KEA

PHYSICS

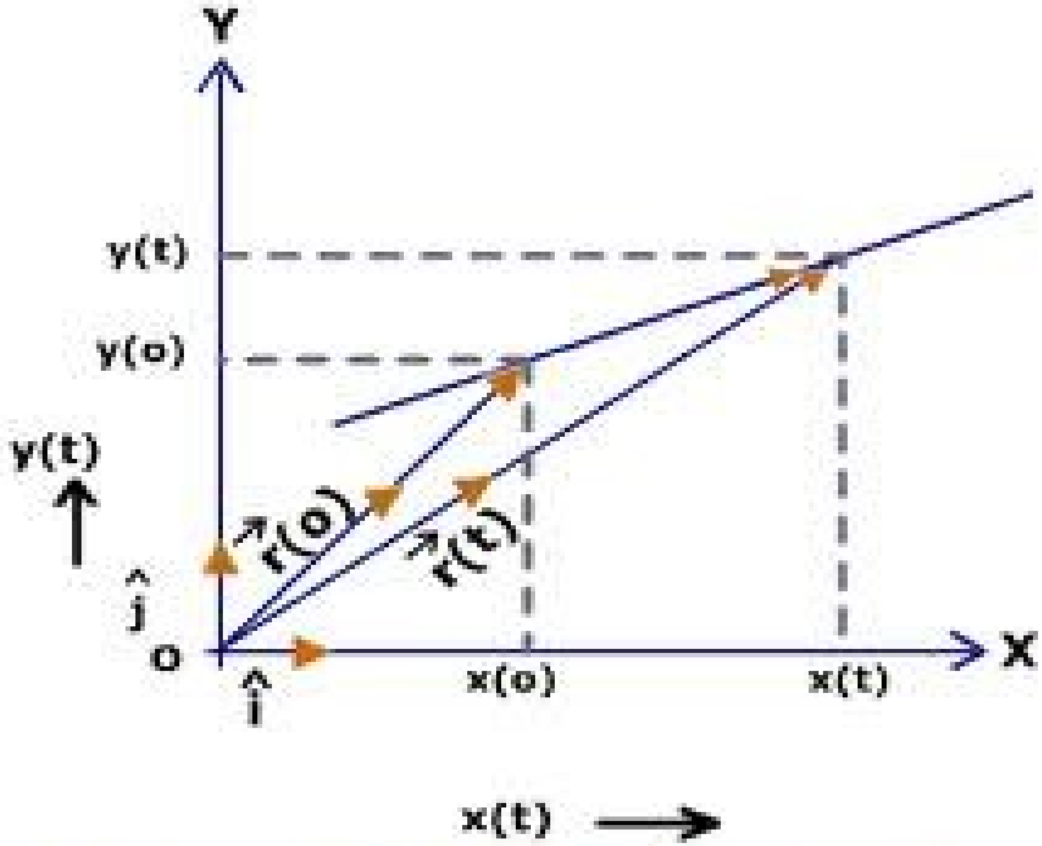
CET-2013

MODEL QUESTIONS

TOPICS

1. MOTION IN TWO DIMENSIONS
2. ROTATIONAL MOTION
3. WORK,POWER,ENERGY AND COLLISION
4. GRAVITATION

MOTION IN TWO DIMENSION



Uniform motion in two dimensions

POSITION,VELOCITY AND ACCELERATION

$$\vec{r}(t) = x(t) \cdot \hat{i} + y(t) \cdot \hat{j}$$

$$\vec{v}(t) = \frac{d\vec{r}(t)}{dt} = \frac{dx(t)}{dt}\hat{i} + \frac{dy(t)}{dt}\hat{j} = v_x \cdot \hat{i} + v_y \cdot \hat{j}$$

$$\vec{a}(t) = \frac{d\vec{v}(t)}{dt} = \frac{dv_x}{dt}\hat{i} + \frac{dv_y}{dt}\hat{j} = a_x \cdot \hat{i} + a_y \cdot \hat{j}$$

