Work, Energy and Power

Question1

A spherical body of mass 2 kg starting from rest acquires a kinetic energy of 10000J at the end of 5^{th} second. The force acted on the body is ___N.
[24-Jan-2023 Shift 1]

Solution:

$$\frac{1}{2} \times 2 \times v^2 = 10000$$
$$\Rightarrow v^2 = 10000$$
$$\Rightarrow v = 100 m / s$$
$$\Rightarrow v = at = a \times 5 = 100$$
$$\Rightarrow a = 20 m / s^2$$
$$F = ma = 2 \times 20 = 40N$$

Question2

A body of mass 1 kg begins to move under the action of a time dependent force $\vec{F} = \left(t\hat{i} + 3t^2\hat{j}\right)N$. where $\hat{i}$ and $\hat{j}$ are the unit vectors along x and y axis. The power developed by above force, at the time t = 2s. will be____ W.
[24-Jan-2023 Shift 2]

Answer: 100

Solution:

$$\vec{F} = ti + 3t^2\hat{j}$$
$$\frac{m d\vec{v}}{dt} = t\hat{i} + 3t^2\hat{j}$$
$$m = 1 kg, \int_0^{\vec{v}} dv = \int_0^t t dt\,\hat{i} + \int_0^t 3t^2 dt\,\hat{j}$$

$\vec{v} = \frac{t^2}{2}\hat{i} + t^3\hat{j}$

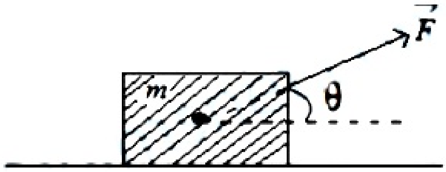
Power $= \vec{F} \cdot \vec{V} = \frac{t^3}{2} + 3t^5$

At $t = 2$, power $= \frac{8}{2} + 3 \times 32$

$= 100$

Question3

An object of mass ' m ' initially at rest on a smooth horizontal plane starts moving under the action of force F = 2N. In the process of its linear motion, the angle θ (as shown in figure) between the direction of force and horizontal varies as θ = kx, where k is a constant and x is the distance covered by the object from its initial position. The expression of kinetic energy of the object will be E = n / ksin θ. The value of n is _______.

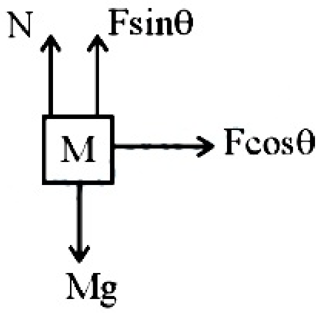


[25-Jan-2023 Shift 1]

Answer: 2

Solution:

Solution:



$F\cos\theta = ma$

$2\cos(kx) = \frac{mvd\,v}{dx}$

$\int_0^v vdv = 2\int_0^x \cos(kx)\,dx$

$\frac{mv^2}{2} = \frac{2}{k}\sin kx$

$K.E. = \frac{2}{k}\sin\theta$

$n = 2$

Question4

A 0.4 kg mass takes 8 s to reach ground when dropped from a certain height ' P ' above surface of earth. The loss of potential energy in the last second of fall is J. [Take $g = 10m / s^2$]
[29-Jan-2023 Shift 1]

Solution:

Solution:
Displacement is 8^{th} sec.
$S_8 = 0 + \frac{1}{2} \times 10 \times (2 \times 8 - 1)$
$S_8 = 5 \times 15$
$\Delta U = 0.4 \times 10 \times 5 \times 15$
$\Delta U = 20 \times 15 = 300$

Question5

Identify the correct statements from the following:
(A) Work done by a man in lifting a bucket out of a well by means of a rope tied to the bucket is negative.
(B) Work done by gravitational force in lifting a bucket out of a well by a rope tied to the bucket is negative.
(C) Work done by friction on a body sliding down an inclined plane is positive.
(D) Work done by an applied force on a body moving on a rough horizontal plane with uniform velocity in zero.
(E) Work done by the air resistance on an oscillating pendulum in negative.
Choose the correct answer from the options given below:
[29-Jan-2023 Shift 2]

Options:

A. B and E only

B. A and C only

C. B, D and E only

D. B and D only

Answer: A

Solution:

Question6

A body of mass 2 kg is initially at rest. It starts moving unidirectionally under the influence of a source of constant power P. Its displacement in 4 s is $\frac{1}{3}\alpha^2\sqrt{P}$m. The value of α will be ______
[30-Jan-2023 Shift 2]

Answer: 4

Solution:

Solution:

$\frac{1}{2}mV^2 = Pt$

$V = \sqrt{\frac{2Pt}{m}}$

$\frac{dx}{dt} = \sqrt{\frac{2Pt}{m}}$

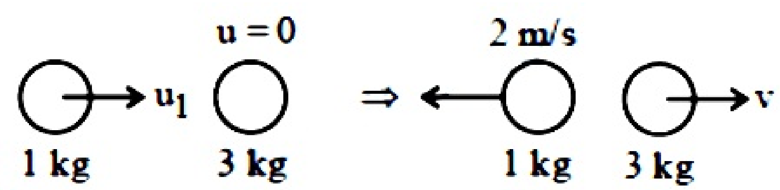
$x = \sqrt{\frac{2P}{m}}\frac{2}{3}[t^{3/2}]_0^4$

$x = \frac{16\sqrt{P}}{3} = \frac{1}{3} \times 16\sqrt{P}$

$\alpha = 4$

Question7

A body of mass 1 kg collides head on elastically with a stationary body of mass 3 kg. After collision, the smaller body reverses its direction of motion and moves with a speed of 2m / s. The initial speed of the smaller body before collision is ______ ms^{-1}.
[25-Jan-2023 Shift 2]



$1 \times u_1 = -2 + 3v \Rightarrow u_1 = -2 + 3v \ldots (1)$

$1 = \frac{v + 2}{u_1} \Rightarrow v + 2 = u_1 \ldots (2)$

Solving (1) and (2)

$u_1 = 4m / s$

Question8

A nucleus disintegrates into two smaller parts, which have their velocities in the ratio 3 : 2. The ratio of their nuclear sizes will be $\left(\frac{x}{3}\right)^{\frac{1}{3}}$. The value of ' x ' is:
[25-Jan-2023 Shift 2]

Solution:

$\frac{v_1}{v_2} = \frac{3}{2}$

$m_1v_1 = m_2v_2 \Rightarrow \frac{m_1}{m_2} = \frac{2}{3}$

Since, Nuclear mass density is constant

$\frac{m_1}{\frac{4}{3}\pi r_1^3} = \frac{m_2}{\frac{4}{3}\pi r_2^3}$

$\left(\frac{r_1}{r_2}\right)^3 = \frac{m_1}{m_2}$

$\frac{r_1}{r_2} = \left(\frac{2}{3}\right)^{\frac{1}{3}}$

So, $x = 2$

Question9

A ball of mass 200g rests on a vertical post of height 20m. A bullet of mass 10g, travelling in horizontal direction, hits the centre of the ball. After collision both travels independently. The ball hits the ground at a distance 30m and the bullet at a distance of 120m from the foot of the post. The value of initial velocity of the bullet will be (if $g = 10m / s^2$) :
[30-Jan-2023 Shift 1]

Options:

A. 120m / s

B. 60m / s

C. 400m / s

D. 360m / s

Answer: D

Solution:

Solution:

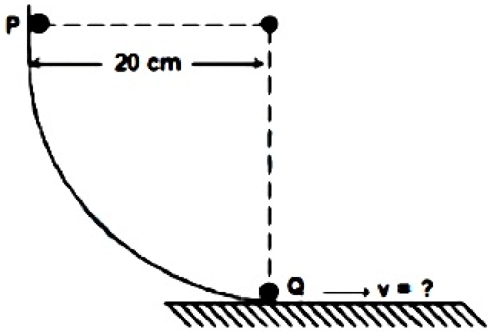
$$v_1 = \frac{30}{\sqrt{\frac{2h}{g}}}, \quad v_2 = \frac{120}{\sqrt{\frac{2h}{g}}}$$

$$(0.01)u = (0.2)\frac{30\sqrt{g}}{\sqrt{2h}} + (0.01)\frac{120\sqrt{g}}{\sqrt{2h}}$$

$$u = 300 + 60 = 360ms^{-1}$$

Question10

As per the given figure, a small ball P slides down the quadrant of a circle and hits the other ball Q of equal mass which is initially at rest. Neglecting the effect of friction and assume the collision to be elastic, the velocity of ball Q after collision will be :($g = 10m / s^2$)



[30-Jan-2023 Shift 1]

Options:

A. 0

B. 0.25m / s

C. 2m / s

D. 4m / s

Answer: C

Solution:

Solution:
The velocities will be interchanged after collision

Question11

A machine gun of mass 10 kg fires 20g bullets at the rate of 180 bullets per minute with a speed of 100m s^{-1} each. The recoil velocity of the gun is :
[30-Jan-2023 Shift 2]

Options:

A. 0.02m / s

B. 2.5m / s

C. 1.5m / s

D. 0.6m / s

Answer: D

Solution:

Solution:

$$20 \times 10^{-3} \times \frac{180}{60} \times 100 = 10V$$

$$\Rightarrow v = 0.6m / s$$

Question12

100 balls each of mass m moving with speed v simultaneously strike a wall normally and reflected back with same speed, in time t s. The total force exerted by the balls on the wall is
[31-Jan-2023 Shift 1]

Options:

A. $\frac{100\ mv}{t}$

B. $\frac{200\ mv}{t}$

C. 200 mvt

D. $\frac{mv}{100t}$

Answer: B

Solution:

Solution:

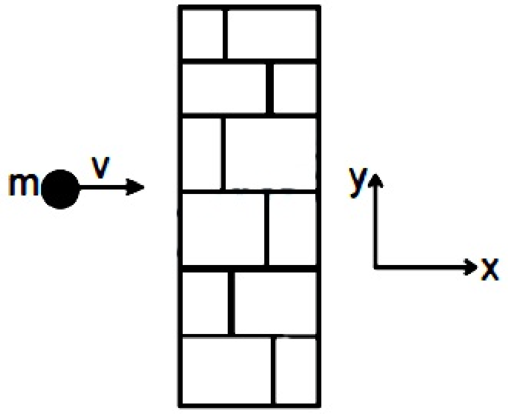
$P_i = Nm \cup \hat{i}$ $\vec{P}_f = -Nmv\hat{i}$

$\Delta\vec{p} = \vec{P}_f - \vec{P}_i = -2\,Nmv\,\hat{i}$

$= -200\,Nm\,\hat{i}$

$\vec{F}_{Total} = \Delta\frac{\vec{P}}{\Delta t} = -\frac{200\ mvt}{t}$

$\left|\vec{F}\right| = \frac{200\ mv}{t}$



Question13

A solid sphere of mass 1 kg rolls without slipping on a plane surface. Its kinetic energy is 7×10^{-3}J. The speed of the centre of mass of the sphere is ______ cm s^{-1}.
[31-Jan-2023 Shift 1]

Solution:

$\frac{1}{2}mv^2 + \frac{1}{2}I^2 = 7 \times 10^{-3}$

$\frac{1}{2}mv^2 + \frac{1}{2}\left(\frac{2}{5}MR^2\right)\left(\frac{V}{R}\right)^2 = 7 \times 10^{-3}$

$\frac{1}{2}MV^2\left[1 + \frac{2}{5}\right] = 7 \times 10^{-3}$

$\frac{1}{2}(1)(V^2)\left(\frac{7}{5}\right) = 7 \times 10^{-3}$

$V^2 = 10^{-2}$

$V = 10^{-1} = 0.1\,m/s = 10\,cm/s$

Ans: 10

Question14

A ball is dropped from a height of 20m. If the coefficient of restitution for the collision between ball and floor is 0.5, after hitting the floor, the

[31-Jan-2023 Shift 2]

Solution:

Solution:
We know, $h' = e^2h$
$h' = (0.5)^2 \times 20m = 5m$

Question15

A small particle moves to position $5\hat{i} - 2\hat{j} + \hat{k}$ from its initial position $2\hat{i} + 3\hat{j} - 4\hat{k}$ under the action of force $5\hat{i} + 2\hat{j} + 7\hat{k}$ N. The value of work done will be ______ J.
[1-Feb-2023 Shift 1]

Answer: 40

$$W = \vec{F} \cdot (\vec{r}_f - \vec{r}_1)$$
$$= (5\hat{i} + 2\hat{j} + 7\hat{k}) \cdot ((5\hat{i} - 2\hat{j} + \hat{k}) - (2\hat{i} + 3\hat{j} - 4\hat{k}))$$
$$W = 40J$$

Question16

A force $F = (5 + 3y^2)$ acts on a particle in the y direction, where F is newton and y is in meter. The work done by the force during a displacement from y = 2m to y = 5m is _______ j.
[1-Feb-2023 Shift 2]

Answer: 132

Solution:

$F = 5 + 3y^2$

$W = \int_2^5 (5 + 3y^2)dy$

$= \left[5y + \frac{3y^3}{3}\right]_2^5$

$= 132J$

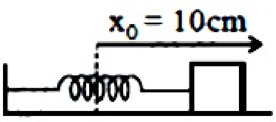
Question17

A block is fastened to a horizontal spring. The block is pulled to a distance x = 10 cm from its equilibrium position (at x = 0) on a frictionless surface from rest. The energy of the block at x = 5 cm is 0.25J. The spring constant of the spring is ______ Nm^{-1}
[1-Feb-2023 Shift 2]

Answer: 67

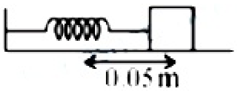
Solution:

Solution:



$U_i = \frac{1}{2}kx_0^2$

$K_i = 0$



$U_f = \frac{1}{2}k\left(\frac{x_0}{2}\right)^2$

$K_f = 0.25J$

$\frac{1}{2}kx_0^2 + 0 = \frac{1}{2}k\frac{x_0^2}{4} + 0.25$

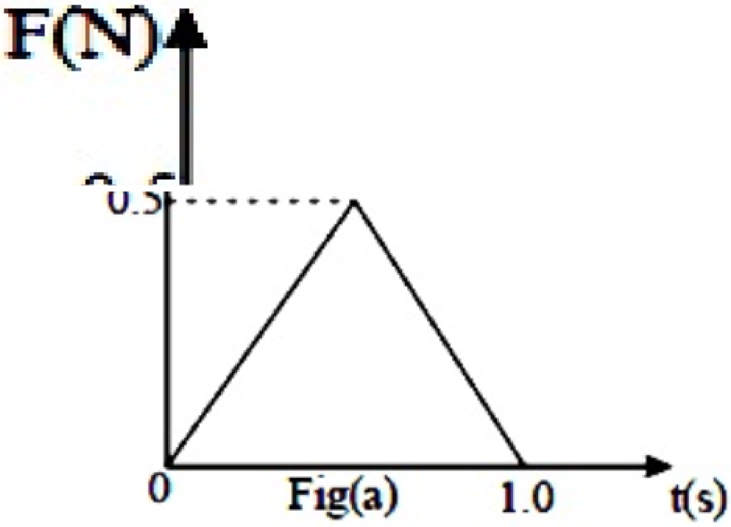
$\frac{1}{2}kx_0^2\frac{3}{4} = \frac{1}{4}$

$\frac{1}{2}k\frac{3}{100} = 1 \Rightarrow k = \frac{200}{3}N/m$

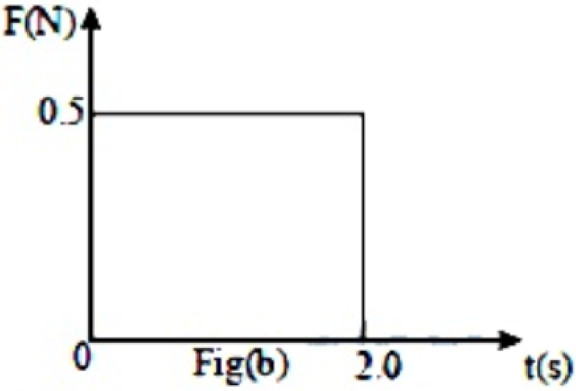
$= 67N/m$

Question18

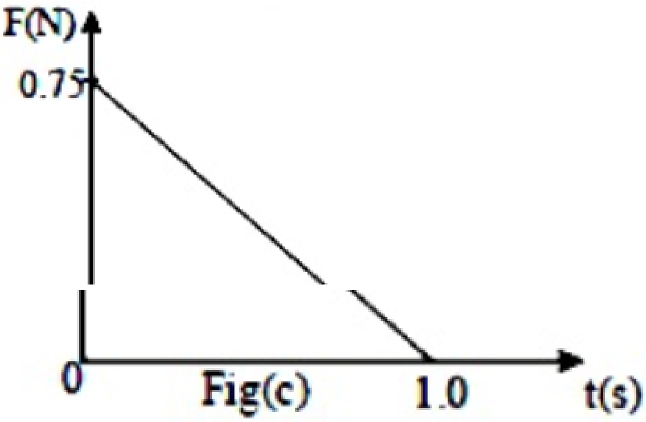
Figures (a), (b), (c) and (d) show variation of force with time.



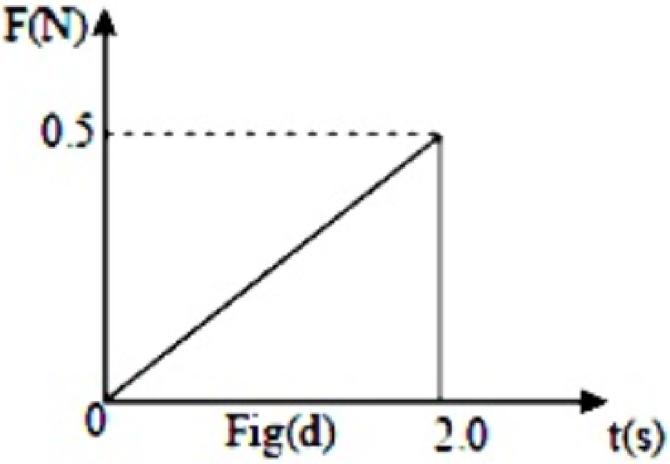
Fig(a)



Fig(b)



Fig(c)



Fig(d)

The impulse is highest in figure.
[1-Feb-2023 Shift 2]

Options:

A. Fig (c)

B. Fig (b)

C. Fig (a)

D. Fig (d)

Answer: B

Solution:

Impulse = Area under F = t curve

(a) $\frac{1}{2} \times 1 \times 0.5 = \frac{1}{4} \mathrm{N.s}$

(b) $0.5 \times 2 = 1$ N.s (maximum)

(c) $\frac{1}{2} \times 1 \times 0.75 = \frac{3}{8} \mathrm{N.s}$

(d) $\frac{1}{2} \times 2 \times 0.5 = \frac{1}{2}$ N.s

Question19

Solution:

Given U $= \frac{1}{2}m\omega^2 r^2$, to find radius r as $f(n)$, where n is orbit

Using Bohr's postulate : angular momentum $L = mvr = \frac{nh}{2\pi}$

or $mr\omega^2 = \frac{nh}{2\pi}$

$\Rightarrow r \propto \sqrt{n}$

Question20

A body is dropped on ground from a height ' h_1 ' and after hitting the ground, it rebounds to a height ' h_2 '. If the ratio of velocities of the body just before and after hitting ground is 4 , then percentage loss in kinetic energy of the body is $\frac{x}{4}$. The value of x is ______.
[6-Apr-2023 shift 2]

Answer: 375

Solution:

Solution:
Let u and v be speeds, just before and after body strikes the ground.
Given $\frac{u}{v} = \frac{4}{1}$

loss in KE : $\Delta KE = \dfrac{\frac{1}{2}mu^2 = \frac{1}{2}mv^2}{\frac{1}{2}mu^2}$

Question21

The momentum of a body is increased by 50%. The percentage increase in the kinetic energy of the body is ______ %.
[8-Apr-2023 shift 1]

Answer: 125

Solution:

$$K_i = \frac{P_i^2}{2m}$$

$$K_f = \frac{\left(P_i + \frac{P_i}{2}\right)^2}{2m} \Rightarrow K_f = \frac{9}{4}\frac{P_i^2}{2m}$$

$$\text{Percentage increase in K.E.} \quad = \frac{K_f - K_i}{K_i} \times 100$$

$$\frac{\frac{9}{4} - 1}{1} \times 100$$

$$= \frac{5}{4} \times 100 = 125\%$$

Question22

A bullet of mass 0.1 kg moving horizontally with speed $400ms^{-1}$ hits a wooden block of mass 3.9 kg kept on a horizontal rough surface. The bullet gets embedded into the block and moves 20m before coming to rest. The coefficient of friction between the block and the surface is (. Given $g = 10m/s^2$)
[8-Apr-2023 shift 2]

