a vector, what rule is used to determine its direction?

Sol. Torque is a vector quantity. $\vec{\tau} = \vec{r} \times \vec{F}$. Its direction is determined by right handed screw rule or right hand thumb rule and is perpendicular to $\vec{r}$ and $\vec{F}$.

Q7. What is moment of inertia of a solid sphere about its diameter?

Sol. $I = \frac{2}{5}MR^2$, where M is the mass and R is of the hollow sphere.

Q8. Is $\hat{i} - \hat{j}$ a unit vector? Explain.

Sol. $(\hat{i} - \hat{j})$ is not a unit vector. If $\vec{R} = \hat{i} - \hat{j}$, then R = $\sqrt{(1)^2 + (-1)^2} = \sqrt{2}$ and angle ß which $\vec{R}$ makes with X – axis, is given by , cosß = $1/\sqrt{2}$ = 45° or ß = 45° below the x-axis.

Q9. What are the two angles of projection of a projectile projected with velocity 30 m/s, so that the horizontal range is 45 m. Take, g = 10 m/s^2

Sol. Horizontal range = 45 = $\frac{u^2 \sin 2\theta}{g} = \frac{30^2 \sin 2\theta}{10}$

$$\sin 2\theta = \frac{45\times10}{30\times30} = \frac{1}{2} = \sin 30^\circ \quad \text{or} \sin 150^\circ$$

$$2\,\theta = 30^\circ \quad \text{or} \quad 150^\circ \quad \text{or} \quad \theta = 15^\circ \quad \text{or} \quad 75^\circ$$

Q10. A man can swim with a speed of 4 km/h in still water. How long does he take to cross a river 1 km wide if the river flows steadily at 3 km/h and he makes his strokes normal to the river current ? How far down the river does he go when he reaches the other bank?

Sol. Time to cross the river, t = $\frac{\text{width of river}}{\text{speed of man}} = \frac{1\text{ km}}{4\text{ km/h}} = \frac{1}{4}\text{ h} = 15\text{ min}$

Distance moved along the river in time t = $u_r \times t = 3\text{ km /h} \times \frac{1}{4} = 750\text{ m}$

Q11. A lift is accelerated upward. Will the apparent weight of a person inside the lift increase, decrease or remain the same relative to its real weight? If the lift is going with uniform speed, then?

Sol. The apparent weight will increase. If the lift is going with uniform speed, the apparent weight will remain the same as the real weight.

Q12. A light body and a heavy body have same linear momentum. Which one has greater K.E.?

Sol. Here, $P_1 = P_2$, i.e., $m_1 v_1 = m_2 v_2$ $\quad \therefore \frac{v_2}{v_1} = \frac{m_1}{m_2}$

As $E_2 = \frac{1}{2} m_2 v_2^2$ and $E_1 = \frac{1}{2} m_1 v_1^2$ $\quad \therefore \frac{E_2}{E_1} = \frac{\frac{1}{2} m_2 v_2^2}{\frac{1}{2} m_1 v_1^2} = \frac{m_2}{m_1}\left(\frac{v_2}{v_1}\right)^2$

Using (i), $\frac{E_2}{E_1} = \frac{m_2}{m_1} . \left(\frac{m_1}{m_2}\right)^2 = \frac{m_1}{m_2}$

If $m_1 < m_2, E_2 < E_1$ or $E_1 > E_2$, i.e., lighter body has more K.E.

Q13. The driver of a truck travelling with a velocity v suddenly notices a brick wall in front of him at a distance d. It is better for him to apply brakes or to make a circular turn without applying brakes in order to just avoid crashing into the wall? Why?

Sol. In applying brakes, suppose F_B is the force required to stop the truck in distance (d)

$$\therefore \quad F_B \times d = \frac{1}{2} mv^2 \quad \text{or} \quad F_B = \frac{mv^2}{2d}$$

In taking a turn of radius d, the force required is

$$F_T = \frac{mv^2}{d} = 2F_B \quad \text{or} \quad F_B = \frac{1}{2} F_T$$

Hence, it is better to apply brakes.

Q14. A force of 5 N changes the velocity of a body from 10 ms^{-1} to 20 ms^{-1} in 5 sec. How much force is required to bring about the same change in 2 sec?

Sol. From $F_1 = \frac{dp}{dt_1}$ and $F_2 = \frac{dp}{dt_2}$

$$\frac{F_2}{F_1} = \frac{dt_1}{dt_2} \; ; \; F_2 = F_1 \times \frac{dt_1}{dt_2} = \frac{5 \times 5}{2} = 12.5 \text{ N}$$

Q15. A new unit of length is chosen such that the speed of light in vacuum is unity. What is the distance between the sun and the earth in terms of the new unit, if light takes 8 min and 20 sec. to cover the distance?