EXAMPLE

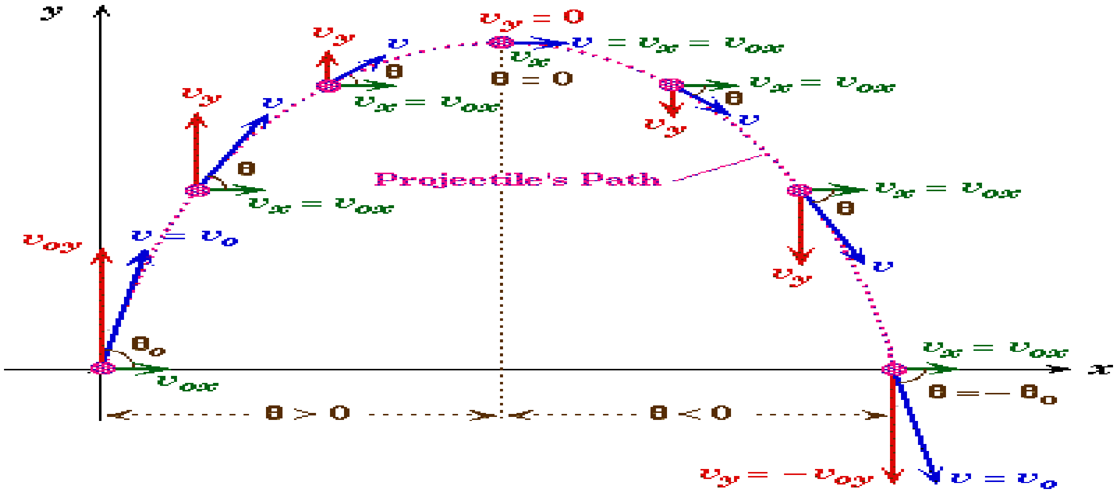
CONSIDER A BODY DESCRIBING TWO DIMENSIONAL MOTION GIVEN BY

$$x(t) = 2t \text{ and } y(t) = -4t^2$$

WHERE X AND Y ARE IN m. AND TIME t IN SECOND. THE VELOCITY AND ACCELERATION ARE GIVEN BY

$$v_x = 2ms^{-1} \text{ and } v_y = -8t\ ms^{-1}; \quad a_x = 0 \text{ and } a_y = -8\ ms^{-2}$$

PROJECTILE MOTION



$$x = x_0 + v_0 \cos\theta_0 \cdot t \quad \text{and} \quad y = y_0 + v_0 \sin\theta_0 \cdot t - \frac{1}{2} g t^2$$

$$v_x = v_0 \cos\theta_0 = \text{constant} \quad \text{and} \quad v_y = v_0 \sin\theta_0 - gt$$

$$a_x = 0 \quad \text{and} \quad a_y = -g$$

IN PARTICULAR, IF $(X_0, Y_0)=(0,0)$. THEN EQN. OF TRAJECTORY, TIME OF FLIGHT, MAX. HEIGHT AND RANGE ARE GIVEN BY

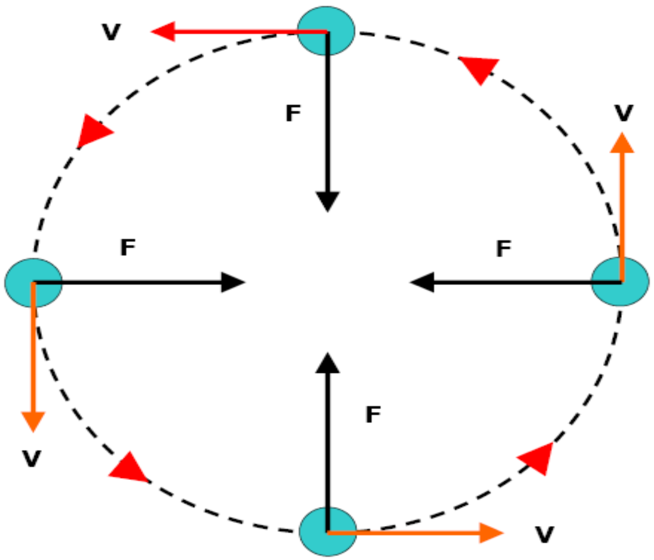
$$y = ax - bx^2 \quad \text{where} \quad a = \tan\theta_0 \quad \text{and} \quad b = \frac{g}{2v_0^2\cos^2\theta_0}$$