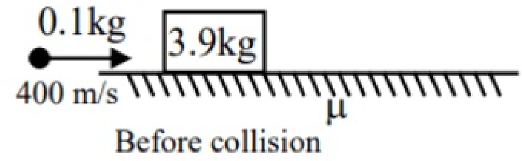
Options:

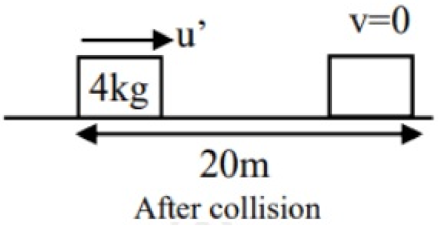
A. 0.90

B. 0.65

C. 0.25

D. 0.50





Apply momentum conservation just before and just after the collision

$0.1 \times 400 = (3.9 + .1)u$

$\Rightarrow u = 10m/s$

$\Delta KE = w_{\text{all FORCE}}$

$\because f = \mu mg$ (kinetic friction)

$\Rightarrow 0 - \frac{1}{2}(4)(10)^2 = -\mu(4)g \times 20$

$\Rightarrow \mu = 0.25$

Question23

A body of mass 5 kg is moving with a momentum of 10 kg ms^{-1}. Now a force of 2N acts on the body in the direction of its motion for 5 s. The increase in the Kinetic energy of the body is ______ J.
[8-Apr-2023 shift 2]

Answer: 30

Solution:

$(KE) = \frac{P^2}{2M}$

$\Rightarrow \frac{1}{2}mu^2 = \frac{(10)^2}{2 \times 5}$

$= \frac{1}{2} \times 5 \times u^2 = \frac{100}{10}$

Initial speed $u = 2m/s$

$\Delta KE = w_{\text{all forces}}$

$= \vec{F} \cdot \vec{S}$ $(\theta = 0^\circ)$

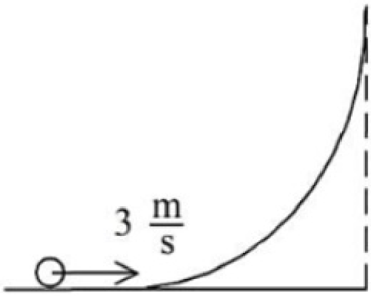
$= F\left(ut + \frac{1}{2}at^2\right)$

$= 2 \cdot \left[2 \times 5 + \frac{1}{2} \times \frac{2}{5} \times 5^2\right]$

$= 30J$

Question24

A hollow spherical ball of uniform density rolls up a curved surface with an initial velocity 3m / s (as shown in figure). Maximum height with respect to the initial position covered by it will be ______ cm(. take, $g = 10m / s^2$)

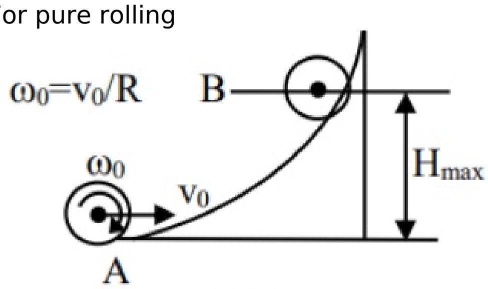


[8-Apr-2023 shift 2]

Answer: 75

Solution:

Solution:
For pure rolling



$(M.E)_A = (M.E)_B$

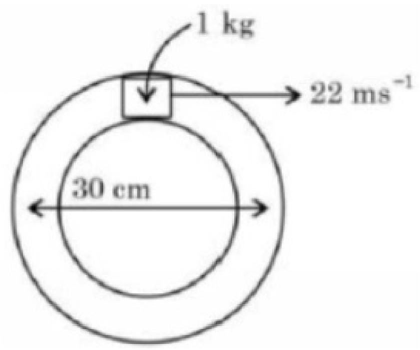
$\Rightarrow \frac{1}{2}mv_0^2 + \frac{1}{2} \times \left(\frac{2}{3}mR^2\right)\left(\frac{v_0}{R}\right)^2 = mgH_{max}$

$\Rightarrow H_{max} = \frac{5}{6}\frac{v_0^2}{g} = \frac{5}{6} \times \frac{3^2}{10} = 0.75m$

$\Rightarrow H_{max} = 75\,cm$

Question25

A closed circular tube of average radius 15 cm, whose inner walls are rough, is kept in vertical plane. A block of mass 1 kg just fit inside the tube. The speed of block is 22m / s, when it is introduced at the top of tube. After completing five oscillations, the block stops at the bottom region of tube. The work done by the tube on the block is ______ J. (Given : $g = 10m / s^2$)



[10-Apr-2023 shift 1]

Solution:

Solution:

$R_{arg} = 15\,\text{cm} = .15\text{m}$

By WET

$W_f + W_{gravity} = \Delta K = Kf - Ki$

$W_f + 10 \times .3 = 0 - \frac{1}{2} \times 1 \times (22)^2$

$W_f = -3 - \frac{484}{2} = 3 - 242 = -245$

Work by friction $= -245$ By NTA $(+245)$

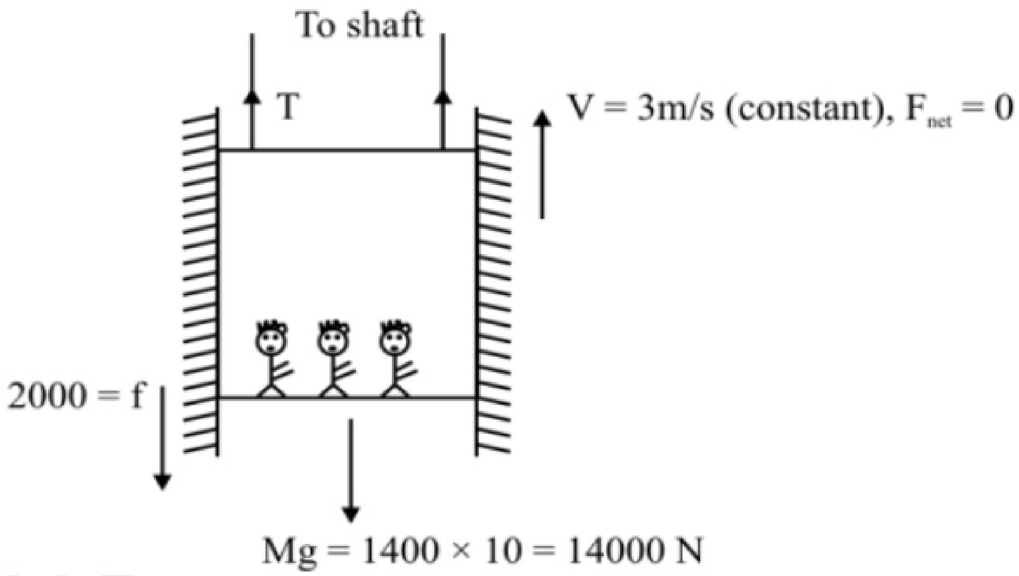
Question26

If the maximum load carried by an elevator is 1400 kg (600 kg− Passengers +800 kg - elevator), which is moving up with a uniform speed of 3m s^{-1} and the frictional force acting on it is 2000N, then the maximum power used by the motor is ______ kW($g = 10\text{m}/\text{s}^2$)
[10-Apr-2023 shift 2]

Answer: 48

Solution:

Solution:



Tension in the string $\Rightarrow 16000\mathrm{N}$
Maximum power $= (\mathrm{F})(\mathrm{V})$
$= 16000 \times 3$
$= 48000$
$= 48\,\mathrm{kW}$
Ans. 48

Question27

A force $\vec{F} = (2 + 3x)\hat{i}$ acts on a particle in the x direc newton and x is in meter. The work done by this for displacement from x = 0 to x = 4m, is _______ mJ. [11-Apr-2023 shift 1]

Answer: 32

Solution:

$\vec{F} = (2 + 3x)i$

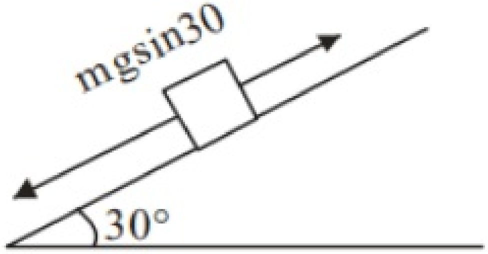
4 4

A block of mass 5 kg starting from rest pulled up on a smooth incline plane making an angle of 30° with horizontal with an affective acceleration of $1ms^{-2}$. The power delivered by the pulling force at t = 10 s from the starts is ______ W.
[use $g = 10ms^{-2}$] (Calculate the nearest integer value)
[11-Apr-2023 shift 2]

Answer: 300

Solution:

$F - mg\sin 30 = ma$
$F = 5 \times 1 + 25 = 30N$
$V = u + at = 0 + 1 \times 10 = 10$
$P = FV = 30 \times 10 = 300\,watt$



Question29

To maintain a speed of 80 km / h by a bus of mass 500 kg on a plane rough road for 4 km distance, the work done by the engine of the bus will be ______ KJ. [The coefficient of fiction between tyre of bus and road is 0.04 .]
[12-Apr-2023 shift 1]

Answer: 784

Solution:

$F = 0.04 \times 500 \times 9.8$
$= 20 \times 9.8 = 196$
$WD = F \times disc$
$= 196 \times 4000$
$= 784\,kJ$

Question30

The ratio of powers of two motors is $\frac{3\sqrt{x}}{\sqrt{x}+1}$, that are capable of raising

300 kg water in 5 minutes and 50 kg water in 2 minutes respectively from a well of 100m deep. The value of x will be
[13-Apr-2023 shift 1]

Options:

A. 16

B. 2

C. 4

D. 2.4

Answer: A

Solution:

Solution:

$$P = \frac{\text{Work}}{\text{Time}}$$

$$P_1 = \frac{mgh}{t_1} = \frac{(300)g(100)}{5}$$

$$P_2 = \frac{(50)g(100)}{2}$$

$$\frac{P_1}{P_2} = \frac{600}{250} = \frac{12}{5} = \frac{3 \times 4}{4 + 1}$$

$$\frac{P_1}{P_2} = \frac{3\sqrt{16}}{\sqrt{16} + 1}$$

$x = 16$

Question31

A body of mass (5 ± 0.5) kg is moving with a velocity of (20 ± 0.4)m / s. Its kinetic energy will be
[13-Apr-2023 shift 1]

Options:

A. (1000 ± 140)J

B. (500 ± 140)J

C. (500 ± 0.14)J

D. (1000 ± 0.14)J

Answer: A

Solution:

Solution:

Kinetic energy, $KE = \frac{1}{2} mv^2$

$KE = \frac{1}{2} \times 5 \times 20^2$

$$\frac{\Delta K}{K} = \frac{\Delta m}{m} + \frac{2\,\Delta v}{v}$$
$$\frac{\Delta K}{1000} = \frac{0.5}{5} + 2 \times \frac{0.4}{20}$$
$$\Delta K = 1000(0.1 + 0.04)$$
$$\Delta K = 1000 \times 0.14$$
$$\Delta K = 140J$$
$$KE = (1000 \pm 140)J$$

Question32

A car accelerates from rest to um / s. The energy spent in this process is EJ. The energy required to accelerate the car from um / s to 2um / s is nEJ. The value of n is ______.
[13-Apr-2023 shift 2]

Answer: 3

Solution:

Solution:

$$E_1 = \frac{1}{2}mu^2 - 0 = \frac{1}{2}mu^2 = E$$
$$E_2 = \frac{1}{2}m(24)^2 - \frac{1}{2}mu^2$$
$$= \frac{3}{2}mu^2 = 3E$$

Question33

A body is released from a height equal to the radius (r) of the earth. The velocity of the body when it strikes the surface of the earth will be : (Given g = acceleration due to gravity on the earth.)
[15-Apr-2023 shift 1]

Options:

A. $\sqrt{gR}$

B. $\sqrt{\frac{gR}{2}}$

C. $\sqrt{4\,gR}$

D. $\sqrt{2gR}$

Answer: A

Solution:

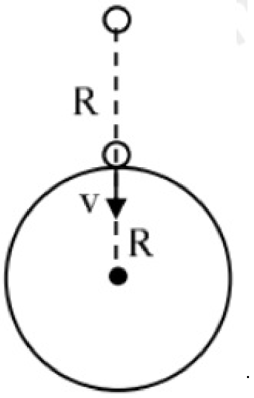
By energy conservation,

$K_1 + U_1 = K_2 + U_2$

$O - \frac{GMm}{2R} = \frac{1}{2}mv^2 - \frac{GMm}{R}$

$V = \sqrt{\frac{GM}{R} \times \frac{R}{R}}$

$V = \sqrt{gR}$



Question34

A block of mass 10 kg is moving along x-axis under the action of force F = 5 xN. The work done by the force in moving the block from x = 2m to 4m will be _______ J.
[15-Apr-2023 shift 1]

Solution:

Work done, $w = \int F dx$

$w = \int_2^4 5\,x dx$

$w = \frac{5}{2}[x^2]_2^4$

$w = \frac{5}{2}(16 - 4)$

$w = 30J$

Question35

A particle of mass m moving with velocity v collides with a stationary particle of mass 2m. After collision, they stick together and continue to move together with velocity
[10-Apr-2023 shift 1]

Options:

A. $\frac{v}{2}$

B. $\frac{v}{3}$

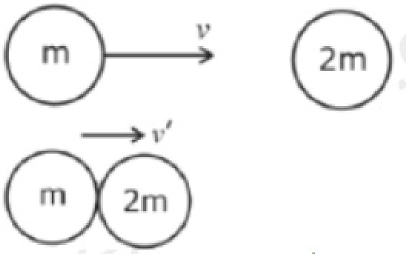
C. $\frac{v}{4}$

D. v

Answer: B

Solution:

Solution:



$pi = pf \Rightarrow\ mv + 2m(0) = 3m(v^{'})$

$v^{'} = \frac{v}{3}$

Question36

An average force of 125N is applied on a machine gun firing bullets each of mass 10g at the speed of 250m / s to keep it in position. The number of bullets fired per second by the machine gun is :
[11-Apr-2023 shift 1]

Options:

A. 25

B. 5

C. 100

D. 50

Answer: D

Solution:

Solution:

$F = 125N$

$F = \frac{dp}{dt}\ \ n \rightarrow$ No. of bullets

$F = \frac{d(nmv)}{dt} = mv\frac{dn}{dt}$

$125 = \frac{10n}{1000} \times 250 \times \frac{dn}{dt}$

$125 \times 1000 \quad dn$

$$\frac{dn}{dt} = 50$$

option → (4)

Question37

A nucleus disintegrates into two nuclear parts, in such a way that ratio of their nuclear sizes is 1 : $2^{1/3}$. Their respective speed have a ratio of n : 1. The value of n is ______
[11-Apr-2023 shift 2]

Answer: 2

Solution:

Solution:

From LCM :

$$m_1V_1 = m_2V_2$$

$$\frac{V_1}{V_2} = \frac{m_2}{m_1} = \frac{{r_2}^3}{{r_1}^3} = \left(\frac{r_2}{r_1}\right)^3$$

$$\frac{V_1}{V_2} = \left(\frac{2^{\frac{1}{3}}}{1}\right)^3 = \frac{2}{1}$$

$$n = 2$$

Question38

Two bodies are having kinetic energies in the ratio 16 : 9. If they have same linear momentum, the ratio of their masses respectively is:
[13-Apr-2023 shift 1]

Options:

A. 16 : 9

B. 4 : 3

C. 9 : 16

D. 3 : 4

Answer: C

Solution:

Solution:

Kinetic energy, $K E = \frac{P^2}{2m}$

$$\frac{k_1}{k_2} = \frac{m_2}{m_1}$$
$$\frac{16}{9} = \frac{m_2}{m_1}$$
$$\frac{m_1}{m_2} = \frac{9}{16}$$

Question39

A bullet of 10g leaves the barrel of gun with a velocity of 600m / s. If the barrel of gun is 50 cm long and mass of gun is 3 kg, then value of impulse supplied to the gun will be:
[13-Apr-2023 shift 1]

Options:

A. 12 Ns

B. 6 Ns

C. 3 Ns

D. 36 Ns

Answer: B

Solution:

Solution:

Impulse, $\left|\vec{I}\right| = \left|\Delta\vec{p}\right|$
$= mV - 0$
$= (10 \times 10^{-3}\,kg)(600m / s)$
$I = 6N - S$

Question40

A block of mass 10 kg starts sliding on a surface with an initial velocity of $9.8ms^{-1}$. The coefficient of friction between the surface and block is 0.5. The distance covered by the block before coming to rest is:
[use $g = 9.8ms^{-2}$]
[24-Jun-2022-Shift-1]

Options:

A. 4.9m

B. 9.8m

C. 12.5m

D. 19.6m

Solution:

Solution:

$S = \frac{u^2}{2a} = \frac{u^2}{2(\mu g)}$

$= \frac{(9.8)^2}{2 \times 0.5 \times (9.8)}$

$= \frac{9.8}{1}$

$= 9.8m$

Question41

A boy ties a stone of mass 100g to the end of a 2m long string and whirls it around in a horizontal plane. The string can withstand the maximum tension of 80N. If the maximum speed with which the stone can revolve is $\frac{K}{\pi}$ rev. / min. The value of K is :
(Assume the string is massless and unstretchable)
[24-Jun-2022-Shift-1]

Options:

A. 400

B. 300

C. 600

D. 800

Answer: C

Solution:

Solution:

$T = m\omega^2 r$

$\Rightarrow 80 = 0.1 \times \left(2\pi \times \frac{K}{\pi} \times \frac{1}{60}\right)^2 \times 2$

$\Rightarrow \frac{800}{2} = \frac{K^2}{900}$

$\Rightarrow K = 30 \times 20 = 600$

Question42

A particle experiences a variable force $\vec{F} = \left(4x\hat{i} + 3y^2\hat{j}\right)$ in a horizontal $x - y$ plane. Assume distance in meters and force is newton. If the particle moves from point (1, 2) to point (2, 3) in the $x - y$ plane, then Kinetic Energy changes by :
[24-Jun-2022-Shift-1]

A. 50.0J

B. 12.5J

C. 25.0J

D. 0J

Answer: C

Solution:

Solution:

$W = \int \vec{F} \cdot d\vec{r}$

$= \int_1^2 4x\,dx + \int_2^3 3y^2\,dy$

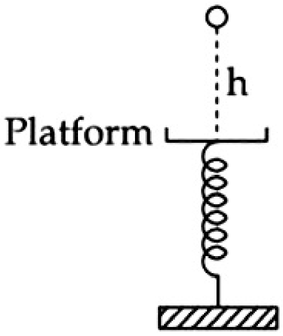
$= [2x^2]_1^2 + [y^3]_2^3$

$= 2 \times 3 + (27 - 8)$

$= 25J$

Question43

A ball of mass 100g is dropped from a height $h = 10\,cm$ on a platform fixed at the top of a vertical spring (as shown in figure). The ball stays on the platform and the platform is depressed by a distance $\frac{h}{2}$. The spring constant is Nm^{-1}.



(Use $g = 10ms^{-2}$)
[24-Jun-2022-Shift-1]

Solution:

$mg\left(h + \frac{h}{2}\right) = \frac{1}{2}k\left(\frac{h}{2}\right)^2$

$\Rightarrow 0.1 \times 10 \times (0.15) = \frac{1}{2}k(0.05)^2$

$\Rightarrow k = 120N / m$

Question44

A stone of mass m, tied to a string is being whirled in a vertical circle with a uniform speed. The tension in the string is
[24-Jun-2022-Shift-2]

Options:

A. the same throughout the motion.

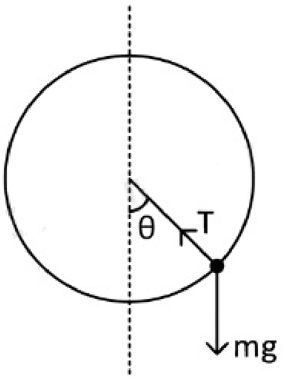
B. minimum at the highest position of the circular path.

C. minimum at the lowest position of the circular path.

D. minimum when the rope is in the horizontal position.

Answer: B

Solution:



At any θ : $T - mg\cos\theta = \frac{mv^2}{R}$

$\Rightarrow T = mg\cos\theta + \frac{mv^2}{R}$

Since v is constant,

$\Rightarrow$T will be minimum when $\cos\theta$ is minimum.