Sol. We are given that velocity of light in vacuum, c = 1 new unit of length s^{-1}. Time taken by light of sun to reach the earth, t = 8 min 20 s = 8 × 60 + 20 = 500 s.

∴ Distance between the sun and earth

$x = c \times t = 1$ New unit of length

Q16. Two particles are moving with constant speed v such that they are always at a constant distance d apart and their velocities are always equal and opposite. After what time, they return to their initial positions?

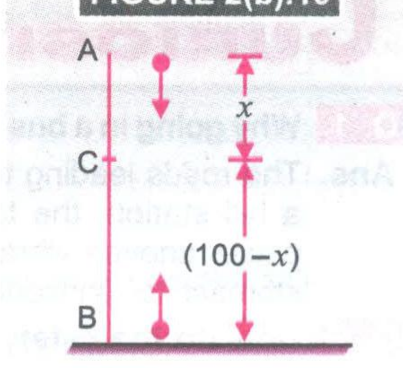
Sol. Since, the particles while moving constant speed v, are always at a constant distance d, they must be at the tow ends of the diameter of a circular path. The diameter of this circular path = d. Each particle will return to its initial position after describing a circular path = 2 π r = π d

(∵ 2r = d). Time interval after which each particle will return to its initial position = distance travelled /speed = π d /v

Q17. From the top of a tower 100 m in height a ball is dropped and at the same time another ball is projected vertically upwards from the ground with a velocity of 25 ms^{-1}. Find when and where the two balls will meet. ($g = 9.8\ ms^{-2}$)

Sol. Let A be the top of a tower and B be its foot. Let the two balls meet at C after time t. Let, AC = x, then BC = 100 – x,

FIGURE 2(b).10



Taking vertically downward motion of the ball dropped from the top,

We have $u = 0, a = 9.8\ ms^{-2}, S = x, t = t$

As , $S = ut + \frac{1}{2}at^2$

$\therefore \quad x = 0 + \frac{1}{2} \times 9.8 \times t^2 = 4.9\ t^2$ ...(i)

Taking vertically upward motion of the ball thrown up from B, we have

$u = 25\ ms^{-1}, a = -9.8\ ms^{-2}, S = (100 - x)$, t = t

As, $S = ut + \frac{1}{2}\ at^2 \quad \therefore \quad 100 - x = 25\ t + \frac{1}{2}\ (-9.8)t^2 = 25\ t - 4.9\ t^2$ ...(ii)

Adding (i) and (ii) we have, 100 = 25t or t =4s

Q18. Rain is falling vertically with a speed of 35 ms^{-1}.Winds starts blowing after sometimes with a speed of 12ms^{-1} in East to West direction. In which direction should a boy waiting at a bus stop hold his umbrella?

Sol. Refer Fig. 2(c). 45, $\vec{v}_w = (\vec{OB})$ = 12 ms^{-1}, along West. $\vec{V}_r = (\vec{OA})$ = 35 ms^{-1}, along vertically downward.

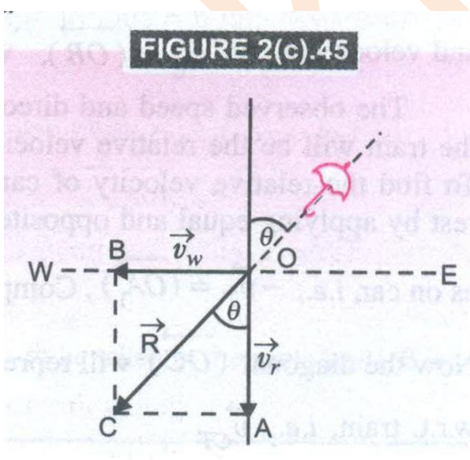


FIGURE 2(c).45

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The boy can protect himself from the rain if he holds his umbrella in the direction of resultant velocity $\vec{R}$, i.e., along the direction OC as shown in Fig. 2 (c). 45. If θ is the angle which $\vec{R}$ makes with the vertical direction, then

$$\tan\theta = \frac{v_w}{v_r} = \frac{12}{35} = 0.3429 = \tan 18° \, 56'$$

∴ $\theta = 18° \, 56'$ With vertical towards East.

Q19. A ball is projected with velocity u at an angle α with horizontal plane. What is its speed when it makes angle ß with horizontal plane?

Sol. Let v be the velocity of ball at an instant, when it makes an angle ß with the horizontal. The horizontal component velocity of the ball = v cos ß.