$$T = \frac{2v_0\sin\theta_0}{g}$$

$$H = \frac{v_0^2\sin^2\theta_0}{2g}$$

$$R = \frac{v_0^2\sin 2\theta_0}{g}$$

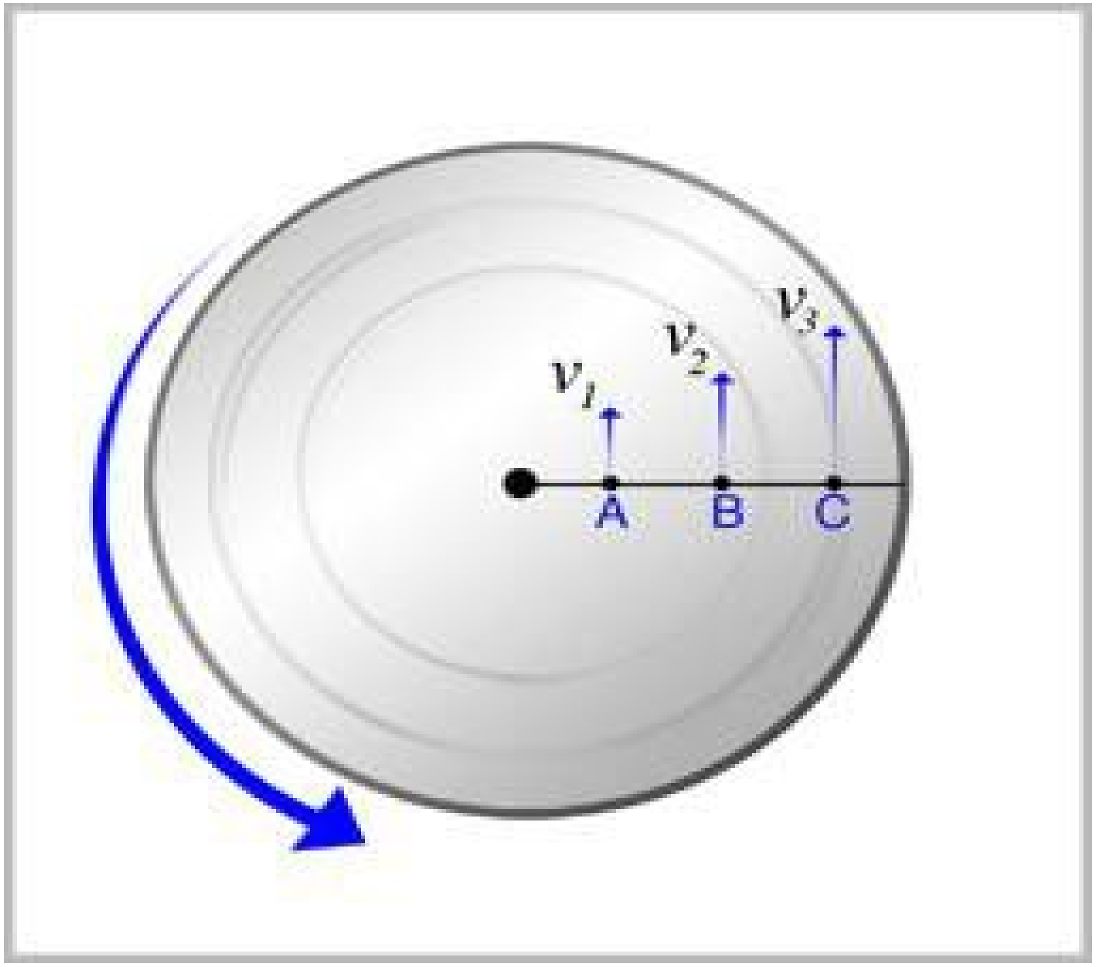
UNIFORM CIRCULAR MOTION



$$a = \frac{v^2}{r} = \omega^2 r = v\omega$$

$$F = m\frac{v^2}{r} = m\omega^2 r = mv\omega$$

ROTATIONAL MOTION



KEA

PHYSICS

LINEAR MOTION	ROTATIONAL MOTION
$d = x_f - x_0$	$\Delta\theta = \theta_f - \theta_0$
$v = \frac{d}{t}$	$\omega = \frac{\Delta\theta}{t}$
$a = \frac{v_f - v_0}{t}$	$\alpha = \frac{\omega_f - \omega_0}{t}$
$v_f = v_0 + at$	$\omega_f = \omega_0 + \alpha t$
$d = \frac{1}{2}(v_f + v_0)t$	$\Delta\theta = \frac{1}{2}(\omega_f + \omega_0)t$
$d = v_0 t + \frac{1}{2}at^2$	$\Delta\theta = \omega_0 t + \frac{1}{2}\alpha t^2$
$v_f^2 = v_0^2 + 2ad$	$\omega_f^2 = \omega_0^2 + 2\alpha\Delta\theta$
$p = mv$	$L = I\omega$
$\sum F = ma$	$\sum \tau = I\alpha$
$KE = \frac{1}{2}mv^2$	$KE_r = \frac{1}{2}I\omega^2$