$\Rightarrow \theta = 180^\circ$ corresponds to T_{minimum}

Question45

Potential energy as a function of r is given by $U = \frac{A}{r^{10}} - \frac{B}{r^5}$, where r is the interatomic distance, A and B are positive constants. The equilibrium distance between the two atoms will be :
[24-Jun-2022-Shift-2]

Options:

A. $\left(\frac{A}{B}\right)^{\frac{1}{5}}$

B. $\left(\frac{B}{A}\right)^{\frac{1}{5}}$

C. $\left(\frac{2A}{B}\right)^{\frac{1}{5}}$

D. $\left(\frac{B}{2A}\right)^{\frac{1}{5}}$

Answer: C

Solution:

Solution:
For equilibrium
$-\frac{dU}{dr} = 0 = \frac{10A}{r^{11}} - \frac{5B}{r^6}$
$\Rightarrow r^5 = \frac{2A}{B}$
And $r = \left(\frac{2A}{B}\right)^{1/5}$

Question46

A 0.5 kg block moving at a speed of $12 ms^{-1}$ compresses a spring through a distance 30 cm when its speed is halved. The spring constant of the spring will be ____Nm^{-1}
[25-Jun-2022-Shift-1]

Answer: 600

Solution:

Solution:
$\frac{1}{2}mV^2 = \frac{1}{2}kx^2 + \frac{1}{2}m\left(\frac{v}{2}\right)^2$
$\Rightarrow \frac{3}{8}mv^2 = \frac{1}{2}kx^2$
$\Rightarrow k = \frac{3}{4} \times \frac{1}{2} \times \frac{144}{9} \times 100$
$= 600$
$\Rightarrow 600$

Question47

The ratio of specific heats $\left(\frac{C_P}{C_V}\right)$ in terms of degree of freedom (f) is given by :
[25-Jun-2022-Shift-2]

A. $\left(1 + \frac{f}{3}\right)$

B. $\left(1 + \frac{2}{f}\right)$

C. $\left(1 + \frac{f}{2}\right)$

D. $\left(1 + \frac{1}{f}\right)$

Answer: B

Solution:

Solution:

$\frac{C_P}{C_V} = \gamma$

$C_V = \left(\frac{f}{2}\right) R$ and $C_P - C_V = R$

$\Rightarrow \frac{C_P}{C} = \frac{1 + f / 2}{f / 2} = 1 + \frac{2}{f}$

Question48

Arrange the four graphs in descending order of total work done; where W_1, W_2, W_3 and W_4 are the work done corresponding to figure a, b, c and d respectively.

Figure-a

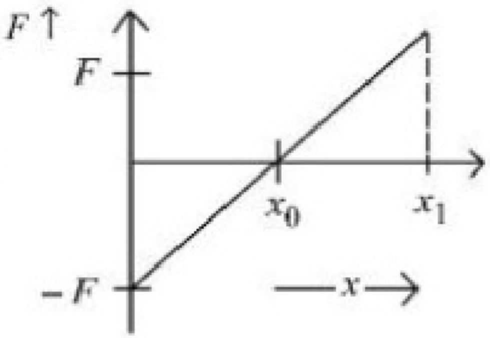


Figure-b

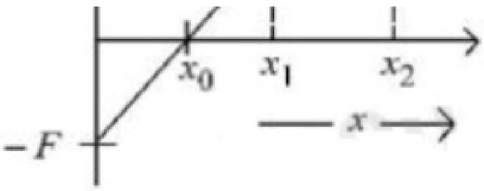


Figure-c

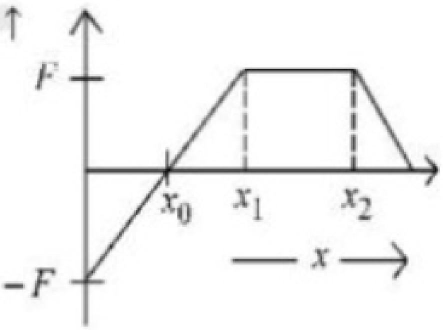
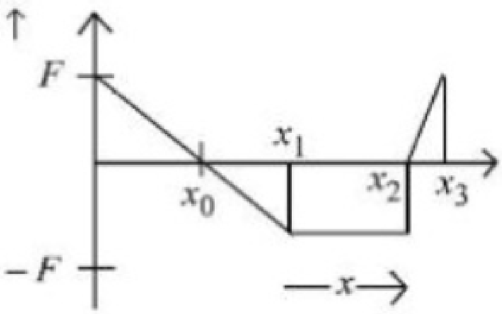


Figure-d



[26-Jun-2022-Shift-2]

Options:

A. $W_3 > W_2 > W_1 > W_4$

B. $W_3 > W_2 > W_4 > W_1$

C. $W_2 > W_3 > W_4 > W_1$

Question49

A stone tide to a spring of length L is whirled in a vertical circle with the other end of the spring at the centre. At a certain instant of time, the stone is at its lowest position and has a speed u. The magnitude of change in its velocity, as it reaches a position where the string is horizontal, is $\sqrt{x(u^2 - gL)}$. The value of x is -
[27-Jun-2022-Shift-2]

Options:

A. 3

B. 2

C. 1

D. 5

Answer: B

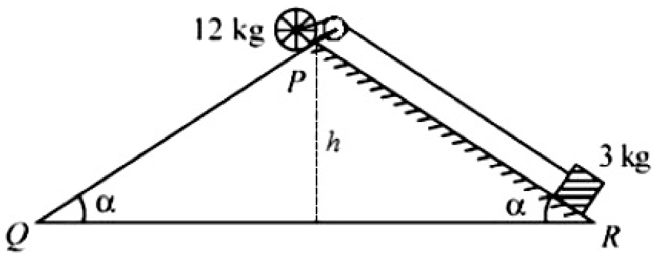
Solution:

$\vec{v} = \sqrt{u^2 - 2gL}\hat{j}$

$\therefore x = 2$

Question50

A rolling wheel of 12 kg is on an inclined plane at position P and connected to a mass of 3 kg through a string of fixed length and pulley as shown in figure. Consider PR as friction free surface. The velocity of centre of mass of the wheel when it reaches at the bottom Q of the inclined plane PQ will be $\frac{1}{2}\sqrt{xgh}$ m / s. The value of x is_____



[27-Jun-2022-Shift-2]

Answer: None

Solution:

Solution:
For rolling wheel

$[12g\sin\alpha - 3g\sin\alpha] \times R = (2 \times 12R^2 + 3R^2) \times \frac{a}{R}$

$\Rightarrow \frac{9g\sin\alpha}{27} = a$

$\Rightarrow a = \frac{g\sin\alpha}{3}$

$\therefore v = \sqrt{2 \times \frac{g\sin\alpha}{3} \times \frac{h}{\sin\alpha}} = \sqrt{\frac{2}{3}gh}$

$= \frac{1}{2} \times \sqrt{\frac{8}{3}gh}$

$\therefore x = \frac{8}{3} = 2.67$

Question51

A particle of mass m is moving in a circular path of constant radius r such that its centripetal acceleration is varying with time t as $a = k^2rt^2$, where k is a constant. The power delivered to the particle by the force acting on it is given as
[28-Jun-2022-Shift-1]

Options:

B. $mk^2r^2t^2$

C. mk^2r^2t

D. $mk^2 rt$

Answer: C

Solution:

Solution:

$a_r = k^2rt^2 = \frac{v^2}{r}$

$\Rightarrow v^2 = k^2r^2t^2$ or $v = krt$

and $\frac{d\,|v|}{d\,t} = kr$

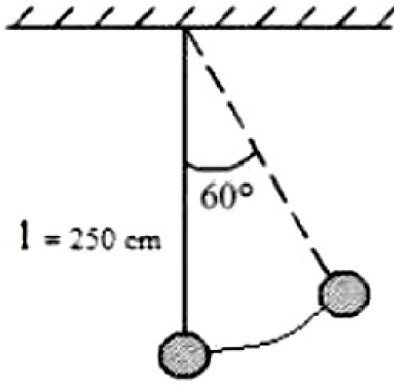
$\Rightarrow a_t = kr$

$\Rightarrow |\overline{F} \cdot \overline{v}| = (mkr)(krt)$

$= mk^2r^2t =$ power delivered

Question52

A pendulum is suspended by a string of length 250 cm. The mass of the bob of the pendulum is 200g. The bob is pulled aside until the string is at 60° with vertical as shown in the figure. After releasing the bob, the maximum velocity attained by the bob will be ____ms^{-1}. (if $g = 10m / s^2$)



[28-Jun-2022-Shift-1]

Answer: 5

Solution:

Solution:

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

$\Rightarrow v = \sqrt{2gl(1 - \cos\theta)}$

$= \sqrt{2 \times 10 \times 2.5 \times \frac{1}{2}}$

$= 5m / s$

Question53

A particle of mass 500 gm is moving in a straight line with velocity $v = bx^{5/2}$. The work done by the net force during its displacement from $x = 0$ to $x = 4m$ is : (Take $.b = 0.25m^{-3/2}s^{-1}$).
[29-Jun-2022-Shift-1]

Options:

A. 2J

B. 4J

C. 8J

D. 16J

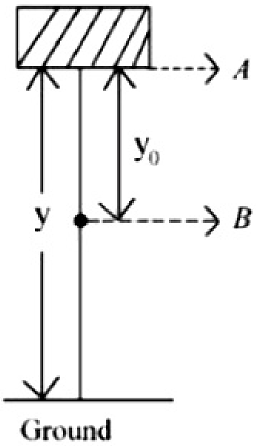
Answer: D

Solution:

Solution:
$W_{total} = \Delta K$
$= \frac{1}{2}\left(\frac{1}{2}\right)[\{b(4)^{5/2}\}^2 - 0]$
$= \frac{b^2}{4} \times 4^5$
$\Rightarrow W_{total} = 16J$

Question54

In the given figure, the block of mass m is dropped from the point ' A '. The expression for kinetic energy of block when it reaches point ' B ' is



[29-Jun-2022-Shift-2]

Options:

A. $\frac{1}{2}mg{y_0}^2$

B. $\frac{1}{2}mgy^2$

C. $mg(y - y_0)$

D. mgy_0

Answer: D

Solution:

Solution:
Loss in potential energy = gain in kinetic energy
$-(mg(y - y_0) - mgy) = KE - 0$
$\Rightarrow KE = mgy_0$

Question55

A batsman hits back a ball of mass 0.4 kg straight in the direction of the bowler without changing its initial speed of $15 ms^{-1}$. The impulse imparted to the ball is ____Ns.
[26-Jun-2022-Shift-2]

Impulse = change in momentum
$= m[v - (-v)] = 2mv$
$= 2 \times 0.4 \times 15 = 12$ N s

Question56

Two blocks of masses 10 kg and 30 kg are placed on the same straight line with coordinates (0, 0) cm and (x, 0) cm respectively. The block of 10 kg is moved on the same line through a distance of 6 cm towards the other block. The distance through which the block of 30 kg must be moved to keep the position of centre of mass of the system unchanged is :
[27-Jun-2022-Shift-1]

Options:

A. 4 cm towards the 10 kg block

B. 2 cm away from the 10 kg block

C. 2 cm towards the 10 kg block

D. 4 cm away from the 10 kg block

Answer: C

Solution:

Solution:
For COM to remain unchanged,
$m_1x_1 = m_2x_2$
$\Rightarrow 10 \times 6 = 30 \times x_2$
$\Rightarrow x_2 = 2$ cm towards 10 kg block.

Question57

What percentage of kinetic energy of a moving particle is transferred to a stationary particle when it strikes the stationary particle of 5 times its mass?
(Assume the collision to be head-on elastic collision)
[27-Jun-2022-Shift-1]

Options:

A. 50.0%

B. 66.6%

C. 55.6%

D. 33.3%

Answer: C

Solution:

Solution:
For a head on elastic collision

$v_2 = \frac{mu_1}{m + 5m} + \frac{mu_1}{m + 5m}$

$= \frac{2u_1}{6}$ or $\frac{u_1}{3}$

Initial kinetic energy of first mass $= \frac{1}{2}m{u_1}^2$

Final kinetic energy of second mass

$= \frac{1}{2} \times 5m\left(\frac{u_1}{3}\right)^2$

$= \frac{5}{9}\left(\frac{1}{2}m{u_1}^2\right)$

$\Rightarrow$ kinetic energy transferred $= 55\%$ of initial kinetic energy of first colliding mass

----

Question58

of mass 75g is fired towards the stationary bob with a speed v. The bullet emerges out of the bob with a speed $\frac{v}{3}$ and the bob just completes the vertical circle. The value of v is _____ms^{-1}. (if $g = 10m / s^2$).
[27-Jun-2022-Shift-1]

Answer: 10

Solution:

Solution:
$v_{bob} = \sqrt{5gl} = \sqrt{5 \times 10 \times 2} = 10m / s$
Conserving momentum :
$75 \times v = 75 \times \frac{v}{3} + 50 \times 10$
$\Rightarrow 50v = 50 \times 10$
$\Rightarrow v = 10m / s$

Question59

The position vector of 1 kg object is $\vec{r} = \left(3\hat{i} - \hat{j}\right)$m and its velocity $\vec{v} = \left(3\hat{j} + \hat{k}\right)ms^{-1}$. The magnitude of its angular momentum is $\sqrt{x}$ Nm where x is ____
[28-Jun-2022-Shift-1]

Answer: 91

Solution:

Solution:
$|\vec{i}| = |\vec{r} \times (m\vec{v})|$
$= \left|\left(3\hat{i} - \hat{j}\right) \times \left(3\hat{j} + \hat{k}\right)\right|$
$= \left|-\hat{i} - 3\hat{j} + 9\hat{k}\right|$
$= \sqrt{91}$

Question60

A body of mass M at rest explodes into three pieces, in the ratio of masses 1 : 1 : 2. Two smaller pieces fly off perpendicular to each other with velocities of $30ms^{-1}$ and $40ms^{-1}$ respectively. The velocity of the

[29-Jun-2022-Shift-1]

Options:

A. $15ms^{-1}$

B. $25ms^{-1}$

C. $35ms^{-1}$

D. $50ms^{-1}$

Answer: B

Solution:

Solution:
Conserving momentum :
$m(30\hat{i}) + m(40\hat{j}) + 2m(\vec{v}) = \vec{0}$
$\Rightarrow \bar{v} = -15\hat{i} - 20\hat{j}$
$\Rightarrow |v| = 25m / s$

Question61

A body of mass 0.5kg travels on straight line path with velocity $v = (3x^2 + 4)m / s$. The net workdone by the force during its displacement from x = 0 to x = 2m is :
[25-Jul-2022-Shift-1]

Options:

A. 64J

B. 60J

C. 120J

D. 128J

Answer: B

Solution:

Solution:
$v = 3x^2 + 4$
at $x = 0, v_1 = 4m / s$
$x = 2, v_n - 16m / s$
$\Rightarrow$ Work done $= \Delta$ kinetic energy
$- \frac{1}{2} \times m(v_2{}^2 - v_1{}^2)$
$= \frac{1}{4}(256 - 16)$
$= 60J$

Question62

A bag of sand of mass 9.8kg is suspended by a rope. A bullet of 200g travelling with speed $10ms^{-1}$ gets embedded in it, then loss of kinetic energy will be :
[25-Jul-2022-Shift-2]

Options:

A. 4.9J

B. 9.8J

C. 14.7J

D. 19.6J

Answer: B

Solution:

Solution:

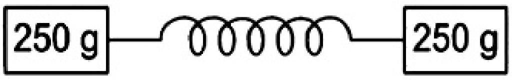
Loss in K E $= \frac{1}{2} \times \frac{m_1 m_2}{m_1 + m_2} \times v^2$

$= \frac{1}{2} \times \frac{9.8 \times 0.2}{10} \times (10)^2$

$= 9.8J$

Question63

As per the given figure, two blocks each of mass 250g are connected to a spring of spring constant $2Nm^{-1}$. If both are given velocity v in opposite directions, then maximum elongation of the spring is:



[26-Jul-2022-Shift-1]

Options:

A. $\frac{v}{2\sqrt{2}}$

B. $\frac{v}{2}$

C. $\frac{v}{4}$

D. $\frac{v}{\sqrt{2}}$

Answer: B

Solution:

Solution:
∵ Loss in K E = Gain in spring energy

$\Rightarrow \frac{1}{2}mv^2 \times 2 = \frac{1}{2}kx_m{}^2$

$\Rightarrow 2 \times \frac{1}{4} \times v^2 = 2 \times x_m{}^2$

$\Rightarrow x_m = \sqrt{\frac{v^2}{4}} = \frac{v}{2}$

Question64

A body of mass 8 kg and another of mass 2 kg are moving with equal kinetic energy. The ratio of their respective momentum will be :
[26-Jul-2022-Shift-2]

Options:

A. 1 : 1

B. 2 : 1

C. 1 : 4

D. 4 : 1

Answer: B

Solution:

Solution:

$K.E = \frac{P^2}{2m}$

$K_1 = \frac{P_1{}^2}{2(8)}; K_2 = \frac{P_2{}^2}{2(2)}$

$K_1 = K_2$

So_0

$4P_2{}^2 = P_1{}^2$

$\frac{P_1}{P_2} = 2$

Question65

Sand is being dropped from a stationary dropper at a rate of $0.5kgs^{-1}$ on a conveyor belt moving with a velocity of $5ms^{-1}$. The power needed to keep the belt moving with the same velocity will be :
[27-Jul-2022-Shift-1]

Options:

A. 1.25W

B. 2.5W

D. 12.5W

Answer: D

Solution:

Solution:

$\frac{dm}{dt} = 0.5\,kg/s$

$v = 5m/s$

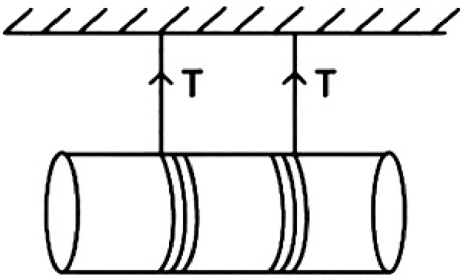
$F = \frac{v\,dm}{dt} = 2.5\,kg\,m/s^2$

$P = \overline{F} \cdot \overline{v} = (2.5)(5)W$

$= 12.5W$

Question66

A solid cylinder length is suspended symmetrically through two massless strings, as shown in the figure. The distance from the initial rest position, the cylinder should be unbinding the strings to achieve a speed of $4ms^{-1}$, is ______ cm. (. take $g = 10ms^{-2}$)



[27-Jul-2022-Shift-2]

Answer: 120

Solution:

Solution:

From energy conservation

$mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$

$mgh = \frac{1}{2}mv^2 + \frac{1}{2}\frac{mR^2}{2}\omega^2$

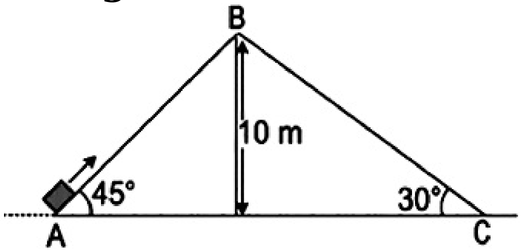
$10h = \frac{16}{2} + \frac{16}{4} \Rightarrow h = 1.2m = 120\,cm$

Question67

Two inclined planes are placed as shown in figure. A block is projected from the Point A of inclined plane AB along its surface with a velocity

reaching the Point B the block slides down on inclined plane BC. Time it takes to reach to the point C from point A is $t(\sqrt{2}+1)$ s. The value of t is _______.

(use $g = 10 m/s^2$)



[27-Jul-2022-Shift-2]

Answer: 2

Solution:

Solution:

From E.C. $= \frac{1}{2} m v_0^2 = mgh$

$v_0 = 10\sqrt{2}$

For A → B

at B, $v = 0$

$a = -g \sin 45^\circ = \frac{-10}{\sqrt{2}}$

$v = u + at_1 \Rightarrow 0 = 10\sqrt{2} - \frac{10}{\sqrt{2}} t_1 \Rightarrow t_1 = 2$ sec

For B → C

$s = ut_2 + \frac{1}{2} a t_2^2$

$\frac{10}{\sin 30^\circ} = \frac{1}{2}(10 \sin 30^\circ) t_2^2$

$t_2 = 2\sqrt{2}$

So total time

$T = t_1 + t_2$

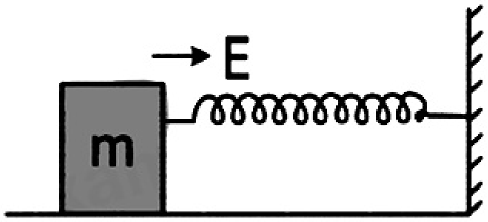
$T = t_1 + t_2$

$= 2\sqrt{2} + 2$

$= 2(\sqrt{2} + 1)$ sec

Question68

A block of mass 'Im' (as shown in figure) moving with kinetic energy E compresses a spring through a distance 25 cm when, its speed is halved. The value of spring constant of used spring will be $nE\,Nm^{-1}$ for n = _______.