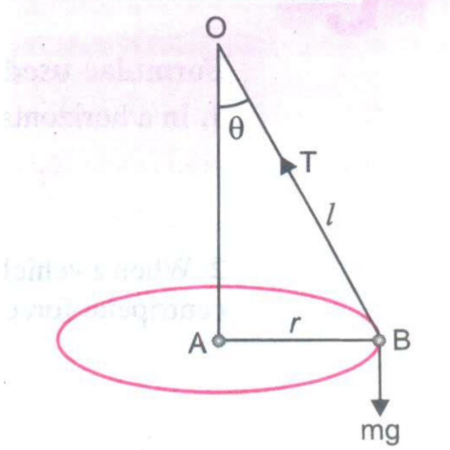
Initial horizontal component velocity of ball = u cos α

In angular projection of a projectile, the horizontal component velocity remains unchanged, hence v cos ß = u cos α or , v = u cos α / cos ß

Q20. A sphere of mass 200 g is attached to an inextensible string of length 130 cm whose upper end is fixed to the ceiling. The sphere is made to describe a horizontal circle of radius 50 cm. Calculate the periodic time of this conical pendulum and the tension in the string.

Sol. Refer to Fig. 3(b) .33,

FIGURE 3(b).33



Here, m = 200g; OB = l = 130 cm;

$OA = \sqrt{l^2 - r^2} \qquad = \sqrt{(130)^2 - (50)^2} \ = 120$ cm.

As is clear from Fig. 3(b). 33,

$T\cos\theta = \ mg$ ..(i)

$T\sin\theta = \frac{mv^2}{r} \ = mr\omega^2$ ...(ii)

Dividing, we get $\tan\theta = \frac{mr\omega^2}{mg} = \frac{r\omega^2}{g}$

$\omega = \sqrt{\frac{g\tan\theta}{r}} \ = \frac{2\pi}{t}$

$t = 2\pi\sqrt{\frac{r}{g\tan\theta}} \ = 2 \times \frac{22}{7}\sqrt{\frac{0.5}{9.8\times5/12}}$ = 2.19 s

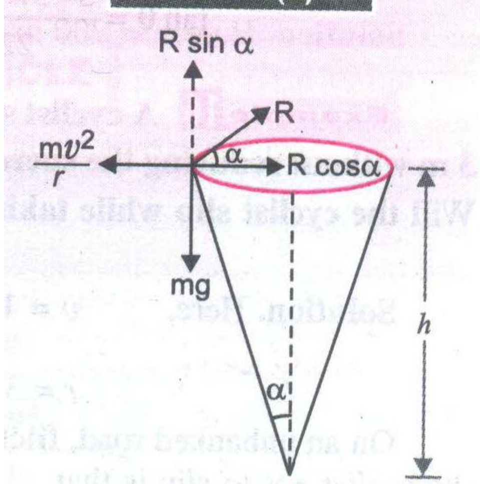
From (i), $T = \frac{mg}{\cos\theta} = \frac{200}{1000} \times \frac{9.8}{12/13} = 2.12$ N

Q21. A particle describes a horizontal circle on the smooth surface of an inverted cone. The height of the plane of the circle above the vertex is 9.8 cm. Find the speed of the particle. Take g = 9.8 m/s^2.

Sol. Here, h = 9.8, v =?

As is clear from Fig. 3(b). 34,

FIGURE 3(b).34



R cos α = $\frac{mv^2}{r}$

$R \sin\alpha = mg$

Dividing, we get,

Tan α = $\frac{rg}{v^2}$ or $\frac{r}{h} = \frac{rg}{v^2}$

$$v = \sqrt{gh} = \sqrt{9.8 \times \frac{9.8}{100}} = 0.98 \text{ m/s}$$

Q22. Why has horse a pull a cart harder during the first few steps of his motion?

Sol. During the first few steps of his motion, the horse has to pull a cart harder, because the horse has to work against the limiting friction, whereas once the motion starts, the horse has to work against the dynamic friction which is less than the limiting friction.

Q23. In a nuclear reactor, a neutron of high speed ($\approx 10^7$ ms^{-1}) must be slowed down to 10^3 ms^{-1} so that it can have a high probability of interacting with isotope ${}_{92}U^{235}$ and causing it to fission. Show that a neutron can lose most of its K.E. in an elastic collision with a light nucleli like deuterium or carbon which has a mass of only a few times the neutron mass. The material making up the light nuclei heavy water (D_2O) of graphite is called a moderator.