MOMENT OF INERTIA

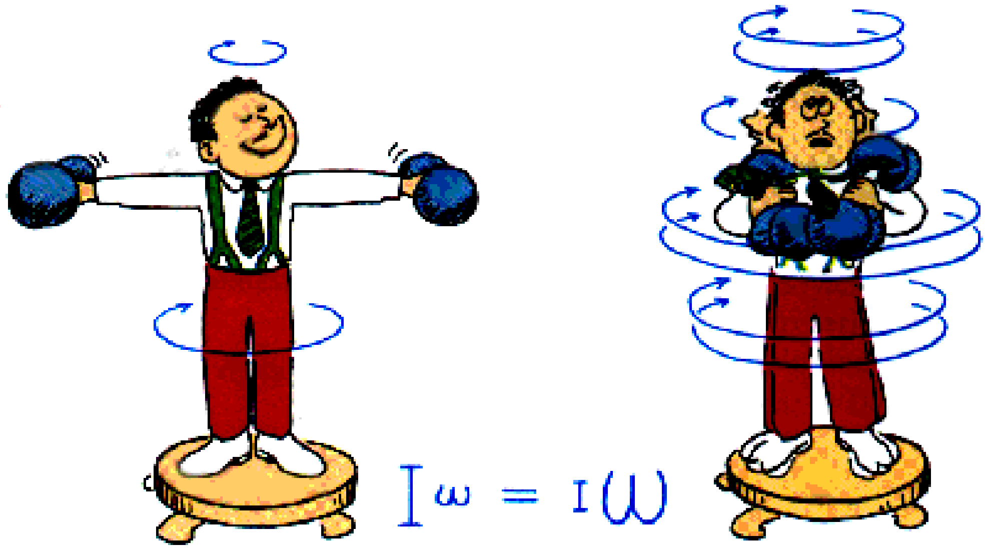
$$I = \sum mr^2 = Mk^2; \quad k^2 = \frac{I}{M} = \frac{\sum mr^2}{M}$$

BODY	AXIS	'k'
Ring	Passing through C.G. and perpendicular to the plane of the ring	R
Circular Disc	Passing through C.G. and perpendicular to the plane of the disc	$\frac{R}{\sqrt{2}}$
Solid cylinder	Passing through C.G. and parallel to the length	$\frac{R}{\sqrt{2}}$
hollow cylinder	Passing through C.G. and perpendicular to the length	R
Solid sphere	Passing through C.G. (centre)	$\sqrt{\frac{2}{5}} \cdot R$
Hollow sphere	Passing through C.G. (centre)	$\sqrt{\frac{2}{3}} \cdot R$

CONSERVATION OF ANGULAR MOMENTUM

In the absence of external torque the total angular momentum of the system remains constant. i.e.,

$$L = I\omega = \text{constant}$$



GRAVITATION

$$F = G \cdot \frac{m_1 m_2}{r^2}$$

$$g = \frac{GM}{R^2}$$

$$g' = \frac{GM}{(R+h)^2} \cong g\left(1 - \frac{2h}{R}\right) \text{ if } h \;\square$$

$$g' = g\left(1 - \frac{h}{R}\right)$$

GRAVITATION

$$V = -\frac{GMm}{r} = -\frac{GMm}{(R+h)}$$

$$v_o = \sqrt{\frac{GM}{r}} \cong \sqrt{gR} \text{ if } h \; \square$$

$$v_e = \sqrt{2gR} \cong 11.2 km \cdot s^{-1} \text{ for earth}$$

1. A particle is initially moving eastward with a velocity of $10ms^{-1}$. In 10s, it's velocity changes to $10ms^{-1}$ northwards. the average acceleration of the particle in this time interval is

1) zero
2) $1ms^{-1}$ towards north
3) $\sqrt{2}ms^{-1}$ towards north – west
4.) $\sqrt{2}ms^{-1}$ towards north – east

SOLUTION

$$\left(\text{east} \rightarrow \hat{i}, \text{west} \rightarrow -\hat{i}\ \text{north} \rightarrow \hat{j}\ \text{south} \rightarrow -\hat{j}\right)$$

$$\vec{V}_i = 10i; \quad \vec{V}_f = 10j$$

$$\vec{a} = \frac{\vec{V}_f - \vec{V}_i}{t} = \frac{\left(10\hat{j} - 10\hat{i}\right)}{10} = \hat{j} - \hat{i}$$

$$|\vec{a}| = \sqrt{1^2 + 1^2} = \sqrt{2}\,\text{ms}^{-2}\ \text{towards north} - \text{west}$$

2. A small body is projected from the origin of a coordinate system at an angle of projection 60^0 . The ratio of horizontal range to maximum height is

1) $\sqrt{3}$ 2) $4\sqrt{3}$ 3) $\frac{4\sqrt{3}}{3}$ 4) $\frac{1}{\sqrt{3}}$

SOLUTION

$$R = \frac{u^2 \sin 2\theta}{g}; \quad H = \frac{u^2 \sin^2 \theta}{2g}$$

$$\therefore \frac{R}{H} = \frac{\sin 2\theta}{\sin^2 \theta} \cdot 2 = 2 \cdot \frac{2 \sin\theta \cos\theta}{\sin^2 \theta} = 4 \cdot \frac{\cos\theta}{\sin\theta} = 4 \cdot \frac{1/2}{\sqrt{3}/2} = \frac{4\sqrt{3}}{3}$$

Option – 3)

3) A bullet is fired from the origin of a coordinate system at an angle of projection 30^0 . The height of the bullet after 20s is same as that at time10s. The velocity of the projection is