[28-Jul-2022-Shift-1]

Answer: 24

Solution:

Solution:
Using work - energy theorem

$W_{net} = (K_f - K_i)$

$\Rightarrow -\frac{1}{2}Kx^2 = \frac{1}{2}m\left(\frac{v}{2}\right)^2 - \frac{1}{2}mv^2 = \frac{E}{4} - E$

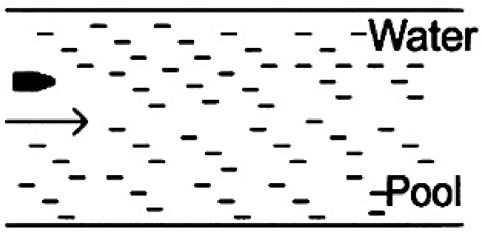
$\Rightarrow \frac{1}{2}Kx^2 = \frac{3E}{4} \Rightarrow K = \frac{3E}{2x^2}$

$\Rightarrow K = \frac{3E}{2 \times \left(\frac{1}{4}\right)^2} = 24E$

$n = 24$

Question69

A bullet of mass 200g having initial kinetic energy 90J is shot inside a long swimming pool as shown in the figure. If it's kinetic energy reduces to 40J within 1 s, the minimum length of the pool, the bullet has to travel so that it completely comes to rest is



[28-Jul-2022-Shift-2]

Options:

A. 45 m

B. 90 m

C. 125 m

D. 25 m

Answer: A

Solution:

Solution:

$\frac{1}{2}mx^2 = 90$

$\Rightarrow \frac{1}{2} \times 0.2 \times x^2 = 90$

$x^2 = 900$

$x = 30m / s$

$\frac{1}{2}mv^2 = 40 \Rightarrow v = \frac{2}{3} \times 30 = 20m / s$

$20 = 30 - a \times 1 \Rightarrow a = -10m / s^2$

$0 - x^2 = 2as$

$s = \frac{x^2}{-2a} = \frac{30 \times 30}{2 \times 10}$

$= 45m$

Question70

Sun light falls normally on a surface of area $36cm^2$ and exerts an average force of $7.2 \times 10^{-9}N$ within a time period of 20 minutes. Considering a case of complete absorption, the energy flux of incident light is
[28-Jul-2022-Shift-2]

Options:

A. $25.92 \times 10^2 W / cm^2$

B. $8.64 \times 10^{-6} W / cm^2$

C. $6.0 W / cm^2$

D. $0.06 W / cm^2$

Answer: D

Solution:

Solution:

$\frac{I}{C} \times \text{area} = \text{force}$

$\frac{I}{C} \times 36 \times 10^{-4} = 7.2 \times 10^{-9}$

$I = \frac{7.2 \times 10^{-9} \times 3 \times 10^8}{36 \times 10^{-9} \times 10}$

$= \frac{6 \times 10^{-1}}{10^{-3}}$

$I = 6 \times 10^2 \frac{w}{m^2}$

$= 0.06 \frac{w}{cm^2}$

If momentum of a body is increased by 20%, then its kinetic energy increases by
[29-Jul-2022-Shift-2]

Options:

A. 36%

B. 40%

C. 44%

D. 48%

Answer: C

Solution:

Solution:
Let, initial momentum of body $(p_i) = p$
$\therefore$ Final momentum $(p_f) = p_i + 20\%$ of p_i
$= p + 0.2p$
$= 1.2p$
We know,
Kinetic energy $(E) = \frac{p^2}{2m}$
$\therefore E_i = \frac{p^2}{2m}$
and $E_f = \frac{(1.2p)^2}{2m} = \frac{1.44p^2}{2m}$
$\therefore$% Change in kinetic energy
$$= \frac{E_f - E_i}{E_i} \times 100$$
$$= \frac{\frac{1.44p^2}{2m} - \frac{p^2}{2m}}{\frac{p^2}{2m}} \times 100$$
$$= \frac{\frac{p^2}{2m}(1.44 - 1)}{\frac{p^2}{2m}} \times 100 = 0.44 \times 100 = 44$$

Question72

Two billiard balls of mass 0.05kg each moving in opposite directions with $10ms^{-1}$ collide and rebound with the same speed. If the time duration of contact is t = 0.005s, then what is the force exerted on the ball due to each other?
[25-Jul-2022-Shift-2]

Options:

A. 100N

B. 200N

C. 300N

D. 400N

Answer: B

Solution:

Solution:
Change in momentum of one ball
$= 2 \times (0.05)(10) \text{kgm / s}$
$= 1 \text{kgm / s}$
$\Rightarrow F_{avg} = \frac{1}{\Delta t} = \frac{1}{0.005} N$
$= 200N$

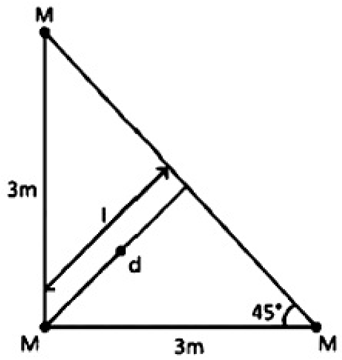
Question73

Three identical spheres each of mass M are placed at the corners of a right angled triangle with mutually perpendicular sides equal to 3m each. Taking point of intersection of mutually perpendicular sides as origin, the magnitude of position vector of centre of mass of the system will be $\sqrt{x}$m. The value of x is___
[25-Jul-2022-Shift-2]

Answer: 2

Solution:

Solution:



$d_{cm} = 3 \sin 45^\circ = \frac{3}{\sqrt{2}}$
$d_{cm} = \frac{2}{3} \times \frac{3}{\sqrt{2}} = \sqrt{2} = \sqrt{x}$
$x = 2$

Question74

A ball of mass 0.15 kg hits the wall with its initial speed of $12 ms^{-1}$ and bounces back without changing its initial speed. If the force applied by

the wall on the ball during the contact is 100N, calculate the time duration of the contact of ball with the wall.
[26-Jul-2022-Shift-2]

Options:

A. 0.018s

B. 0.036s

C. 0.009s

D. 0.072s

Answer: B

Solution:

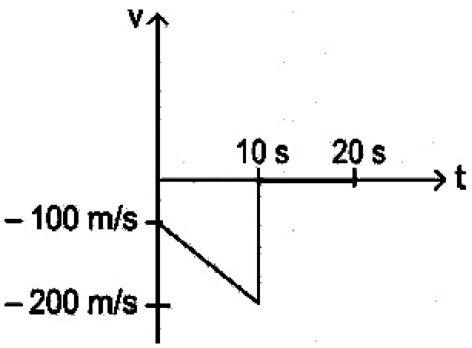
Solution:
$\vec{P}_i = 0.15 \times 12(\hat{i})$
$\vec{P}_f = 0.15 \times 12(-\hat{i})$
$|\Delta\vec{P}| = 3.6\,\text{kg} - \text{m} / \text{s}$
$3.6 = F\,\Delta t$
$3.6 = 100\,\Delta t$
$\Delta t = 0.036\,\text{sec}$

Question75

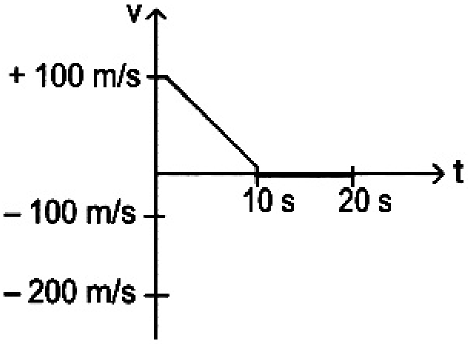
A bullet is shot vertically downwards with an initial velocity of 100m / s from a certain height. Within 10s, the bullet reaches the ground and instantaneously comes to rest due to the perfectly inelastic collision. The velocity-time curve for total time t = 20s will be:
(Take .g = 10m / s^2).
[27-Jul-2022-Shift-1]

Options:

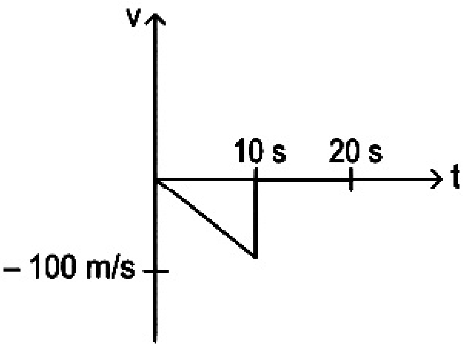
A.



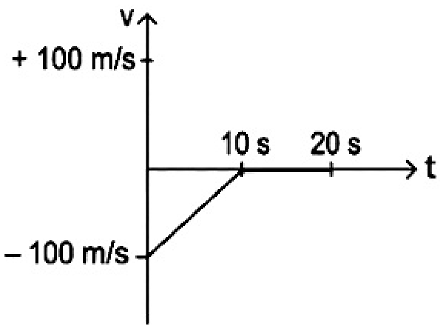
B.



C.



D.



Answer: A

Solution:

Solution:
$|v_{10}| = (100 + 10 \times 10) \mathrm{m} / \mathrm{s}$
$v_{10} = -200 \mathrm{m} / \mathrm{s}$ and $v_0 = -100 \mathrm{m} / \mathrm{s}$
from 10 s to 20 s velocity remains zero
⇒ from $t = 0$ s to 10s velocity increases in magnitude linearly.
⇒ graph given in option A fits correctly.

Question76

The velocity of the bullet becomes one third after it penetrates $4 \mathrm{~cm}$ in a wooden block. Assuming that bullet is facing a constant resistance during its motion in the block. The bullet stops completely after travelling at $(4+x) \mathrm{cm}$ inside the block. The value of x is :
[27-Jul-2022-Shift-2]

A. 2.0

B. 1.0

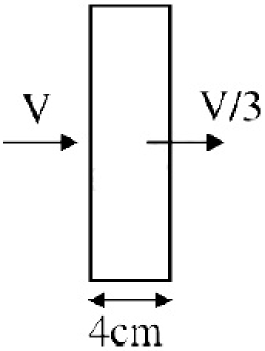
C. 0.5

D. 1.5

Answer: C

Solution:

Solution:



$\left(\frac{V}{3}\right)^2 = V^2 - 2a(4) \Rightarrow a = \frac{8V^2}{9(8)} = \frac{V^2}{9}$

$0 = V^2 - 2a(4 + x)$

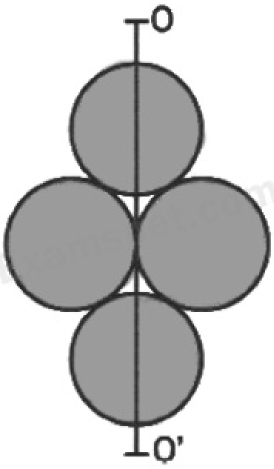
$\Rightarrow V^2 = 2\left(\frac{V^2}{9}\right)(4 + x)$

$4.5 = 4 + x$

$x = 0.5$

Question77

Four identical discs each of mass ' M ' and diameter 'a' are arranged in a small plane as shown in figure. If the moment of inertia of the system about OO' is $\frac{x}{4}Ma^2$. Then, the value of x will be ________.



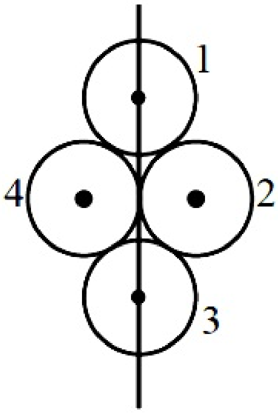
[28-Jul-2022-Shift-1]

Solution:

Solution:

$I_1 = I_3 = \frac{MR^2}{4}$

$I_2 = \frac{MR^2}{4} + MR^2 = \frac{5}{4}MR^2 = I_4$



So $I = I_1 + I_2 + I_3 + I_4$

$= \frac{MR^2}{2} + \frac{5}{2}MR^2$

$= 3MR^2$, Putting $R = \frac{a}{2}$

$I = \frac{3Ma^2}{4}$, So $x = 3$

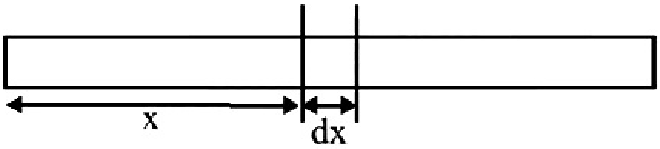
Question78

The distance of centre of mass from end A of a one dimensional rod (AB) having mass density $\rho = \rho_0\left(1 - \frac{x^2}{L^2}\right)$ kg / m and length L (in meter) is $\frac{3L}{\alpha}$m. The value of α is_____ (where x is the distance from end A) [28-Jul-2022-Shift-2]

Answer: 8

Solution:

Solution:



$dm = \lambda \cdot dx = \lambda_0\left(1 - \frac{x^2}{\ell^2}\right)$

$X_{cm} = \frac{\int xdm}{\int dm_\ell}$

$$= \frac{\lambda_0 \int_0^{\ell} \left(x - \frac{x^3}{\ell^2} \right) dx}{\int_0^{\ell} \lambda_0 \left(1 - \frac{x^2}{\ell^2} \right) dx} = \frac{\frac{\ell^2}{2} - \frac{\ell^4}{4\ell^2}}{\ell - \frac{\ell^3}{3\ell^2}} = \frac{3\ell}{8}$$

Question79

Two bodies of mass 1 kg and 3 kg have position vectors $\hat{i} + 2\hat{j} + \hat{k}$ and $-3\hat{i} - 2\hat{j} + \hat{k}$ respectively. The magnitude of position vector of centre of mass of this system will be similar to the magnitude of vector :
[29-Jul-2022-Shift-1]

Options:

A. $\hat{i} + 2\hat{j} + \hat{k}$

B. $-3\hat{i} - 2\hat{j} + \hat{k}$

C. $-2\hat{i} + 2\hat{k}$

D. $2\hat{i} - \hat{j} + 2\hat{k}$

Answer: A

Solution:

Solution:

$$\bar{r}_{com} = \frac{m_1\bar{r}_1 + m_2\bar{r}_2}{m_1 + m_2}$$

$$= \frac{(1 - 9)\hat{i} + (2 - 6)\hat{j} + (1 + 3)\hat{k}}{4}$$

$$= \frac{-8\hat{i} - 4\hat{j} + 4\hat{k}}{4}$$

$$\bar{r}_{com} = -2\hat{i} - \hat{j} + \hat{k}$$

$$|\bar{r}| = \sqrt{4 + 1 + 1} = \sqrt{6}$$

$$\left|\hat{i} + 2\hat{j} + \hat{k}\right| = \sqrt{6}$$

Question80

Two particles having masses 4g and 16g respectively are moving with equal kinetic energies. The ratio of the magnitudes of their linear momentum is n : 2. The value of n will be ....
[25 Feb 2021 Shift 2]

Solution:

Solution:
Given, mass of particle A, $m_A = 4g$
Mass of particle B, $m_B = 16g$
Kinetic energy of A and B is same
i.e. $KE_A = KE_B$
As, kinetic energy $(KE) = p^2 / 2m$
where, p is momentum and m is mass.

$$\therefore \frac{(p_A)^2}{m_A} = \frac{(p_B{}^2)}{m_B} \Rightarrow \frac{p_A{}^2}{4} = \frac{p_B{}^2}{16} \Rightarrow \frac{p_A}{p_B} = \frac{1}{2}$$

$\because$ linear momentum is $n : 2$.
$\therefore n = 1$

Question81

Two solids A and B of mass 1kg and 2kg respectively are moving with equal linear momentum. The ratio of their kinetic energies $(KE)_A : (KE)_B$ will be $\frac{A}{1}$, so the value of A will be ....
[24 Feb 2021 Shift 2]

Solution:

Given, $m_A = 1kg$, $m_B = 2kg$, $(KE)_A : (KE)_B = A : 1$
Linear momentum of A and B are equal.
$\Rightarrow p_A = p_B$
$\because$ Kinetic energy $(KE) = p^2 / 2m$

$$\therefore \frac{KE_A}{KE_B} = \frac{m_B}{m_A} = \frac{2}{1} = \frac{A}{1} \Rightarrow A = 2$$

Question82

A small bob tied at one end of a thin string of length 1m is describing a vertical circle, so that the maximum and minimum tension in the string are in the ratio 5 : 1. The velocity of the bob at the highest position is .... m / s. (Take, $g = 10m / s^2$)
[25 Feb 2021 Shift 1]

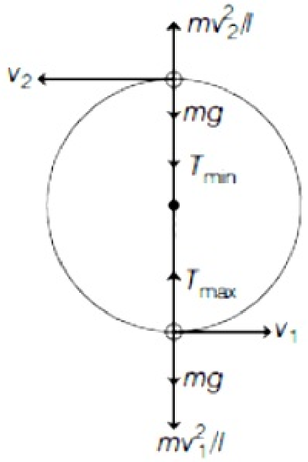
Answer: 5

Solution:

Solution:

Given, length of string, $l = 1m$

T_{max} and T_{min} be the tension in string and v_1 and v_2 be the velocities of bob at bottom and top in vertical circle.



$T_{max} = mg + mv_1^2 / l$

and $T_{min} = mv_2^2 / l - mg$

$\because \frac{T_{max}}{T_{min}} = \frac{mg + mv_1^2 / l}{mv_2^2 / l - mg} = \frac{5}{1}$

$\Rightarrow mg + mv_1^2 / l = 5mv_2^2 / l - 5mg$

Here, $v_1 = \sqrt{v_2^2 + 4gl}$

$\Rightarrow mg + \frac{m}{l}(v_2^2 + 4gl) = \frac{5mv_2^2}{l} - 5mg$

$\Rightarrow g + \frac{v_2^2 + 4gl}{l} = \frac{5v_2^2}{l} - 5g$

$\Rightarrow 6gl = 5v_2^2 - v_2^2 - 4gl \Rightarrow 10gl = 4v_2^2$

$\Rightarrow v_2 = \sqrt{\frac{10gl}{4}} = \sqrt{\frac{10 \times 10 \times 1}{4}}$

$= \sqrt{25} = 5m / s$

Question83

Given below are two statements : one is labelled as Assertion A and the other is labelled as Reason R.

Assertion A Body P having mass M moving with speed u has head-on collision elastically with another body Q having mass m initially at rest. If $m \ll M$, body Q will have a maximum speed equal to 2u after collision.

Reason R During elastic collision, the momentum and kinetic energy are both conserved.

In the light of the above statements, choose the most appropriate answer from the options given below.
[26 Feb 2021 Shift 1]

Options:

B. Both A and R are correct but R is not the correct explanation of A.

C. Both A and R are correct and R is the correct explanation of A.

D. A is correct but R is not correct.

Answer: C

Solution:

Solution:
Let v_1 and v_2 are the speed of P and Q after collision.
By using law of conservation of mementum,

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$
$$M u + m \cdot 0 = M v_1 + mv_2$$
$$\Rightarrow \frac{M(u - v_1)}{m} = v_2$$

and by using law of conservation of energy,

$$\frac{1}{2}m_1{u_1}^2 + \frac{1}{2}m_2{u_2}^2 = \frac{1}{2}m_1{v_1}^2 + \frac{1}{2}m_2{v_2}^2$$
$$\Rightarrow M u^2 + 0 = M {v_1}^2 + m{v_2}^2$$
$$\Rightarrow M(u^2 - {v_1}^2) = m{v_2}^2$$
$$\Rightarrow M(u - v_1)(u + v_1) / m = {v_2}^2$$
$$\frac{1}{2}m_1{u_1}^2 + \frac{1}{2}m_2{u_2}^2 = \frac{1}{2}m_1{v_1}^2$$
$$M u^2 + 0 = M {v_1}^2 + mv^2$$
$$\Rightarrow M(u^2 - {v_1}^2) = m{v_2}^2$$
$$\Rightarrow M(u - v_1)(u + v_1) / m = {v_2}^2$$

Substituting the value of $M \frac{(u - v_1)}{m}$ from Eq. (i) in Eq. (ii), we get

$$v_2(u + v_1) = {v_2}^2$$
$$u + v_1 = v_2$$
$$\Rightarrow M \gg m$$
$$v_1 = u$$
$$v_2 = 2u$$

Eq. (ii), we get

$$v_2(u + v_1) = {v_2}^2$$
$$u + v_1 = v_2$$
$$M > > m$$
$$v_1 = u$$
$$v_2 = 2u$$

Hence, option (c) is the correct.

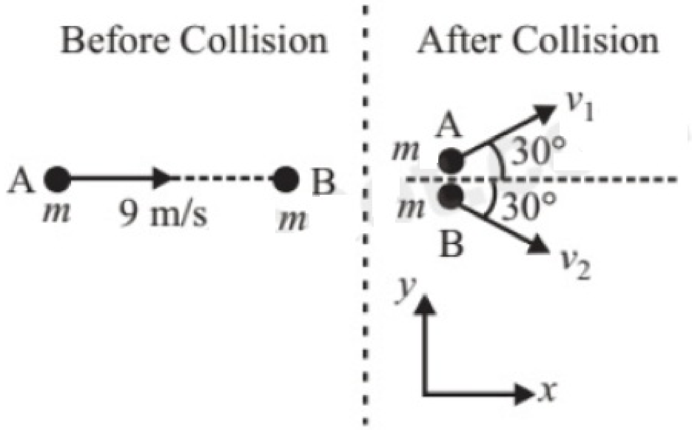
Question84

A ball with a speed of 9m / s collides with another identical ball at rest. After the collision, the direction of each ball makes an angle of 30° with the original direction. The ratio of velocities of the balls after collision is x : y, where x is [24feb2021shift1]

Answer: 1

Solution:

Solution:



From conservation of momentum along y -axis.