Sol. Initial K.E. of neutron is $K_1 = \frac{1}{2} m_1 u_1^2$

Velocity of neutron after collision with deuterium, $v_1 = \frac{(m_1 - m_2)u_1}{m_1 + m_2}$

Final K.E. of neutron is $K_2 = \frac{1}{2} m_1 v_1^2 = \frac{1}{2} m_1 \left(\frac{m_1 - m_2}{m_1 + m_2}\right)^2 u_1^2$

∴ Fractional K.E. retained by neutron is $f_1 = \frac{K_2}{K_1} = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)^2$

For deuterium, $m_2 = 2m_1$ ∴ $f_1 = \frac{1}{9}$, Fractional K.E. lost by neutron $f_2 = 1 - f_1 = 1 - \frac{1}{9} = \frac{8}{9}$

$\approx 90\%$

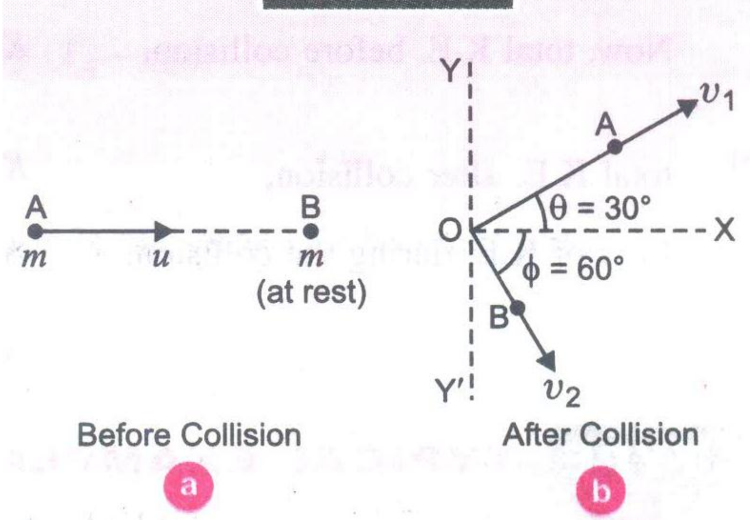
This is the frictional K.E. gained by moderating nuclei.

Therefore, almost 90% of neutrons energy is transferred to deuterium. Similarly, in case of carbon, we can show that $f_1 = 28.4\ \%$ and $f_2 = 71.6\%$

Q24. A and B are two particles having the same mass m. A is moving along X – axis with a speed of 10 ms^{-1} is at rest. After undergoing a perfectly elastic collision with B, particle A gets scattered through an angle of 30°. What is the direction of motion B, and the speeds of A and B, after the collusion?

Sol. Fig. 4.41(a) shows the particles A and B before collision; and Fig. 4.41 (b) shows the two particles after perfectly elastic collision in two dimensions

FIGURE 4.41



Here, u = 10 ms^{-1}, θ = 30°, $\phi = ?$

v_1 =? v_2 =?

As is known from Art. 4.24, special case

$\theta + \phi = 90° \ \therefore\ \phi = 90° - \theta = 90° - 30° = 60°$

Using law of conservation of linear momentum along X-axis, Q25. The identical cylinders 'run a race' starting from rest at the top of an inclined plane, one slide without rolling and other rolls without slipping. Assuming that no mechanical energy is dissipated in heat, which one will win?

Sol. When a cylinder slides without rolling, E = $\frac{1}{2}$ mv'^2 , $v'^2 = \sqrt{2E/m}$

When the cylinder rolls without slipping

$$E = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 = \frac{1}{2}mv^2 + \frac{1}{2}\left(\frac{1}{2}mr^2\right)\omega^2 = \frac{1}{2}mv^2 + \frac{1}{4}mv^2 = \frac{3}{4}mv^2$$

$$\therefore \quad v = \sqrt{\frac{4E}{3m}}$$

As v' > v, therefore sliding cylinder will the race.

Q26. Can a satellite coast in a stable orbit in a plane not passing through the earth's centre? Explain your answer.

Sol. NO, in case of satellite motion centripetal force is provided by gravitation between the earth and the satellite. If earth is not at the centre of the orbit. If the plane of the orbit is not passing through the centre of earth, the gravitational force F will not directed towards the centre of the orbit O' and hence the orbit will not be stable. The component of gravitational force perpendicular to the plane of orbit will pull the satellite till its plane passes through the centre of the earth.

Q27. An object weight 10 N at the north – pole of the earth. In a geostationary satellite distant 7R from the centre of earth (of radius R) what will be its (a) true weight. (b) Apparent weight.

Sol. (a) The true weight of a body is given by mg and with height 'g' decrease;

$$So, \frac{W_S}{W_E} = \frac{mg\prime}{mg} = \frac{1}{\left[1+\left(\frac{h}{R}\right)\right]^2} \qquad \left[as\ g' = \frac{g}{\left[1+\left(\frac{h}{R}\right)\right]^2}\right]$$

But here h = 7R – R = 6R, i.e., $\frac{h}{R} = 6$

$$So, \quad W_s = \frac{W_E}{(1+6)^2}$$

$$= \frac{10}{49} \simeq 0.2\ N$$

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(b) If g' is the acceleration due to gravity of earth at the position of satellite, the apparent weight of a body in the satellite will be

$W_{app} = m(g' - a)$

But as satellite is a freely falling body,

i.e., g' = a

So, $W_{app} = 0$