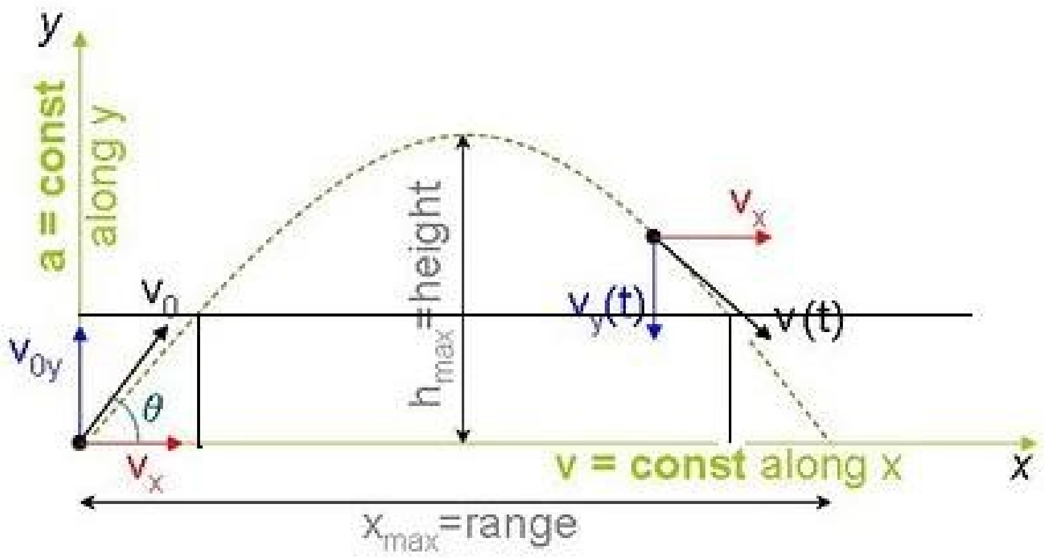
(take $g=10ms^{-2}$)

1) $200ms^{-1}$

2) $400ms^{-1}$

3) $300ms^{-1}$

4)$600ms^{-1}$



If t_1 and t_2 are the time corresponding to the same vertical displacement then the time of flight

$T=t_1+t_2=10+20=30s$

SOLUTION

$$T = \frac{2u\sin\theta}{g}$$

$$\Rightarrow u = \frac{gT}{2\sin\theta}$$

$$= \frac{10 \times 30}{2 \times \sin 30} = 300\,ms^{-1}$$

PHYSICS

4) A PARTICLE IS PROJECTED AT 60 TO THE HORIZONTAL WITH KE ‘K’. THE KE AT THE HIGHEST POINT IS

1) K

2) ZERO

3) K / 2

4) K / 4

SOLUTION

$$(KE)_{origin} = \frac{1}{2}mu^2 = K$$

$$(KE)_{peak} = \frac{1}{2}m(u\cos 60)^2 = \frac{1}{2}m\left(\frac{u}{2}\right)^2 = \frac{K}{4}$$

OPTION-4)

5) A body is tied to a string of length 1m. and whirled in a vertical circle with a constant velocity $5ms^{-1}$. The ratio of maximum to minimum tension in the string is

(take $g=10ms^{-2}$)

1) 7:3 2) 2:1 3) 3:1 4) 5:4

SOLUTION

AT THE LOWEST POINT THE DOWNWARD FORCE DUE TO WEIGHT AND THE CENTRIFUGAL FORCE ACTS ALONG THE SAME DIRECTION SO THAT THE TENSION IS MAXIMUM. AT THE HIGHEST POINT, DOWNWARD FORCE DUE TO WEIGHT AND THE CENTRIFUGAL FORCE ACTS ALONG THE OPPOSITE DIRECTIONS SO THAT TENSION IS MINIMUM.

SOLUTION

$$T_{max} = \frac{mv^2}{g} + mg$$

$$T_{min} = \frac{mv^2}{g} - mg$$

$$\frac{T_{max}}{T_{min}} = \frac{\frac{mv^2}{g} + mg}{\frac{mv^2}{g} - mg} = \frac{\frac{v^2}{g} + g}{\frac{v^2}{g} - g} = \frac{25+10}{25-10} = \frac{7}{3}$$

$$option - 1)$$

6) A CIRCULAR RING AND A CIRCULA DISC BOTH ARE OF SAME MASS AND RADIUS ROTATING BOUT THE AXES PASSING THROUGH THEIR C.G. PERPENDICULAR TO THE PLANE WITH SAME ANGULAR VELOCITY. THEN

1) BOTH HAVE SAME ANGULAR MOMENTUM
2) RING HAS GREATER ANGULAR MOMENTUM THAN THE DISC
3) DISC HAS GREATER ANGULAR MOMENTUM THAN THE RING
4) BOTH HAVE SAME KINETIC ENERGY