$\vec{P}_{iy} = \vec{P}_{fy}$

$0 + 0 = mv_1 \sin 30^\circ \hat{j} + mv_2 \sin 30^\circ(-\hat{j})$

$mv_2 \sin 30^\circ = mv_1 \sin 30^\circ$

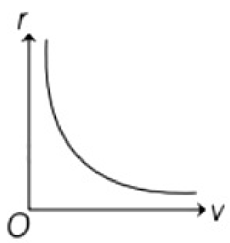
$v_2 = v_1$ or $\frac{v_1}{v_2} = 1$

Question85

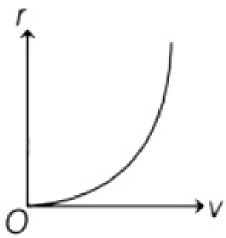
A particle of mass m moves in a circular orbit under the central potential field, U (r) = $\frac{-C}{r}$, where C is a positive constant. The correct radius-velocity graph of the particle's motion is
[18 Mar 2021 Shift 2]

Options:

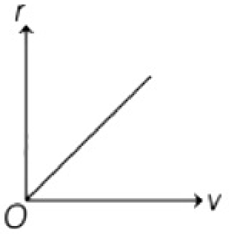
A.



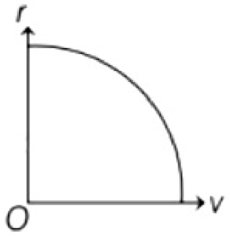
B.



C.



D.



Answer: A

Solution:

Solution:
The central potential field when particle moves in circular orbit,

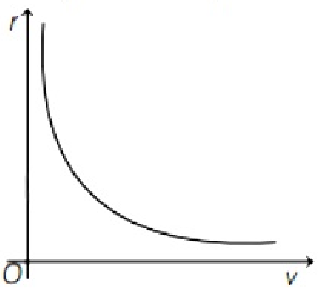
$U(r) = -\frac{C}{r}$

We know that,

$F = -\frac{dU}{dr}$

$\Rightarrow F = -\frac{d}{dr}\left(-\frac{C}{r}\right) \Rightarrow |F| = -\frac{C}{r^2}$

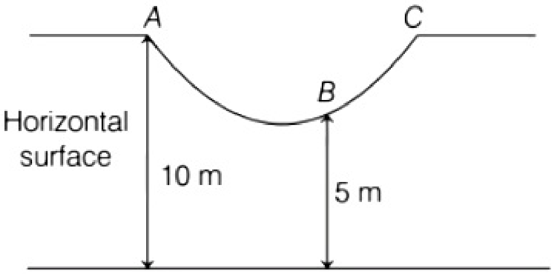
$\Rightarrow \frac{mv^2}{r} = -\frac{C}{r^2} \Rightarrow v^2 \propto \frac{1}{r}$



The graph between velocity and radius is hyperbolic.

Question86

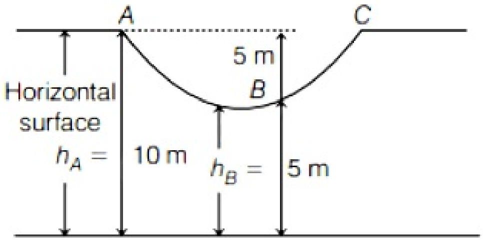
As shown in the figure, a particle of mass 10kg is placed at a point A. When the particle is slightly displaced to its right, it starts moving and reaches the point B. The speed of the particle at B is xm/s. (Take, $g = 10 m/s^2$)
The value of x to the nearest integer is



[18 Mar 2021 Shift 1]

Solution:

Solution:
Given,
The mass of the particle, $m = 10kg$
The speed of the particle at point A, $v_A = 0m/s$
The elevation of the point A from the point B, $h_A = 5 + h_B$
Let's consider the speed of the particle at point B $= v_B$



Using the law of conservation of energy.
Energy at point A = Energy at point B
$\frac{1}{2}mv_A^2 + mgh_A = \frac{1}{2}mv_B^2 + mgh_B$
Substituting the values in the above equations, we get
$\frac{1}{2}(10)(0)^2 + 10 \times 10 \times (5 + h_B) = \frac{1}{2}(10)v_B^2 + 10 \times 10 \times h_B$
$v_B = 10m / s = xm / s$
$\therefore\ x = 10$

Question87

A constant power delivering machine has towed a box, which was initially at rest, along a horizontal straight line. The distance moved by the box in time t is proportional to
[18 Mar 2021 Shift 1]

Options:

A. $t^{\frac{2}{3}}$

B. $t^{\frac{3}{2}}$

C. t

D. $t^{\frac{1}{2}}$

Answer: B

Solution:

Solution:
We know that,
Power = force × velocity [∵ Given, power = constant]
∴ Force × velocity = constant
⇒ $ma \times v =$ constant
⇒ $a \times v =$ constant
⇒ $\left(v\frac{dv}{dx}\right)\left(\frac{dx}{dt}\right) = C \Rightarrow \int v\,dv = \int C\,dt$
⇒ $\frac{v^2}{2} = Ct \Rightarrow v = \sqrt{2Ct}$
⇒ $\frac{dx}{dt} = \sqrt{2Ct}$ $\left[\because v = \frac{dx}{dt}\right]$
⇒ $\int dx = \int \sqrt{2Ct}\,dt \Rightarrow x = \sqrt{2C}\left(\frac{t^{3/2}}{3/2}\right)$
⇒ $x \propto t^{3/2}$

Question88

A ball of mass 4kg, moving with a velocity of $10ms^{-1}$, collides with a spring of length 8m and force constant $100N\,m^{-1}$. The length of the compressed spring is xm. The value of x to the nearest integer, is [18 Mar 2021 Shift 2]

Answer: 6

Solution:

Solution:
Given, mass of the ball, $m = 4kg$
Velocity of the ball, $v = 10m/s$
Force constant, $k = 100N/m$
The length of the spring, $x = 8m$
Let x is the compressed length of the spring.
Using the work-energy theorem,
"It states that kinetic energy of the ball is converted into the stored energy of spring".
$\frac{mv^2}{2} = \frac{kx^2}{2}$
⇒ $\frac{4(10)^2}{2} = \frac{(100)x^2}{2}$
⇒$x = 2m$
The final length (compressed) of the spring
$= 8 - 2 = 6m$
Hence, the value of x to the nearest integer is 6 .

An object of mass m_1 collides with another object of mass m_2, which is at rest. After the collision, the objects move with equal speeds in opposite direction. The ratio of the masses $m_2 : m_1$ is
[18 Mar 2021 Shift 2]

Options:

A. 3 : 1

B. 2 : 1

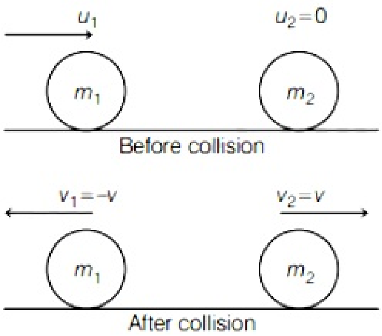
C. 1 : 2

D. 1 : 1

Answer: A

Solution:

Solution:
The mass m_1 is moving with speed u_1 initially and mass m_2 is at rest. After the collision, the mass m_1 and m_2 move with speed v in opposite directions.



Using the law of conservation of linear momentum,
$m_1U_1 + m_2U_2 = m_1v_1 + m_2v_2$
$\Rightarrow\ m_1u_1 + m_2(0) = m_1(-v) + m_2v$
$\Rightarrow\ m_1u_1 = (-m_1 + m_2)v\ldots$(i)
Since, the collision is elastic because they move with same speed after the collision. Hence, coefficient of restitution, $e = 1$

$\therefore\ e = \dfrac{v_2 - v_1}{u_1 - u_2} \Rightarrow 1 = \dfrac{v - (-v)}{u_1 - 0}$

$u_1 = 2v\ldots$(ii)
Putting the above value in Eq. (i), we get
$m_7(2v) = (-m_1 + m_2)v$

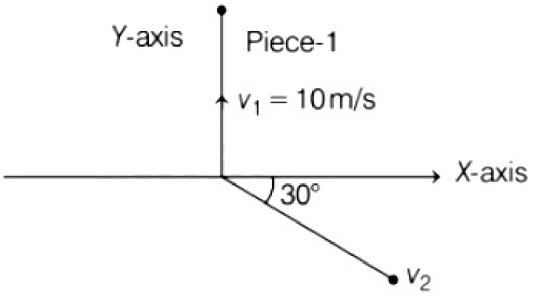
$\Rightarrow\ 3m_1 = m_2 \Rightarrow \dfrac{m_2}{m_1} = \dfrac{3}{1}$

$\Rightarrow\ m_7 : m_1 = 3 : 1$

Question90

A ball of mass 10kg moving with a velocity $10\sqrt{3}$m / s along the X -axis, hits another ball of mass 20kg which is at rest. After the collision, first ball comes to rest while the second ball disintegrates into two equal pieces. One piece starts moving along Y -axis with a speed of 10m / s. The second piece starts moving at an angle of 30° with respect to the X -

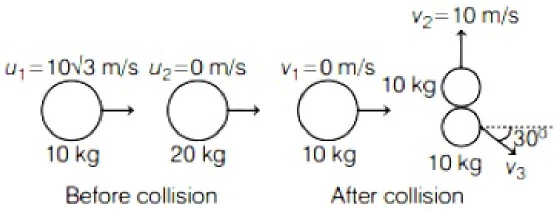
configuration of pieces after collision is shown in the figure below. The value of x to the nearest integer is



[18 Mar 2021 Shift 1]

Solution:

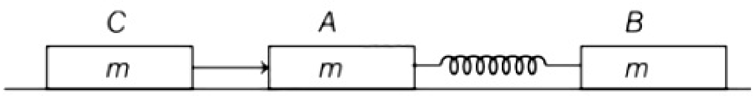
Solution:
Given,
The mass of the first ball, $m_1 = 10$kg The mass of the second ball, $m_2 = 20$kg
The initial velocity of the first ball, $u_1 = 10\sqrt{3}$m/s
The initial velocity of the second ball, $u_2 = 0$m/s
The final velocity of the first ball, $v_1 = 0$m/s
The final velocity of the first piece of the second ball, $v_2 = 10$m/s
Let's consider the final velocity of the second piece of the second ball $= v_2$
As shown in the figure,



The net external force on the system is to be zero. Hence, we can use the law of conservation of linear momentum in both directions. ln x-direction the linear momentum conserved,
In x-direction the linear momentum conserved,
$m_1U_{1x} + m_2U_{2x} = m_1v_{1x} + m_2v_{2x} + m_3V_{3x}$
$\Rightarrow\ 10(10\sqrt{3}) + 0 = 10(0) + 0 + 10v_3\cos 30^\circ$
$\Rightarrow\ v_3 = 20$m/s
Hence, the velocity of the ball moving at 30° with respect to the X -axis is 20m/s.
So, the value of x to the nearest integer is 20 .

Question91

Two identical blocks A and B each of mass m resting on the smooth horizontal floor are connected by a light spring of natural length L and spring constant k. A third block C of mass m moving with a speed v along the line joining A and B collides with A. The maximum compression in the spring is



Options:

A. $v\sqrt{\frac{m}{2k}}$

B. $\sqrt{\frac{mv}{2k}}$

C. $\sqrt{\frac{mv}{k}}$

D. $\sqrt{\frac{m}{2k}}$

Answer: A

Solution:

Solution:
Let v is the speed of the third block C.
The velocity of centre of mass of A and B is

$v_{CM} = \frac{v}{2}$

The spring is compressed maximum by x distance.
Using the law of conservation of energy.

$\frac{1}{2}mv^2 = \frac{1}{2}m\left(\frac{v}{2}\right)^2 + \frac{1}{2}m\left(\frac{v}{2}\right)^2 + \frac{1}{2}kx^2$

$\Rightarrow \frac{1}{4}mv^2 = \frac{1}{2}kx^2 \Rightarrow x = \sqrt{\frac{mv^2}{2k}}$

$\Rightarrow x = v\sqrt{\frac{m}{2k}}$

Question92

A rubber ball is released from a height of 5m above the floor. It bounces back repeatedly, always rising to $\frac{81}{100}$ of the height through which it falls. Find the average speed of the ball.
(Take, $g = 10ms^{-2}$)
[17 Mar 2021 Shift 2]

Options:

A. $3.0ms^{-1}$

B. $3.5ms^{-1}$

C. $2.0ms^{-1}$

D. $2.5ms^{-1}$

Answer: D

Solution:

Velocity of rubber ball when it strikes to the ground, $v_0 = \sqrt{2gh_0}$
Using the formula of coefficient of restitution,

$$e = \frac{\text{velocity after collision}}{\text{velocity before collision}}$$

$$\Rightarrow e = \frac{v_1 - 0}{v_0 - 0} \Rightarrow e = \frac{v_1}{\sqrt{2gh_0}}$$

$\Rightarrow v_1 = e\sqrt{2gh_0}$...(i)
As, initial height of the ball $= h_0$.

∴ The first height of the rebound, $h_1 = \frac{{v_1}^2}{2g}$

$\Rightarrow h_1 = e^2 h_0$ [Using Eq. (i)]
The nth height of the ball to the rebound,

$$h_n = \frac{{v_n}^2}{2g} \Rightarrow h_n = e^{2n} h_0$$

The velocity of the ball after nth rebound, $v_n = e^n v_0$
Now, the total distance travelled by the ball after nth rebound is

$$H = h_0 + 2h_1 + 2h_2 + 2h_3 \cdots$$

$$H = h_0 + 2e^2 h_0 + 2e^4 h_0 + 2e^6 h_0 \cdots$$

$$H = h_0[1 + 2e^2(1 + e^2 + e^4 + e^6 \ldots)]$$

Using the formula,

$$1 + e^2 + e^4 + \ldots = \frac{1}{1 - e^2}$$

$$\Rightarrow H = h_0\left[1 + 2e^2\left(\frac{1}{1 - e^2}\right)\right]$$

$$\Rightarrow H = h_0\left(\frac{1 + e^2}{1 - e^2}\right)$$

$$\Rightarrow H = 5\left(\frac{1 + (0.81)}{1 - (0.81)}\right) \left(\because e^2 = \frac{h_1}{h_0} = \frac{81}{100}\right)$$

$H = 47.6\text{m}$
Now, the total time taken by the ball to come to rest

$$T = t_0 + 2t_1 + 2t_2 + \ldots$$

$$T = \sqrt{\frac{2h_0}{g}} + 2\sqrt{\frac{2h_1}{g}} + 2\sqrt{\frac{2h_2}{g}} + \ldots$$

$$T = \sqrt{\frac{2h_0}{g}}[1 + 2e + 2e^2 + \ldots]$$

$$T = \sqrt{\frac{2h_0}{g}}[1 + 2e(1 + e + e^2 + \ldots)]$$

$$T = \sqrt{\frac{2h_0}{g}}\left(\frac{1 + e}{1 - e}\right) \Rightarrow T = \sqrt{\frac{2(5)}{10}}\left(\frac{1 + \sqrt{0.81}}{1 - \sqrt{0.81}}\right)$$

$T = 19\text{s}$
The average velocity,

$$v_{avg} = \frac{H}{T} = \frac{47.6}{19}$$

$= 2.5\text{m / s}$
Hence, the average velocity is 2.5m/s.

Question93

- A boy is rolling a 0.5kg ball on the frictionless floor with the speed of 20ms^{-1}. The ball gets deflected by an obstacle on the way. After deflection it moves with 5% of its initial kinetic energy. What is the speed of the ball now ?
[17 Mar 2021 Shift 1]

Options:

A. 19.0ms^{-1}

C. $14.41ms^{-1}$

D. $1.00ms^{-1}$

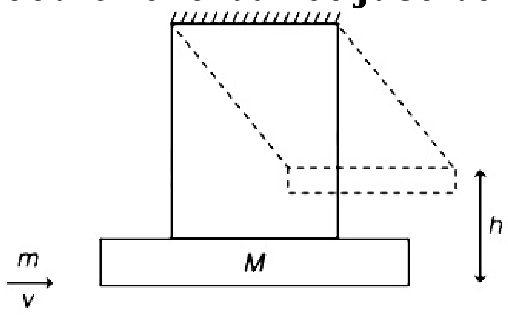
Answer: B

Solution:

Solution:
Given, mass of rolling ball, $m = 0.5kg$
Speed of ball, $u = 20ms^{-1}$
Before deflection,
Initial kinetic energy, $KE_1 = \frac{1}{2}mu^2$
$= \frac{1}{2} \times 0.5 \times (20)^2$
$= \frac{1}{2} \times 0.5 \times 400 = \frac{1}{2} \times \frac{1}{2} \times 400 = 100J$
It is given in the question that after deflection the ball moves with 5% of its initial kinetic energy
$KE_f = 5\%$ of $KE_i \Rightarrow KE_f = \frac{5}{100} \times 100 = 5J$
If the final speed of the ball is vms^{-1}, then
$KE_f = \frac{1}{2}mv^2$
$\Rightarrow 5 = \frac{1}{2} \times 0.5 \times v^2 \Rightarrow 10 = 0.5 \times v^2$
$\Rightarrow v^2 = \frac{10}{0.5} = \frac{100}{5} \Rightarrow v^2 = 20$
$\Rightarrow v = \sqrt{20} = 4.47ms^{-1}$
$\Rightarrow v = 4.47ms^{-1}$

Question94

A large block of wood of mass $M = 5.99kg$ is hanging from two long massless cords. A bullet of mass $m = 10g$ is fired into the block and gets embedded in it. The system (block + bullet) then swing upwards, their centre of mass rising a vertical distance $h = 9.8cm$ before the (block + bullet) pendulum comes momentarily to rest at the end of its arc. The speed of the bullet just before collision is (Take $g = 9.8ms^{-2}$)



[16 Mar 2021 Shift 2]

Options:

A. 841.4m/s

B. 811.4m/s

C. 831.4m/s

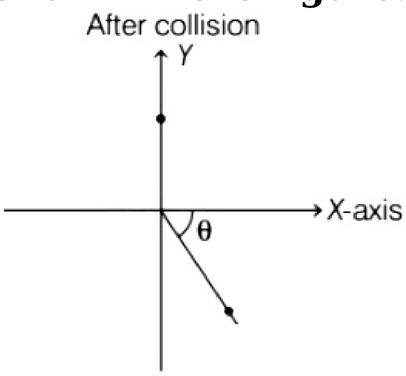
Answer: C

Solution:

Solution:
Given
Mass of large block of wood, $M = 5.99\text{kg}$
Mass of bullet, $m = 10\text{g}$
Height at which their centre of mass rise, $h = 9.8\text{cm}$
From the law of conservation of energy,
Energy of the system when bullet gets embedded = Energy of the system till it momentarily comes to rest.
$\Rightarrow \frac{1}{2}(M + m){v_1}^2 = (M + m)gh$
where, $v_1 =$ velocity of bullet + block system
$\Rightarrow v_1 = \sqrt{2gh}$.....(i)
According to law of conservation of momentum,
Momentum before collision = Momentum after collision.
$\Rightarrow mv = (M + m)v_1$
[where, $v =$ velocity of bullet before collision]
$\Rightarrow mv = (M + m)\sqrt{2gh}$ [using Eq. (i)]
$\Rightarrow v = \left(\frac{M + m}{m}\right)\sqrt{2gh}$
$\Rightarrow v = \frac{(5.99 + 0.01)}{10 \times 10^{-3}} \times \sqrt{2 \times 9.8 \times 9.8 \times 10^{-2}}$
$\Rightarrow v = 831.55\text{ms}^{-1}$