7) A SOLID SPHERE OF RADIUS 0.1m AND MASS 5kg IS SPINNING ABOUT THE AXIS PASSING THROUGH IT'S CENTRE WITH AN ANGULAR VELOCITY 100RAD/SEC. THE MINIMUM CONSTANT TANGENTIAL FORCE REQUIRED TO STOP THE SPINNING IN 10SEC IS

1) 10N 2)5N 3)1N 4)2N

SOLUTION

$$\text{torque } \tau = I\alpha = I\left(\frac{\omega_i - \omega_f}{t}\right)$$

$$\text{torque due tangential force } F = F \cdot R$$

$$\therefore F \cdot R = I\left(\frac{\omega_i - \omega_f}{t}\right) = Mk^2 \cdot \left(\frac{100 - 0}{10}\right)$$

$$\text{for sphere } k^2 = \frac{2}{5}R^2.\text{ Substituting}$$

$$\text{and simplifying we get } F = 2N$$

OPTION-4)

8) A CIRCULAR DISC OF MASS M AND RADIUS R IS ROTATING WITH ANGULAR VELOCITY ω ABOUT THE AXIS PASSING THROUGH THE CENTRE AND PERPENDICULAR TO THE PLANE. A SMALL BODY OF MASS m IS GENTLY PLACED AT THE RIM OF THE DISC. THE ANGULAR VELOCITY CHANGES TO

1) $M\omega/(M+m)$
2) $m\omega/(M+m)$
3) $M\omega/(M+2m)$
4) $m\omega/(M+2m)$

SOLUTION

$$I\omega = I'\omega'$$

$$\Rightarrow \frac{MR^2}{2}\omega = \left(\frac{MR^2}{2}\omega + mR^2\right)\omega'$$

$$\Rightarrow \omega' = \frac{M}{M+2m}\omega$$

OPTION-3)

9) A BODY OF MASS 'M' IS SUSPENDED BY AN INEXTENSIBLE STRING OF LENGTH 5m. IF THE BODY IS PULLED ASIDE THROUGH AN ANGLE 60^0 WITH THE VERTICAL AND THEN RELEASED, THE VELOCITY OF THE BODY AT THE TIME IT CROSSES THE MEAN POSITION IS ($g=9.8ms^{-2}$)

1) $1ms^{-1}$ 2) $0.7ms^{-1}$ 3) $1.28ms^{-1}$ 4) $7ms^{-1}$

SOLUTION

Increase in KE = decrease in PE

$$\frac{1}{2}mv^2 = mgl(1-\cos\theta)$$

$$\Rightarrow v = \sqrt{2gl(1-\cos\theta)} = \sqrt{2\times 9.8\times 5\left(1-\frac{1}{2}\right)} = 7ms^{-1}$$

Option-4)

10) A bullet fired into a fixed target loses half of its velocity after penetrating 3 cm. How much further it will penetrate before coming to rest assuming that it faces constant resistance to motion?

(1) 3.0 cm **(2) 2.0 cm**

(3) 1.5 cm **(4) 1.0 cm**

SOLUTION

$$\text{work done} = \text{decrease in KE}$$

$$\Rightarrow F \cdot S = \frac{1}{2}mu^2 - \frac{1}{2}m\left(\frac{u}{2}\right)^2 = \frac{3}{4}(KE)_{initial}$$

$$F \cdot (S + X) = (KE)_{initial}$$

$$\frac{F \cdot (S + X)}{F \cdot S} = \frac{(KE)_{initial}}{\frac{3}{4}(KE)_{initial}} = \frac{4}{3} \Rightarrow X = 1cm$$

OPTION-4)

11) IDENTICAL BRICKS EACH OF MASS 5kg AND THICKNESS 0.2m LYING ON A HORIZONTAL FLOOR. AMOUNT OF WORK DONE IN PLACING THEM ONE ABOVE THE OTHER IS

1) 441 J 2) 980 J 3) 196 J 4) 490 J

SOLUTION

$$\left(PE\right)_{initial} = 10mg \cdot \frac{h}{2} = 49J$$

$$\left(PE\right)_{final} = 10mg \cdot \frac{H}{2} = 490J \left(\because \qquad \imath\right)$$

$$\text{work done} = \left(PE\right)_{final} - \left(PE\right)_{initial} = 441J$$

OPTION-1)

12) A body of mass M kg is suspended by a weightless string. The horizontal force that is required to displace it until the string make an angle of 45^0 with the initial vertical direction is

1) $Mg\left(\sqrt{2}-1\right)$

3) $Mg\cdot\sqrt{2}$

2) $Mg\left(\sqrt{2}+1\right)$

4) $Mg/\sqrt{2}$

SOLUTION

work done = increase in PE

$$\Rightarrow Fl\sin\theta = Mgl(1-\cos\theta)$$

$$F = \frac{Mg(1-\cos\theta)}{\sin\theta} = Mg\left(\sqrt{2}-1\right)$$

OPTION-1)

13) During an inelastic collision

1) Both linear momentum and kinetic energy are conserved

2) Linear momentum is not conserved but kinetic energy is conserved

3) Neither linear momentum nor kinetic energy are conserved

4) Linear momentum is conserved but kinetic energy is not conserved

Option-4)

14) A body of mass 16kg is initially at rest explodes into fragments of masses 4kg and 12kg. The larger fragment moves with a KE 27J. The KE of the smaller fragment is

1) 9J　　2) 81J　　3) 3J　　4) 243J

SOLUTION

$$m_1 v_1 = m_2 v_2 \Rightarrow 4v_1 = 12v_2 \Rightarrow v_1 = 3v_2$$

$$KE_{small} = \frac{1}{2} m_1 v_1^2 \quad KE_{large} = \frac{1}{2} m_2 v_2^2$$

$$\frac{KE_{small}}{KE_{large}} = \frac{m_1}{m_2} \cdot \left(\frac{v_1}{v_2}\right)^2 = \frac{1}{3} \cdot 3^3 = 3$$

$$\therefore KE_{small} = 3 \cdot KE_{large} = 3 \times 27 = 81J$$

OPTION-2)

15) Out of the following pair, which one does NOT have identical dimensions

(1) angular momentum and Planck's constant

(2) impulse and momentum

(3) moment of inertia and moment of a force

(4) work and torque

OPTION-3)

16) A planet in a distant solar system is 10times more massive than the earth and it's radius is 10times smaller than earth. If v_e is the escape velocity of earth then the escape velocity v'_e of the planet is

1) $0.1v_e$

2) v_e

3) $10v_e$

4) $100v_e$

SOLUTION

$$v'_e = \sqrt{\frac{GM'}{R'}}$$

$$= \sqrt{\frac{G \cdot 10R}{R/10}} = 10 \cdot \sqrt{\frac{GM}{R}} = 10v_e$$

OPTION-3)

17) A bullet of mass 0.05kg moving at $100ms^{-1}$ strikes a block of wood of mass 1.2kg which is suspended by weightless string. If the bullet after striking the block gets embedded inside the block, then to what height the block will rise before it starts falling? (take $g=10ms^{-2}$)

1) 1m 2) 0.8m 3) 1.6m 4) 2m

SOLUTION

$$m_1u_1 + 0 = (m_1 + m_2)v$$

$$\Rightarrow v = \frac{m_1}{(m_1 + m_2)}u_1 = \frac{0.05}{1.25} \times 100 = 4ms^{-1}$$

$$\frac{1}{2}(m_1 + m_2)v^2 = (m_1 + m_2)gh$$

$$\Rightarrow h = \frac{v^2}{2g} = 0.8m$$

OPTION-2)

18) DURING THE REVOLUTION OF A PLANET AROUND THE SUN

1) ONLY THE LINEAR MOMENTUM IS CONSERVED
2) ONLY THE ANGULAR MOMENTUM IS CONSERVED
3) BOTH LINEAR MOMENTUM AND ANGULAR MOMENTUM ARE CONSERVED
4) NEITHER LINEAR MOMENTUM NOR ANGULAR MOMENTUM ARE CONSERVED

19) The change in the value of g at height h above the surface of earth is the same as at a depth d below the surface of earth. When both h and d are much smaller compared to the radius of earth, then which one among the following is correct?

d=h / 2 2) d=3h / 2 3) d=2h 4) d=h

SOLUTION

$$g'_{height} = g\left(1 - \frac{2h}{R}\right)$$

$$g'_{depth} = g\left(1 - \frac{d}{R}\right)$$

$$g'_{height} = g'_{depth} \Rightarrow 1 - \frac{2h}{R} = 1 - \frac{d}{R} \Rightarrow d = 2h$$

OPTION-3)

20) A satellite is put into the orbit at a height h very small compared to radius of the earth. If satellite is released with a tangential velocity v_e / 2 then which one among the following statement is correct?

1) Satellite will fall to earth describing a parabolic trajectory.

2) Satellite escape from earth describing a parabolic trajectory.

3) Satellite will describe circular trajectory around earth.

4) Satellite will describe an elliptical trajectory around earth.