Question95

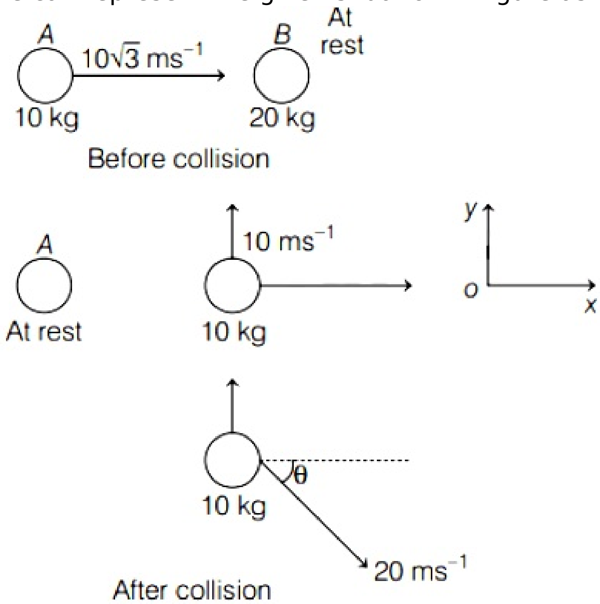
A ball of mass 10kg moving with a velocity $10\sqrt{3}\text{ms}^{-1}$ along X-axis, hits another ball of mass 20kg, which is at rest. After collision, the first ball comes to rest and the second one disintegrates into two equal pieces. One of the pieces starts moving along Y-axis at a speed of 10m / s. The second piece starts moving at a speed of 20m / s at an angle θ (degree) with respect to the X-axis. The configuration of pieces after collision is shown in the figure. The value of θ to the nearest integer is



[16 Mar 2021 Shift 1]

Solution:

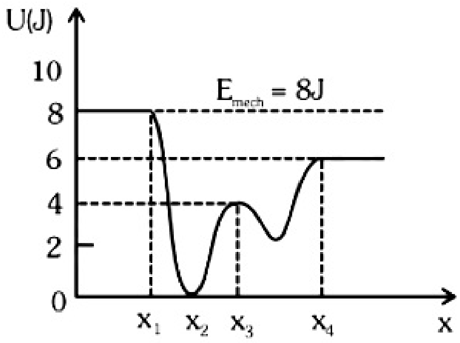
We can represent the given situation in figure as



It means linear momentum is conserved along X -axis.
According to the law of conservation of linear momentum,
$p_i = p_f$
$m_A u_A + m_B u_B = m_A v_A + (m_B v_B \cos\theta)$
$= m_A v_A + m_{B_1} v_{B_1} \cos 90^\circ + m_{B_2} v_{B_2} \cos\theta$
$\Rightarrow 10 \times 10\sqrt{3} + 20 \times 0 = 10 \times 0 + 10 \times 10 \times 0 + 10 \times 20 \cos\theta$
$\Rightarrow\ 10 \times 10\sqrt{3} = 200 \cos\theta$
where, $\cos\theta$ being the horizontal component i.e., along X -axis
$\Rightarrow\ \cos\theta = \sqrt{3}/2$
$\Rightarrow\ \theta = 30^\circ\ [\because \cos 30^\circ = \sqrt{3}/2]$

Question96

Given below is the plot of a potential energy function U (x) for a system, in which a particle is in one dimensional motion, while a conservative force F (x) acts on it. Suppose that $E_{mech} = 8J$, the incorrect statement for this system is:



[where K.E. = kinetic energy]

[27 Jul 2021 Shift 2]

Options:

A. at $x > x_4$, K . E . is constant throughout the region.

B. at $x < x_1$, K . E . is smallest and the particle is moving at the slowest speed.

C. at $x = x_2$, K . E . is greatest and the particle is moving at the fastest speed.

Answer: B

Solution:

Solution:
$E_{mech} = 8J$
(A) at $x > x_4$, $U = \text{constant} = 6J$
$K = E_{mech.} - U = 2J = \text{constant}$
(B) at $x < x_1$, $U = \text{constant} = 8J$
$K = E_{mech.} - U = 8 - 8 = 0J$
Particle is at rest.
(C) At $x = x_2$, $U = 0 \Rightarrow E_{mech.} = K = 8J$
KE is greatest, and particle is moving at fastest speed.
(D) At $x = x_3$, $U = 4J$
$U + K = 8J$
$K = 4J$

Question97

A force of $F = (5y + 20)\hat{j}N$ acts on a particle. The workdone by this force when the particle is moved from y = 0m to y = 10m is ______ J.
[25 Jul 2021 Shift 2]

Answer: 450

Solution:

Solution:
$F = (5y + 20)\hat{j}$
$\omega = \int F\,dy = \int_0^{10}(5y + 20)dy$
$= \left(\frac{5y^2}{2} + 20y\right)_0^{10}$
$= \frac{5}{2} \times 100 + 20 \times 10$
$= 250 + 200 = 450J$

Question98

A porter lifts a heavy suitcase of mass 80kg and at the destination lowers it down by a distance of 80cm with a constant velocity. Calculate the workdone by the porter in lowering the suitcase.
(take $g = 9.8ms^{-2}$)
[22 Jul 2021 Shift 2]

Options:

B. $-627.2J$

C. $+627.2J$

D. $784.0J$

Answer: B

Solution:

Solution:
$W_{Porter} + W_{mg} = \Delta K.E. = 0$
$W_{Porter} = -W_{mg} = -mgh$
$= -80 \times 9.8 \times .8 = -627.2J$

Question99

If the Kinetic energy of a moving body becomes four times its initial Kinetic energy, then the percentage change in its momentum will be : [20 Jul 2021 Shift 2]

Options:

A. 100%

B. 200%

C. 300%

D. 400%

Answer: A

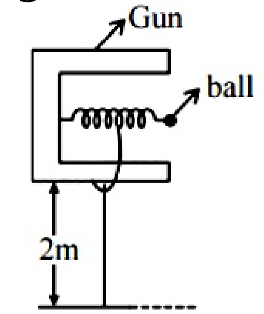
Solution:

Solution:
$K_2 = 4K_1$
$\frac{1}{2}mv_2^{\ 2} = 4\frac{1}{2}mv_1^{\ 2}$
$v_2 = 2v_1$
$P = mv$
$P_2 = mv_2 = 2mv_1$
$P_1 = mv_1$
% change $= \frac{\Delta P}{P_1} \times 100 = \frac{2mv_1 - mv_1}{mv_1} \times 100 = 100\%$

Question100

In a spring gun having spring constant 100N / m a small ball 'B' of mass 100g is put in its barrel (as shown in figure) by compressing the spring through 0.05m. There should be a box placed at a distance 'd' on the ground so that the ball falls in it. If the ball leaves the gun horizontally

($g = 10m / s^2$)

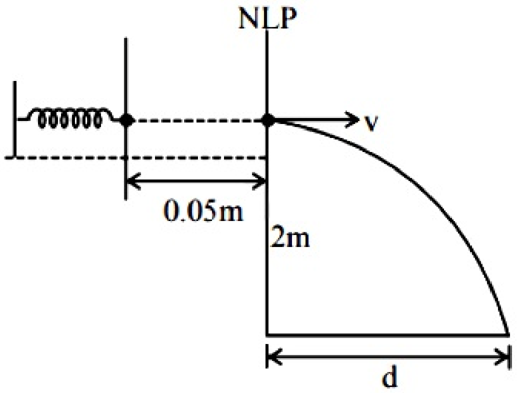


[20 Jul 2021 Shift 1]

Answer: 1

Solution:

Solution:



$\frac{1}{2}kx^2 = \frac{1}{2}mv^2$

$Kx^2 = mv^2$

$v = x\sqrt{\frac{k}{m}} = 0.05\sqrt{\frac{100}{0.1}} = 0.05 \times 10\sqrt{10}$

$v = 0.5\sqrt{10}$

From $h = \frac{1}{2}gt^2$

$t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2 \times 2}{10}} = \frac{2}{\sqrt{10}}$

$\therefore d = vt = 0.5\sqrt{10} \times \frac{2}{\sqrt{10}} = 1m$

Question101

An automobile of mass 'm' accelerates starting from origin and initially at rest, while the engine supplies constant power P. The position is given as a function of time by:
[27 Jul 2021 Shift 2]

Options:

A. $\left(9P \right)^{\frac{1}{2}} t^{\frac{3}{2}}$

B. $\left(\frac{8P}{9m}\right)^{\frac{1}{2}} t^{\frac{2}{3}}$

C. $\left(\frac{9m}{8P}\right)^{\frac{1}{2}} t^{\frac{3}{2}}$

D. $\left(\frac{8P}{9m}\right)^{\frac{1}{2}} t^{\frac{3}{2}}$

Answer: D

Solution:

Solution:

P = const.

$$P = Fv = \frac{mv^2 dv}{dx}$$

$$\int_0^x \frac{P}{m} dx = \int_0^v v^2 dv$$

$$\frac{Px}{m} = \frac{v^3}{3}$$

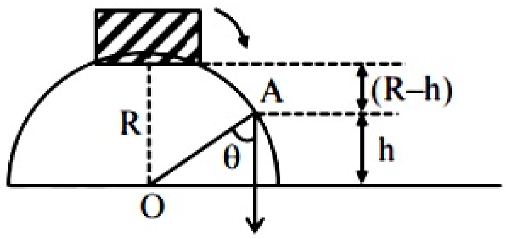
$$\left(\frac{3Px}{m}\right)^{1/3} = v = \frac{dx}{dt}$$

$$\left(\frac{3P}{m}\right)^{1/3} \int_0^t dt = \int_0^x x^{-1/3} dx$$

$$\Rightarrow x = \left(\frac{8P}{9m}\right)^{1/2} t^{3/2}$$

Question102

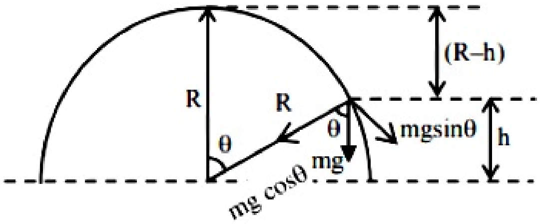
A small block slides down from the top of hemisphere of radius R = 3 m as shown in the figure. The height 'h' at which the block will lose contact with the surface of the sphere is ____m.
(Assume there is no friction between the block and the hemisphere)



2]

Answer: 2

Solution:



$mg\cos\theta = \frac{mv^2}{R}$ ....(1)

$\cos\theta = \frac{h}{R}$

Energy conservation

$mg\{R-h\} = \frac{1}{2}mv^2$ .....(2)

from (1) & (2)

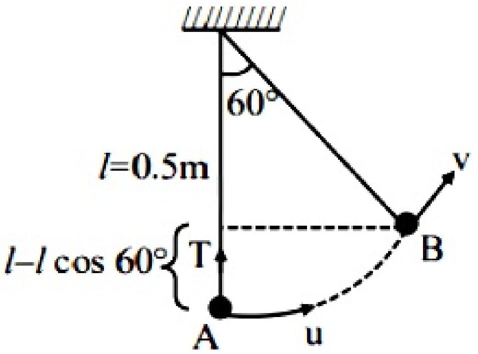
$\Rightarrow mg\left\{\frac{h}{R}\right\} = \frac{2mg\{R-h\}}{R}$

$h = \frac{2R}{3} = 2m$

Question103

A pendulum bob has a speed of 3 m/s at its lowest position. The pendulum is 50 cm long. The speed of bob, when the length makes an angle of 60° to the vertical will be ($g = 10\ m/s^2$) ______ m/s.
[25 Jul 2021 Shift 1]

Solution:



Applying work energy theorem:

$W_g + w_T = \Delta K$

$-mgl(1-\cos 60°) = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$

$v^2 = u^2 - 2gl(1-\cos 60°)$

$v^2 = 9 - 2\times 10\times 0.5\left(\frac{1}{2}\right)$

$v^2 = 4$

$v = 2m/s$

Question104

A body at rest is moved along a horizontal straight line by a machine delivering a constant power. The distance moved by the body in time 't' is proportional to:
[20 Jul 2021 Shift 2]

Options:

A. $t^{\frac{3}{2}}$

B. $t^{\frac{1}{2}}$

C. $t^{\frac{1}{4}}$

D. $t^{\frac{3}{4}}$

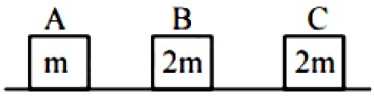
Answer: A

Solution:

Solution:
P = constant
$\frac{1}{2}mv^2 = Pt$
$\Rightarrow v \propto \sqrt{t}$
$\frac{dx}{dt} = C\sqrt{t}$ C = constant
by integration.
$x = C\frac{t^{\frac{1}{2}+1}}{\frac{1}{2}+1}$
$x \propto t^{3/2}$

Question105

Three objects A, B and C are kept in a straight line on a frictionless horizontal surface. The masses of A, B and C are m, 2 m and 2 m respectively. A moves towards B with a speed of 9 m/s and makes an elastic collision with it. Thereafter B makes a completely inelastic collision with C. All motions occur along same straight line. The final speed of C is :



[27 Jul 2021 Shift 1]

Options:

A. 6 m/s

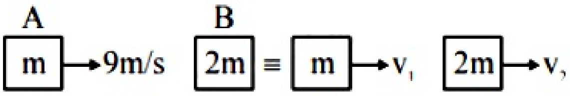
B. 9 m/s

D. 3 m/s

Answer: D

Solution:

Solution:
Collision between A and B

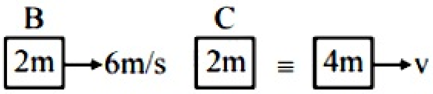


$m \times 9 = mv_1 + 2mv_2$ (from momentum conservation)

$e = 1 = \frac{v_2 - v_1}{9}$

$\Rightarrow v_2 = 6m / sec, v_1 = -3m / sec$

collision between B and C



$2m \times 6 = 4mv$ (from momentum conservation)
v = 3 m/s

Question106

A body of mass M moving at speed v_0 collides elastically with a mass m at rest. After the collision, the two masses move at angles θ_1 and θ_2 with respect to the initial direction of motion of the body of mass M. The largest possible value of the ratio $\frac{M}{m}$, for which the angles θ_1 and θ_2 will be equal, is
[31 Aug 2021 Shift 1]

Options:

A. 4

B. 1

C. 3

D. 2

Answer: C

Solution:

Solution:
Given, mass of body 1 = M
Mass of body 2 = m
Initial speed of body 1, $u_1 = v_0$
Initial speed of body 2, $u_1 = 0$
Final speed of body 1 and 2 = v_1 and v_2
Angle made by body 1 and 2 after collision with respect to initial direction = θ_1, θ_2
By using law of conservation of momentum, Along X-axis
$Mv_0 + m.0 = Mv_1 \cos\theta_1 + 2\cos\theta_2$

$\therefore Mv_0 = Mv_1 \cos\theta + mv_2 \cos\theta$ ...(i)
Along Y-axis,
$Mv_1 \sin\theta_1 = mv_2 \sin\theta_2$ [since, $\theta_1 = \theta_2 = \theta$]
$v_2 = \frac{Mv_1}{m}$...(ii)
Substituting the value of v_2 in Eq. (i), we get

$$Mv_0 = Mv_1 \cos\theta + m\left(\frac{Mv_1}{m}\right)\cos\theta$$
$$= 2Mv_1 \cos\theta$$
$$v_1 = \frac{v_0}{2\cos\theta} \text{ ...(iii)}$$

By using law of conservation of energy along X-axis

$$\frac{1}{2}Mv_0^{\ 2} = \frac{1}{2}Mv_1^{\ 2} + \frac{1}{2}mv_2^{\ 2}$$
$$\Rightarrow Mv_0^{\ 2} = Mv_1^{\ 2} + m\left(\frac{M}{m}v_1\right)^2 \text{ [from Eq. (ii)]}$$
$$\Rightarrow Mv_0^{\ 2} = Mv_1^{\ 2} + \frac{M^2v_1^{\ 2}}{m} = Mv_1^{\ 2}m(m + M)$$
$$\Rightarrow v_0^{\ 2} = \left(\frac{v_0}{2\cos\theta}\right)^2\left(\frac{m + M}{m}\right) \text{ [From Eq. (iii)]}$$
$$\Rightarrow v_0^{\ 2} = \frac{v_0^{\ 2}}{4\cos^2\theta}\left(1 + \frac{M}{m}\right)$$
$$\Rightarrow 4\cos^2\theta = 1 + \frac{M}{m}$$
$$\Rightarrow \frac{M}{m} = 4\cos^2\theta - 1 \text{ [For largest possible value of } \frac{M}{m}, \theta = 0 \text{]}$$
$$= 4\cos^2 0° - 1 = 4 - 1 = 3$$

Question107

A block moving horizontally on a smooth surface with a speed of 40m / s splits into two parts with masses in the ratio of 1 : 2. If the smaller part moves at 60m / s in the same direction, then the fractional change in kinetic energy is
[31 Aug 2021 Shift 2]

Options:

A. $\frac{1}{3}$

B. $\frac{2}{3}$

C. $\frac{1}{8}$

D. $\frac{1}{4}$

Answer: C

Solution:

Solution:
Let a block of mass M splits into two masses m_1 and m_2 in ratio 1: 2.
Then, mass of smaller part, $m_1 = \frac{M}{1 + 2} = \frac{M}{3}$

Speed of mass m_1, $v_1 = 60m / s$
Let speed of mass m_2, $v_2 = v$
Using conservation of linear momentum,
$p_i = p_f$
$Mv = m_1v_1 + m_2v_2$
$M \times 40 = \frac{M}{3} \times 60 + \frac{2M}{3} \times v$
⇒ = 30 m/s
∴ The fractional change in kinetic energy,
$\frac{\Delta K}{K} = \frac{K_f - K_i}{K_i} = \frac{K_f}{K_i} - 1$
$= \frac{\frac{1}{2}m_1{v_1}^2 + \frac{1}{2}m_2{v_2}^2}{\frac{1}{2}Mv^2} - 1$
$= \frac{\frac{1}{2}\left[\frac{M}{3} \times (60)^2 + \frac{2M}{3} \times (30)^2\right]}{\frac{1}{2}M \times (40)^2} - 1 = \frac{9}{8} - 1 = \frac{1}{8}$

Question108

A block moving horizontally on a smooth surface with a speed of $40ms^{-1}$ splits into two equal parts. If one of the parts moves at $60ms^{-1}$ in the same direction, then the fractional change in the kinetic energy will be x: 4, where x is
[31 Aug 2021 Shift 1]

Answer: 5

Solution:

Solution:
Given, initial speed of block, $u = 40ms^{-1}$
Let total mass of block = m
∴ Broken masses, $m_1 = m_2 = \frac{m}{2}$
Final speed of m_1, $v_1 = 60ms^{-1}$
As we know that, kinetic energy, $KE = \frac{1}{2}mv^2$
∴ Initial kinetic energy $KE_i = \frac{1}{2}mu^2$
$= \frac{1}{2}m(40)^2 = 800m$ ...(i)
By using law of conservation of momentum,
$mu = m_1v_1 + m_2v_2$
$\therefore v_2 = \frac{m \times 40 - \frac{m}{2} \times 60}{\frac{m}{2}}$
$= \frac{10m}{\frac{m}{2}} = 20ms^{-1}$
So, final kinetic energy $KE_f = \frac{1}{2}m_1{v_1}^2 + \frac{1}{2}m_2{v_2}^2$

$= \frac{m}{4}(3600 + 400)$
$= 1000m$ ...(ii)
∴ Divide Eq (ii) by Eq. (i), we get
$\frac{KE_f}{KE_i} = \frac{1000m}{800} = \frac{5}{4}m$
So, x = 5

Question109

Two persons A and B perform same amount of work in moving a body through a certain distance d with application of forces acting at angle 45° and 60° with the direction of displacement respectively. The ratio of force applied by person A to the force applied by person B is $\frac{1}{\sqrt{x}}$. The value of x is ....
[27 Aug 2021 Shift 1]

Solution:

Given, work done by both person is same,
$W_A = W_B$
Direction of first force with displacement, $\theta_1 = 45°$
Direction of first force with displacement, $\theta_2 = 60°$
Ratio of force applied by person A to force applied by person B is
$F_A : F_B = 1 : \sqrt{x}$.
Work done by both person is same,
$W_A = W_B =$
$\Rightarrow F_A d \cos\theta_1 = F_B d \cos\theta_2$
(∵ distance is same for both = d)
$\frac{F_A}{F_B} = \frac{\cos\theta_1}{\cos\theta_2} = \frac{\cos 60°}{\cos 45°}$
$\Rightarrow \frac{F_A}{F_B} = \frac{\frac{1}{2}}{\frac{1}{\sqrt{2}}} = \frac{1}{\sqrt{2}}$
$\Rightarrow \frac{F_A}{F_B} = \frac{1}{\sqrt{x}} = \frac{1}{\sqrt{2}}$
$\Rightarrow x = 2$
Thus, the value of x is 2.

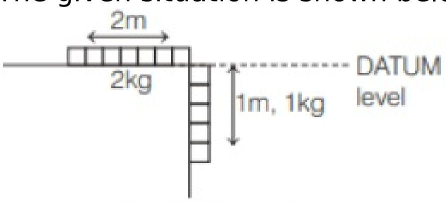
Question110

A uniform chain of length 3m and mass 3 kg overhangs a smooth table with 2m laying on the table. If k is the kinetic energy of the chain in joule as it completely slips off the table, then the value of k is .... (Take, $g = 10m / s^2$)
[26 Aug 2021 Shift 1]

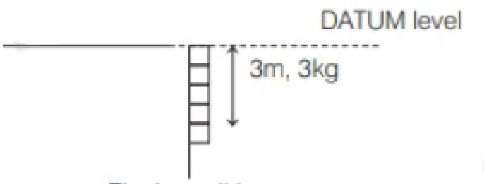
Answer: 40

Solution:

The given situation is shown below as



Initial condition



Final condition

Applying law of conservation of energy, we get

$K_{initial} + U_{initial} = K_{final} + U_{final}$

$K_{initial} = 0$

$\Rightarrow U_{initial} = -1 \times 10 \times \frac{1}{2}$ (1m lie below DATUM level, so negative)

$K_{final} = ?$

$U_{final} = -3 \times 10 \times \frac{3}{2}$(3m lie below DATUMlevel, so negative)

$0 - 1 \times 10 \times \frac{1}{2} = K_{final} - 3 \times 10 \times \frac{3}{2}$

$\Rightarrow -5 = K_{final} - 45$

$\Rightarrow K_{final} = 45 - 5$

= 40 J

Question111

A body of mass m dropped from a height h reaches the ground with a speed of $0.8\sqrt{gh}$. The value of workdone by the air-friction is [1 Sep 2021 Shift 2]

Options:

A. $-0.68\,mgh$

B. mgh

C. $1.64\,mgh$

D. $0.64\,mgh$

Answer: A

Solution:

Given, the mass of the body = m
The height from which the body dropped = h
The speed of the body when reached the ground, $v_f = 0.8\sqrt{gh}$
Initial velocity of the body, v = 0 m / s
Using the work-energy theorem,
Work done by gravity + Work done by air-friction = Final kinetic energy - Initial kinetic energy

$$W_{mg} + W_{air-friction} = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$

Here, work done by gravity = mgh

$$\Rightarrow mgh + W_{air-friction} = \frac{1}{2}m(0.8\sqrt{gh})^2 - \frac{1}{2}m(0)^2$$

$$\Rightarrow W_{air-fricion} = \frac{0.64mgh}{2} - mgh$$

= 0.32 mgh - mgh = -0.68 mgh
The value of the work done by the air friction is -0.68 mgh.

Question112

An engine is attached to a wagon through a shock absorber of length 1.5m. The system with a total mass of 40000 kg is moving with a speed of $72 kmh^{-1}$, when the brakes are applied to bring it to rest. In the process of the system being brought to rest, the spring of the shock absorber gets compressed by 1.0m. If 90% of energy of the wagon is lost due to friction, the spring constant is .... × 10^5N / m.
[1 Sep 2021 Shift 2]

Answer: 16

Solution:

Solution:
Given, the length of the shock absorber, l = 1.5 m
The total mass of the system, M = 40000 kg
The speed of the wagon, v = 72 km/h
When brakes are applied, the final velocity, $v_f = 0$
The compressed spring of the shock absorber, x = 1mApplying the work-energy theorem,
Work done by the system = Change in kinetic energy
W = Δ KE

$$W_{friction} + W_{spring} = \frac{1}{2}mv_f^2 + \frac{1}{2}mv_i^2$$

$$-\frac{90}{100}\left(\frac{1}{2}mv^2\right) + W_{spring} = 0 - \frac{1}{2}mv_i^2$$ (∵ 90% energy lost due to friction)

$$W_{spring} = -\frac{10}{100} \times \frac{1}{2}mv^2$$

$$-\frac{1}{2}kx^2 = \frac{1}{20}mv^2$$

$$k = \frac{mv^2}{10 \times x^2}$$

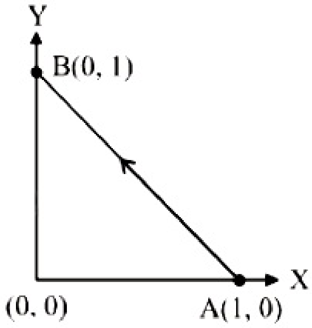
Substituting the values in the above equation, we get

$$k = \frac{40000 \times \left(72 \times \frac{5}{18}\right)^2}{10(1)^2}$$

The value of the x = 16.

Question113

Consider a force $\vec{F} = -x\hat{i} + y\hat{j}$. The work done by this force in moving a particle from point A(1, 0) to B(0, 1) along the line segment is: (all quantities are in SI units)



[9 Jan. 2020 I]

Options:

A. 2J

B. $\frac{1}{2}$J

C. 1J

D. $\frac{3}{2}$J

Answer: C

Solution:

Solution:

Work done, $W = \int \vec{F} . \vec{ds}$

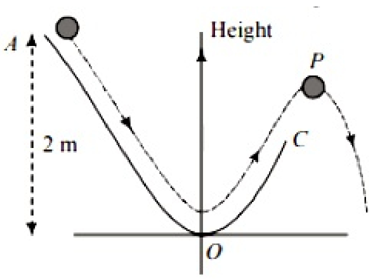
$= \left(-x\hat{i} + y\hat{j}\right) . \left(d \times \hat{i} + d\hat{y}\right)$

$\Rightarrow W = -\int_1^0 x d x + \int_0^1 y d y$

$= \left(0 + \frac{1}{2}\right) + \frac{1}{2} = 1J$

Question114

A particle (m = 1kg) slides down a frictionless track (AOC) starting from rest at a point A (height 2m). After reaching C, the particle continues to move freely in air as a projectile. When it reaching its highest point P (height 1m), the kinetic energy of the particle (in J) is:
(Figure drawn is schematic and not to scale; take g = 10 ms^{-2}) ________.



[NA 7 Jan. 2020 I]

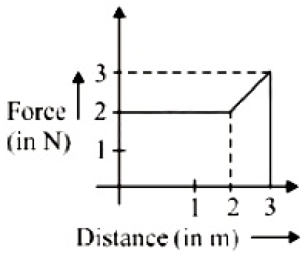
Answer: 10

Solution:

Solution:
Kinetic energy = change in potential energy of the particle,
$KE = mg\Delta h$
Given, $m = 1kg$
$\Delta h = h_2 - h_1 = 2 - 1 = 1m$
$\therefore KE = 1 \times 10 \times 1 = 10J$

Question115

A particle moves in one dimension from rest under the influence of a force that varies with the distance travelled by the particle as shown in the figure. The kinetic energy of the particle after it has travelled 3m is :



[7 Jan. 2020 II]

Options:

A. 4J

B. 2.5J

C. 6.5J

D. 5J

Answer: C

Solution:

Solution:

$\therefore W = \frac{1}{2} \times (3+2) \times (3-2) + 2 \times 2 = 2.5 + 4 = 6.5J$

Using work energy theorem,
$\Delta K.E =$ work done
$\therefore \Delta K.E = 6.5J$

Question116

A 60 HP electric motor lifts an elevator having a maximum total load capacity of 2000 kg. If the frictional force on the elevator is 4000 N, the speed of the elevator at full load is close to: (1 HP = 746 W, g = 10 ms^{-2}) [7 Jan. 2020 I]

Options:

A. 1.7 ms^{-1}

B. 1.9 ms^{-1}

C. 1.5 ms^{-1}

D. 2.0 m^{-1}

Answer: B

Solution:

Solution:
Total force required to lift maximum load capacity against frictional force = 400 N
$F_{total} = Mg +$ friction
$= 2000 \times 10 + 4000$
$= 20,000 + 4000 = 24000N$
Using power, $P = F \times v$
$60 \times 746 = 24000 \times v$
$\Rightarrow v = 1.86m/s \approx 1.9m/s$
Hence speed of the elevator at full load is close to $1.9ms^{-1}$

Question117

**Two particles of equal mass m have respective initial velocities $u\hat{i}$ and $u\left(\frac{\hat{i}+\hat{j}}{2}\right)$. They collide completely inelastically. The energy lost in the process is:
[9 Jan. 2020 I]**

Options:

A. $\frac{1}{3}mu^2$

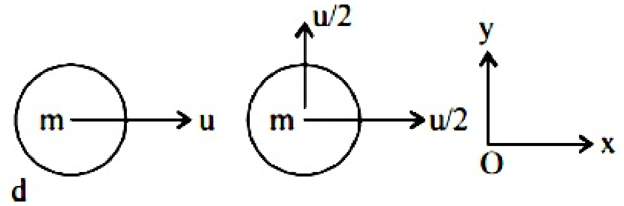
B. $\frac{1}{8}mu^2$

D. $\sqrt{\frac{2}{3}mu^2}$

Answer: B

Solution:

Solution:



x-direction

$mu + \frac{mu}{2} = 2mv_x' \Rightarrow V_x' = \frac{3u}{4}$

y-direction $0 + \frac{mu}{2} = 2mv_y' \Rightarrow v_y' = \frac{u}{4}$

$K.E_{.i} = \frac{1}{2}mu^2 + \frac{1}{2}m\left[\left(\frac{u}{2}\right)^2 + \left(\frac{u}{2}\right)^2\right]$

$= \frac{1}{2}mu^2 + \frac{mu^2}{4} = \frac{3mu^2}{4}$

$K.E.f = \frac{1}{2}(2m)(v_x')^2 + \frac{1}{2}(2m)(v_y')^2$

$= \frac{1}{2}2m\left[\left(\frac{3u}{4}\right)^2 + \left(\frac{u}{4}\right)^2\right] = \frac{5}{8}mu^2$

∴ Loss in $KE = KE_f - KE_i$

$= mu^2\left(\frac{6}{8} - \frac{5}{8}\right) = \frac{mu^2}{8}$

Question118

A body A, of mass m = 0.1kg has an initial velocity of $3\hat{i}\,ms^{-1}$ It collides elastically with another body, B of the same mass which has an initial velocity of $5\hat{j}\,ms^{-1}$. After collision, A moves with a velocity $\vec{v} = 4(\hat{i} + \hat{j})$. The energy of B after collision is written as $\frac{x}{10}J$. The value of x is ________. [NA 8 Jan. 2020 I]

Answer: 1

Solution:

Solution:

For elastic collision $KE_i = KE_f$

$\frac{1}{2}m \times 25 + \frac{1}{2} \times m \times 9 = \frac{1}{2}m \times 32 + \frac{1}{2}mv_B^2$

$34 = 32 + V_B^2 \Rightarrow V_B = \sqrt{2}$

$KE_B = \frac{1}{2}mv_B^2 = \frac{1}{2} \times 0.1 \times 2 = 0.1J = \frac{1}{10}J$

$\therefore x = 1$

Question119

A particle of mass m is dropped from a height h above the ground. At the same time another particle of the same mass is thrown vertically upwards from the ground with a speed of $\sqrt{2gh}$. If they collide head-on completely inelastically, the time taken for the combined mass to reach the ground, in units of $\sqrt{\frac{h}{g}}$ is:

[8 Jan. 2020 II]

Options:

A. $\sqrt{\frac{1}{2}}$

B. $\sqrt{\frac{3}{4}}$

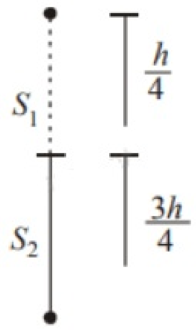
C. $\frac{1}{2}$

D. $\sqrt{\frac{3}{2}}$

Answer: D

Solution:

Solution:
Let t be the time taken by the particle dropped from height h to collide with particle thrown upward.
Using,



$v^2 - u^2 = 2gh$
$\Rightarrow v^2 - 0^2 = 2gh$
$\Rightarrow v = \sqrt{2gh}$
Downward distance travelled
$S_1 = \frac{1}{2}gt^2 = \frac{1}{2}g \cdot \frac{h}{2g} = \frac{h}{4}$
Distance of collision point from ground
$s_2 = h - \frac{h}{4} = \frac{3h}{4}$
Speed of (A) just before collision
$v_1 = gt = \sqrt{\frac{gh}{2}}$
And speed of (B) just before collision
$v_2 = \sqrt{2gh} - \sqrt{\frac{gh}{2}}$
Using principle of conservation of linear momentum

$$\Rightarrow \frac{v_f = m\left(\sqrt{2gh} - \sqrt{\frac{gh}{2}}\right) - m\sqrt{\frac{gh}{2}} = 0}{2m}$$

After collision, time taken (t_1) for combined mass to reach the ground is

$$\Rightarrow \frac{3h}{4} = \frac{1}{2} g t_1^{\,2}$$

$$\Rightarrow t_1 = \sqrt{\frac{3h}{2g}}$$

Question120

A person pushes a box on a rough horizontal platform surface. He applies a force of 200N over a distance of 15m . Thereafter, he gets progressively tired and his applied force reduces linearly with distance to 100N . The total distance through which the box has been moved is 30m . What is the work done by the person during the total movement of the box?
[4 Sep. 2020 (II)]

Options:

A. 3280J

B. 2780J

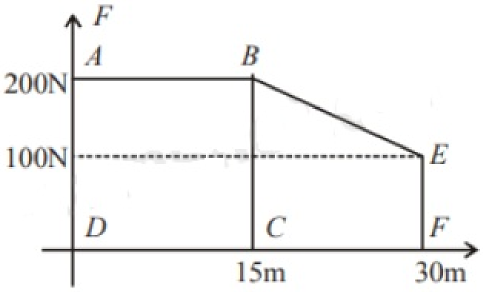
C. 5690J

D. 5250J

Answer: D

Solution:

Solution:
The given situation can be drawn graphically as shown in figure.
Work done = Area under $F - x$ graph
= Area of rectangle $ABCD$ + Area of trapezium $BCFE$



$$W = (200 \times 15) + \frac{1}{2}(100 + 200) \times 15 = 3000 + 2250$$

$$\Rightarrow W = 5250\text{J}$$

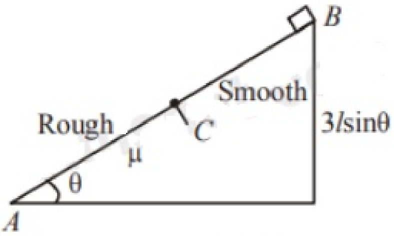
Question121

A small block starts slipping down from a point B on an inclined plane AB, which is making an angle θ with the horizontal section BC is smooth and the remaining section CA is rough with a coefficient of friction μ . It is found that the block comes to rest as it reaches the bottom (point A) of the inclined plane. If BC = 2AC , the coefficient of friction is given by μ = k tan θ. The value of k is ________.
[NA 2 Sep. 2020 (I)]

Answer: 3

Solution:

Solution:
If $AC = l$ then according to question, $BC = 2l$ and $AB = 3l$.



Here, work done by all the forces is zero.
$W_{friction} + W_{mg} = 0$
$mg(3l)\sin\theta - \mu mg\cos\theta(l) = 0$
$\Rightarrow \mu mg\cos\theta l = 3mgl\sin\theta$
$\Rightarrow \mu = 3\tan\theta = k\tan\theta$
$\therefore k = 3$

Question122

A cricket ball of mass 0.15kg is thrown vertically up by a bowling machine so that it rises to a maximum height of 20 m after leaving the machine. If the part pushing the ball applies a constant force F on the ball and moves horizontally a distance of 0.2m while launching the ball, the value of F (in N) is ($g = 10ms^{-2}$) ________.
[NA 3 Sep. 2020 (I)]

Answer: 150

Solution:

Solution:
From work energy theorem,
$W = F.s = \Delta KE = \frac{1}{2}mv^2$

$\therefore F \cdot s = F \times \frac{2}{10} = \frac{1}{2} \times \frac{15}{100} \times 2 \times 10 \times 20$

$\therefore F = 150N$

Question123

A body of mass 2 kg is driven by an engine delivering a constant power of 1 J/s. The body starts from rest and moves in a straight line. After 9 seconds, the body has moved a distance (in m) ________.
[5 Sep. 2020 (II)]

Answer: 18

Solution:

Solution:
Given, Mass of the body, m = 2 kg
Power delivered by engine, P = 1 J/s
Time, t = 9 seconds
Power, P = Fv

$\Rightarrow P = mav[\because F = ma]$

$\Rightarrow m\frac{dv}{dt}v = P\left(\because a = \frac{dv}{dt}\right)$

$\Rightarrow vdv = \frac{P}{m}dt$

Integrating both sides we get

$\Rightarrow \int_0^v vdv = \frac{P}{m}\int_0^t dt$

$\Rightarrow \frac{v^2}{2} = Ptm \Rightarrow v = \left(\frac{2Pt}{m}\right)^{1/2}$

$\Rightarrow \frac{dx}{dt} = \sqrt{\frac{2P}{m}}t^{1/2}\left(\because v = \frac{dx}{dt}\right)$

$\Rightarrow \int_0^x dx = \sqrt{\frac{2P}{m}}\int_0^t t^{1/2}dt$

$\therefore$ Distance, $x = \sqrt{\frac{2P}{m}}\frac{t^{3/2}}{3/2} = \sqrt{\frac{2P}{m}} \times \frac{2}{3}t^{3/2}$

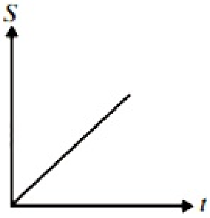
$\Rightarrow x = \sqrt{\frac{2 \times 1}{2}} \times \frac{2}{3} \times 9^{3/2} = \frac{2}{3} \times 27 = 18$

Question124

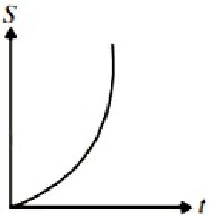
A particle is moving unidirectionally on a horizontal plane under the action of a constant power supplying energy source. The displacement (s) - time (t) graph that describes the motion of the particle is (graphs are drawn schematically and are not to scale) :
[3 Sep. 2020 (II)]

Options:

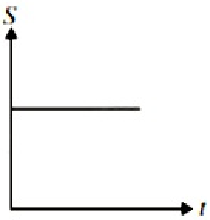
A.



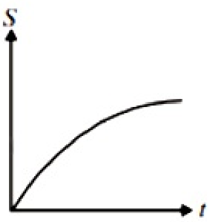
B.



C.



D.



Answer: B

Solution:

Solution:
We know that
Power, P = Fv

But $F = mav = m\frac{dv}{dt}v$

$\therefore P = mv\frac{dv}{dt} \Rightarrow Pdt = mvdv$

Integrating both sides $\int_0^t Pdt = m\int_0^v vdv$

$P.t = \frac{1}{2}mv^2 \Rightarrow v = \left(\sqrt{\frac{2P}{m}}\right)t^{1/2}$

Distance, $s = \int_0^t vdt = \sqrt{\frac{2P}{m}}\int_0^t t^{1/2}dt = \sqrt{\frac{2P}{m}} \cdot \frac{t^{3/2}}{3/2}$

$\Rightarrow s = \sqrt{\frac{8P}{9m}} \cdot t^{3/2} \Rightarrow s \propto t^{3/2}$

So, graph (b) is correct.