SOLUTION

orbital velocty of a satelite in circular orbit

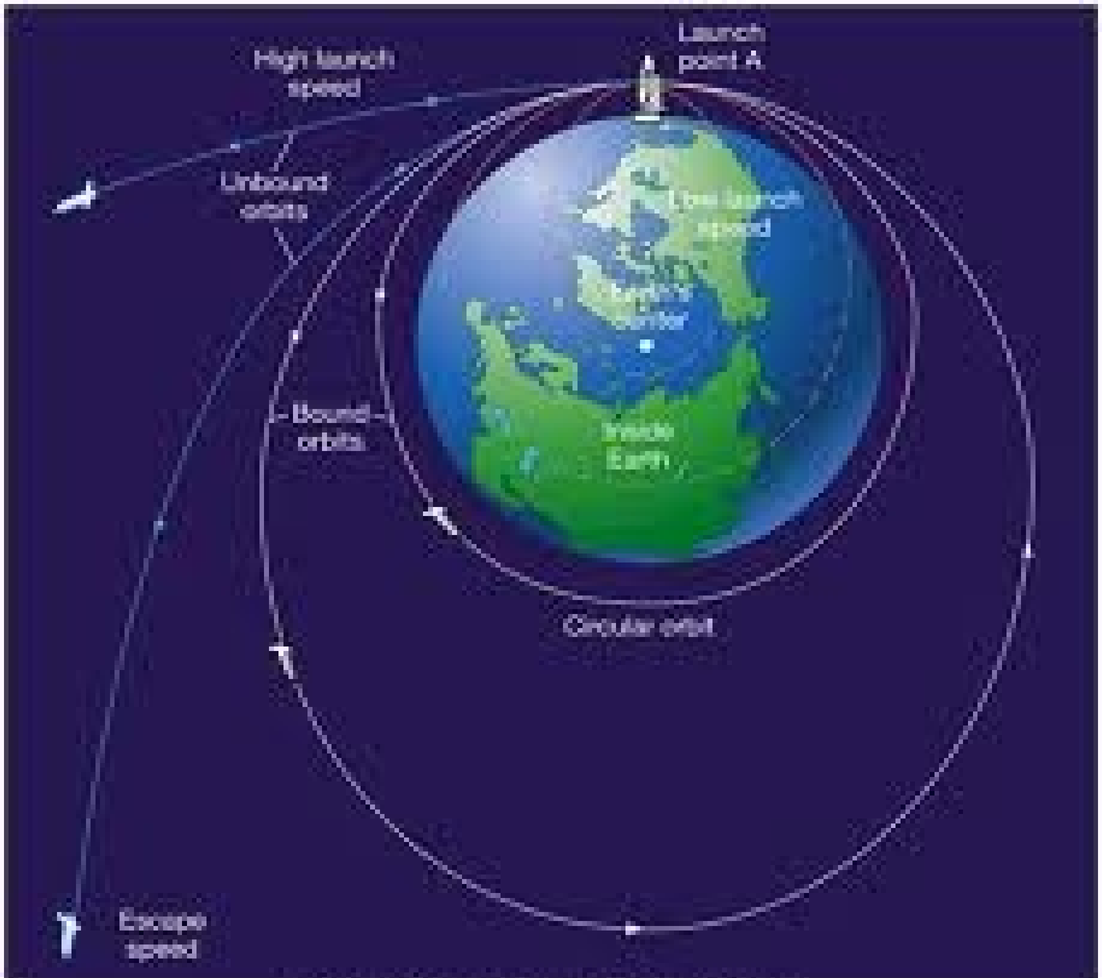
$$v_0 = \sqrt{\frac{GM}{R+h}} = \sqrt{gR} = \frac{v_e}{\sqrt{2}} \text{ if } h \text{ □}$$

$$\text{if } v_0 \langle \frac{v_e}{\sqrt{2}} \text{ fall to earth}$$

$$\text{if } v_e \rangle\, v_0 \rangle \frac{v_e}{\sqrt{2}} \text{ elliptical path}$$

PHYSICS

ORBITS OF A SATELLITE



21) TWO BODIES OF MASSES M AND 4M ARE SEPARATED BY A DISTANCE R. THE DISTANCE OF THE POINT FROM THE SMALLER BODY OF MASS M AT WHICH THE NET GRAVITATIONAL FIELD IS ZERO IS

1) r / 2 2) 2r / 3 3) r / 3 4) r / 4

OPTION-3)

22) IF TWO PLANETS IN A SOLAR SYSTEM HAVE THEIR TIME PERIODS OF REVOLUTION IN THE RATIO 1:8, THEN THEIR MEAN DISTANCES FROM THE SUN ARE IN THE RATIO

1)1:2 2) 1:4 3) 1:8 4) 1:16

OPTION-2)

23) A BODY IS THROWN HORIZONTALLY WITH A VELOCITY OF 10M/S FROM THE TOP OF A BUILDING OF HEIGHT19.6M. THE HORIZONTAL DISTANCE FROM THE BUILDING WHERE THE BODY WILL HIT THE GROUND IS

1) 10m 2)15m 3)20m 4) 25m

OPTION-3)

THANK YOU

PHYSICS