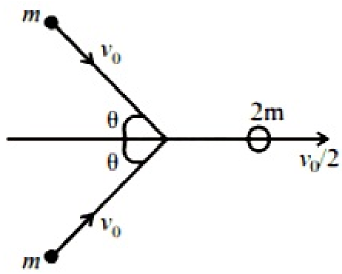
Question125

Two bodies of the same mass are moving with the same speed, but in different directions in a plane. They have a completely inelastic collision and move together thereafter with a final speed which is half of their initial speed. The angle between the initial velocities of the two bodies (in degree) is ________.
[NA 6 Sep. 2020 (I)]

Answer: 120

Solution:

Solution:



Momentum conservation along x direction,

$2mv_0 \cos\theta = 2m\frac{v_0}{2} \Rightarrow \cos\theta = \frac{1}{2}$ or $\theta = 60°$

Hence angle between the initial velocities of the two bodies $= \theta + \theta = 60° + 60° = 120°$

Question126

Particle A of mass m_1 moving with velocity $\left(\sqrt{3}\hat{i} + \hat{j}\right)ms^{-1}$ collides with another particle B of mass m_2 which is at rest initially. Let $\vec{v}_1$ and $\vec{v}_2$ be the velocities of particles A andB after collision respectively. If $m_1 = 2m_2$ and after collision $\vec{v}_1 = \left(\hat{i} + \sqrt{3}\hat{j}\right)ms^{-1}$, the angle between $\vec{v}_1$ and $\vec{v}_2$ is:
[6 Sep. 2020 (II)]

Options:

A. 15°

B. 60°

C. −45°

D. 105°

Answer: D

Solution:

Solution:
Before collision,

Velocity of particle A, $u_1 = (\sqrt{3}\hat{i} + \hat{j})\,m/s$
Velocity of particle B, $u_2 = 0$
After collision,

Velocity of particle A, $v_1 = (\hat{i} + \sqrt{3}\hat{j})$
Velocity of particle B, $v_2 = 0$
Using principal of conservation of angular momentum

$m_1\vec{u}_1 + m_2\vec{u}_2 = m_1\vec{v}_1 + m_2\vec{v}_2$

$\Rightarrow 2m_2(\sqrt{3}\hat{i} + \hat{j}) + m_2 \times 0 = 2m_2(\hat{i} + \sqrt{3}\hat{j}) + m_2 \times \vec{v}_2$

$\Rightarrow 2\sqrt{3}\hat{i} + 2\hat{j} = 2\hat{i} + 2\sqrt{3}\hat{j} + \vec{v}_2$

$\Rightarrow \vec{v}_2 = (\sqrt{3} - 1)\hat{i} - (\sqrt{3} - 1)\hat{j}$

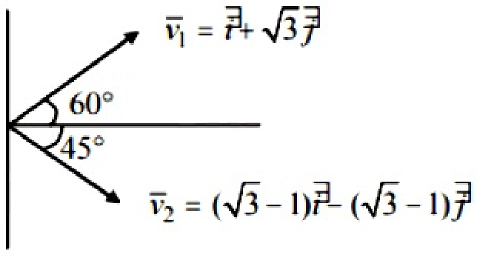
$\Rightarrow \vec{v}_1 = \hat{i} + \sqrt{3}\hat{j}$

For angle between $\vec{v}_1$ and $\vec{v}_2$,

$\cos\theta = \frac{\vec{v}_1 \cdot \vec{v}_2}{\vec{v}_1\vec{v}_2} = \frac{2(\sqrt{3}-1)(1-\sqrt{3})}{2 \times 2\sqrt{2}(\sqrt{3}-1)} = \frac{1-\sqrt{3}}{2\sqrt{2}}$

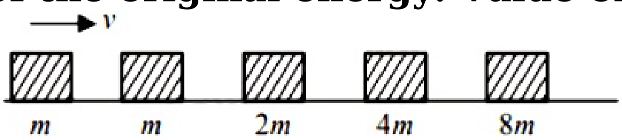
$\Rightarrow \theta = 105°$

Angle between $\vec{v}_1$ and $\vec{v}_2$ is 105°



Question127

Blocks of masses m, 2m, 4m and 8m are arranged in a line on a frictionless floor. Another block of mass m, moving with speed v along the same line (see figure) collides with mass m in perfectly inelastic manner. All the subsequent collisions are also perfectly inelastic. By the time the last block of mass 8m starts moving the total energy loss is p% of the original energy. Value of ′p ' is close to:



[4 Sep. 2020 (I)]

Options:

A. 77

B. 94

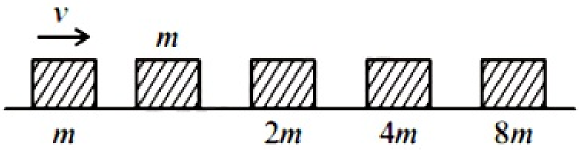
C. 37

D. 87

Answer: B

Solution:

According to the question, all collisions are perfectly inelastic, so after the final collision, all blocks are moving together.



Let the final velocity be v', using momentum conservation

$mv = 16mv' \Rightarrow v' = \frac{v}{16}$

Now initial energy $E_i = \frac{1}{2}mv^2$

Final energy: $E_f = \frac{1}{2} \times 16m \times \left(\frac{v}{16}\right)^2 = \frac{1}{2}\frac{mv^2}{16}$

Energy loss : $E_i - E_f = \frac{1}{2}mv^2 - \frac{1}{2}m\frac{v^2}{16}$

$\Rightarrow \frac{1}{2}mv^2\left[1 - \frac{1}{16}\right] \Rightarrow \frac{1}{2}mv^2\left[\frac{15}{16}\right]$

The total energy loss is P% of the original energy.

$\therefore \%P = \frac{\text{Energy loss}}{\text{Original energy}} \times 100$

$= \frac{\frac{1}{2}mv^2\left[\frac{15}{16}\right]}{\frac{1}{2}mv^2} \times 100 = 93.75\%$

Question128

A block of mass 1.9kg is at rest at the edge of a table, of height 1m. A bullet of mass 0.1kg collides with the block and sticks to it. If the velocity of the bullet is 20m / s in the horizontal direction just before the collision then the kinetic energy just before the combined system strikes the floor, is [Take g = 10m / s^2. Assume there is no rotational motion and losss of energy after the collision is negligiable.
[3 Sep. 2020 (II)]

Options:

A. 20J

B. 21J

C. 19J

D. 23J

Answer: B

Solution:

Solution:
Given,
Mass of block, $m_1 = 1.9$ kg
Mass of bullet, $m_2 = 0.1$ kg
Velocity of bullet, $v_2 = 20$ m/s
Let v be the velocity of the combined system. It is an inelastic collision.
Using conservation of linear momentum
$m_1 \times 0 + m_2 \times v_2 = (m_1 + m_2)v$

Using work energy theorem
Work done = Change in Kinetic energy
Let K be the Kinetic energy of combined system.
$(m_1 + m_2)gh$
$= K - \frac{1}{2}(m_1 + m_2)V^2$
$\Rightarrow 2 \times g \times 1 = K - \frac{1}{2} \times 2 \times 1^2 \Rightarrow K = 21J$

Question129

A particle of mass m with an initial velocity $u\hat{i}$ collides perfectly elastically with a mass 3m at rest. It moves with a velocity $v\hat{j}$ after collision, then, v is given by :
[2 Sep. 2020 (I)]

Options:

A. $v = \sqrt{\frac{2}{3}}u$

B. $v = \frac{u}{\sqrt{3}}$

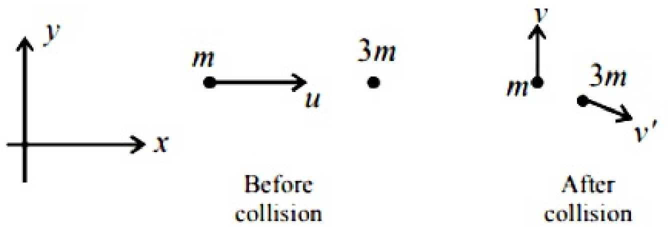
C. $v = \frac{u}{\sqrt{2}}$

D. $v = \frac{1}{\sqrt{6}}u$

Answer: C

Solution:

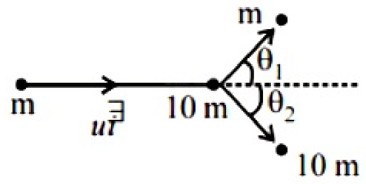
Solution:
From conservation of linear momentum
$mu\hat{i} + 0 = mv\hat{j} + 3m\vec{v}'$
$\vec{v}' = \frac{u}{3}\hat{i} - \frac{v}{3}\hat{j}$



From kinetic energy conservation,
$\frac{1}{2}mu^2 = \frac{1}{2}mv^2 + \frac{1}{2}(3m)\left(\left(\frac{u}{3}\right)^2 + \left(\frac{v}{3}\right)^2\right)$
or, $mu^2 = mv^2 + \frac{mu^2}{3} + \frac{mv^2}{3}$
$\therefore v = \frac{u}{\sqrt{2}}$

Question130

A particle of mass m is moving along the x -axis with initial velocity $u\hat{i}$. It collides elastically with a particle of mass 10m at rest and then moves with half its initial kinetic energy (see figure). If $\sin\theta_1 = \sqrt{n}\sin\theta_2$, then value of n is ______.



[NA 2 Sep. 2020 (II)]

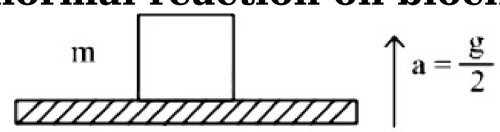
Answer: 10

Solution:

Solution:
From momentum conservation in perpendicular direction of initial motion.
$mu_1\sin\theta_1 = 10mv_1\sin\theta_2$ ...(i)
It is given that energy of m reduced by half. If u_1 be velocity of m after collision, then
$\left(\frac{1}{2}mu^2\right)\frac{1}{2} = \frac{1}{2}mu_1^{\ 2}$
$\Rightarrow u_1 = \frac{u}{\sqrt{2}}$
If v_1 be the velocity of mass 10m after collision, then
$\frac{1}{2}\times 10m\times v_1^{\ 2} = \frac{1}{2}m\frac{u^2}{2} \Rightarrow v_1 = \frac{u}{\sqrt{20}}$
From equation (i), we have
$\sin\theta_1 = \sqrt{10}\sin\theta_2$

Question131

A block of mass m is kept on a platform which starts from rest with constant acceleration g / 2 upward, as shown in fig. work done by normal reaction on block in time t is:



[10 Jan. 2019 I]

Options:

A. $-\frac{mg^2t^2}{8}$

B. $\frac{mg^2t^2}{8}$

C. 0

D. $3mg^2t^2$

Answer: D

Solution:

Solution:

Here, $N - mg = ma = \frac{mg}{2} \Rightarrow N = \frac{3mg}{2}$

$N =$ normal reaction Now, work done by normal reaction 'N' on block in time t, $W = \vec{N}\vec{S} = \left(\frac{3mg}{2}\right)\left(\frac{1}{2}g / 2t^2\right)$

or, $W = \frac{3mg^2t^2}{8}$

Question132

A particle which is experiencing a force, given by $\vec{F} = 3\vec{i} - 12\vec{j}$, undergoes a displacement of $\vec{d} = 4\vec{i}$. If the particle had a kinetic energy of 3J at the beginning of the displacement, what is its kinetic energy at the end of the displacement?
[10 Jan. 2019 II]

Options:

A. 9J

B. 12J

C. 10J

D. 15J

Answer: D

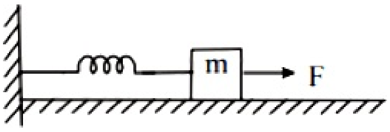
Solution:

Solution:

Work done $= \vec{F} . \vec{d} = \left(3\vec{i} - 12\vec{j}\right) . \left(4\vec{i}\right) = 12J$
From work energy theorem,
$w_{net} = \Delta K . E . = k_f - k_i$
$\Rightarrow 12 = k_f - 3$
$\therefore K_f = 15J$

Question133

A block of mass m, lying on a smooth horizontal surface, is attached to a spring (of negligible mass) of spring constant k. The other end of the spring is fixed, as shown in the figure. The block is initally at rest in its equilibrium position. If now the block is pulled with a constant force F, the maximum speed of the block is:



[9 Jan. 2019 I]

Options:

A. $\frac{2F}{\sqrt{mk}}$

B. $\frac{F}{\pi\sqrt{mk}}$

C. $\frac{\pi F}{\sqrt{mk}}$

D. $\frac{F}{\sqrt{mk}}$

Answer: D

Solution:

Solution:
Maximum speed is at mean position or equilibrium
At equilibrium Position
$F = kx \Rightarrow x = \frac{F}{k}$
From work-energy theorem,
$W_F + W_{sp} = \Delta K E$
$F(x) - \frac{1}{2}kx^2 = \frac{1}{2}mv^2 - 0$
$F\left(\frac{F}{k}\right) - \frac{1}{2}k\left(\frac{F}{k}\right)^2 = \frac{1}{2}mv^2$
$\Rightarrow \frac{1}{2}\frac{F^2}{K} = \frac{1}{2}mv^2$
or, $v_{max} = \frac{F}{\sqrt{mk}}$

Question134

A force acts on a 2kg object so that its position is given as a function of time as $x = 3t^2 + 5$. What is the work done by this force in first 5 seconds?
[9 Jan. 2019 II]

Options:

A. 850J

B. 950J

C. 875J

D. 900J

Answer: D

Solution:
Position, $x = 3t^2 + 5$

$\therefore$ Velocity ,$v = \frac{dx}{dt} \Rightarrow v = \frac{d(3t^2 + 5)}{dt}$

$\Rightarrow v = 6t + 0$
At $t = 0$
And, at $t = 5$ sec
$v = 0$
$v = 30m / s$
According to work-energy theorem, $w = \Delta KE$

or $W = \frac{1}{2}mv^2 - 0 = \frac{1}{2}(2)(30)^2 = 900J$

Question135

An alpha-particle of mass m suffers 1 -dimensional elastic collision with a nucleus at rest of unknown mass. It is scattered directly backwards losing, 64% of its initial kinetic energy. The mass of the nucleus is : [12 Jan. 2019 II]

Options:

A. 2m

B. 3.5m

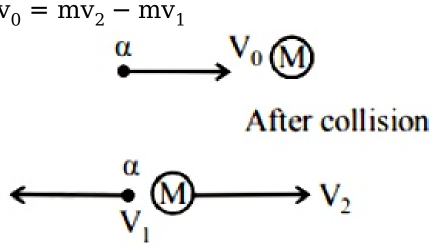
C. 1.5m

D. 4m

Answer: D

Solution:

Solution:
Using conservation of momentum,
$mv_0 = mv_2 - mv_1$



$\frac{1}{2}mv_1^{\ 2} = 0.36 \times \frac{1}{2}mv_0^{\ 2}$

$\Rightarrow v_1 = 0.6v_0$
The collision is elastic. So,

$\frac{1}{2}MV_2^{\ 2} = 0.64 \times \frac{1}{2}mv_0^{\ 2}$[$\therefore M$ = mass of nucleus]

$\Rightarrow V_2 = \sqrt{\frac{m}{M}} \times 0.8V_0$

$mV_0 = \sqrt{mM} \times 0.8V_0 - m \times 0.6V_0$

$\Rightarrow 1.6m = 0.8\sqrt{mM}$

$\Rightarrow 4m^2 = mM$

$\therefore M = 4m$

A piece of wood of mass 0.03kg is dropped from the top of a 100m height building. At the same time, a bullet of mass 0.02kg is fired vertically upward, with a velocity $100ms^{-1}$, from the ground. The bullet gets embedded in the wood. Then the maximum height to which the combined system reaches above the top of the building before falling below is: ($g = 10ms^{-2}$)
[10 Jan. 2019 I]

Options:

A. 20m

B. 30m

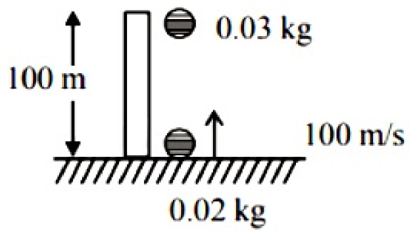
C. 40m

D. 10m

Answer: C

Solution:

Solution:



Time taken for the particles to collide,

$t = \frac{d}{V_{rel}} = \frac{100}{100} = 1sec$

Speed of wood just before collision = gt = 10 m/s and speed of bullet just before collision = v – gt = 100 − 10 = 90 m/s

$S = 100 \times 1 - \frac{1}{2} \times 10 \times 1 = 95m$

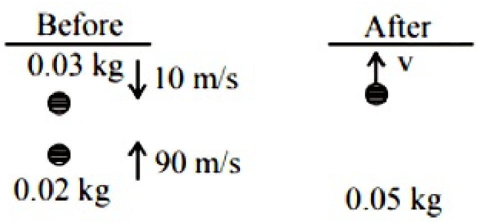
Now, using conservation of linear momentum just before and after the collision

– (0.03) (10) + (0.02) (90) = (0.05)v

⇒ 150 = 5v ∴ v = 30m/s

Max. height reached by body

$h = \frac{30 \times 30}{2 \times 10} = 45m$

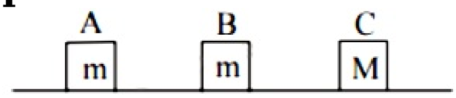


∴ Height above tower = 40 m

Question137

There block A, B and C are lying on a smooth horizontal surface, as shown in the figure. A and B have equal masses, m while C has mass M . Block A is given an inital speed v towards B due to which it collides with

perfectly inelastically $\frac{5}{6}$ th of the initial kinetic energy is lost in whole process. What is value of M / m ?



[9 Jan. 2019 I]

Options:

A. 5

B. 2

C. 4

D. 3

Answer: C

Solution:

Solution:
Kinetic energy of block A

$k_1 = \frac{1}{2} m v_0^2$

∴ From principle of linear momentum conservation

$m v_0 = (2m + M) v_f \Rightarrow v_f = \frac{m v_0}{2m + M}$

According to question, of $\frac{5}{6}$ th the initial kinetic energy is lost in whole process.

$$\therefore \frac{k_i}{k_f} = 6 \Rightarrow \frac{\frac{1}{2} m v_0^2}{\frac{1}{2}(2m + M)\left(\frac{m v_0}{2m + M}\right)^2} = 6$$

$$\Rightarrow \frac{2m + M}{m} = 6 \therefore \frac{M}{m} = 4$$

Question138

A spring whose unstretched length is l has a force constant k. The spring is cut into two pieces of unstretched lengths I_1 and l_2 where, $l_1 = n l_2$ and n is an integer. The ratio $\frac{k_1}{k_2}$ of the corresponding force constants, k_1 and k_2 will be:
[12 April 2019 II]

Options:

A. n

B. $\frac{1}{n^2}$

C. $\frac{1}{n}$

D. n^2

Answer: C

Solution:

Solution:

$l_1 + l_2 = l$ and $l_1 = nl_2$

$\therefore l_1 = \frac{nl}{n+1}$ and $l_2 = \frac{l}{n+1}$

As $k \propto \frac{1}{l}$

$\therefore \frac{k_1}{k_2} = \frac{l/(n+1)}{(nl)/(n+1)} = \frac{1}{n}$

Question139

A body of mass 1kg falls freely from a height of 100m, on a platform of mass 3kg which is mounted on a spring having spring constant $k = 1.25 \times 10^6 N/m$. The bodysticks to the platform and the spring's maximum compression is found to be x. Given that $g = 10ms^{-2}$, the value of x will be close to :
[11 April 2019 I]

Options:

A. 40cm

B. 4cm

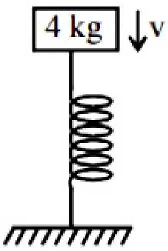
C. 80cm

D. 8cm

Answer: B

Solution:

Solution:



Velocity of 1 kg block just before it collides with 3 kg block $= \sqrt{2gh} = \sqrt{2000} m/s$
Using principle of conservation of linear momentum just before and just after collision, we get

$1 \times \sqrt{2000} = 4v \Rightarrow v = \frac{\sqrt{2000}}{4}$ m/s

Initial compression of spring

$1.25 \times 10^6 x_0 = 30 \Rightarrow x_0 \approx 0$

using work energy theorem,

$W_g + W_{sp} = \Delta KE$

$\Rightarrow 40 \times x + \frac{1}{2} \times 1.25 \times 10^6 (0^2 - x^2)$

solving $x \approx 4cm$

Question140

A uniform cable of mass 'M' and length ' L ' is placed on a horizontal surface such that its $\left(\frac{1}{n}\right)^{th}$ part is hanging below the edge of the surface. To lift the hanging part of the cable upto the surface, the work done should be:
[9 April 2019 I]

Options:

A. $\frac{MgL}{2n^2}$

B. $\frac{MgL}{n^2}$

C. $\frac{2MgL}{n^2}$

D. $nMgL$

Answer: A

Solution:

Solution:
$W = u_f - u_i$
$= 0 - \left(-\frac{mg}{n} \times \frac{L}{2n}\right) = \frac{MgL}{2n^2}.$

Question141

A wedge of mass $M = 4m$ lies on a frictionless plane. particle of mass m approaches the wedge with speed v. There is no friction between the particle and the plane or between the particle and the wedge. The maximum height climbed by the particle on the wedge is given by:
[9 April 2019 II]

Options:

A. $\frac{v^2}{g}$

B. $\frac{2v^2}{7g}$

C. $\frac{2v^2}{5g}$

D. $\frac{v^2}{\ldots}$

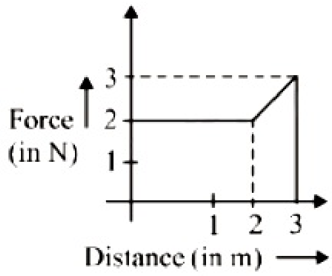
Answer: C

Solution:

Solution:
$mv = (m + M)V'$
or $v = \frac{mv}{m + M} = \frac{mv}{m + 4m} = \frac{v}{5}$
Using conservation of ME, we have
$\frac{1}{2}mv^2 = \frac{1}{2}(m + 4m)\left(\frac{v}{5}\right)^2 + mgh$
or $h = \frac{2}{5}\frac{v^2}{g}$

Question142

A particle moves in one dimension from rest under the influence of a force that varies with the distance travelled by the particle as shown in the figure. The kinetic energy of the particle after it has travelled 3m is:



[8 April 2019 I]

Options:

A. 4 J

B. 2.5J

C. 6.5J

D. 5J

Answer: C

Solution:

Solution:
We know area under F-x graph gives the work done by the body
$\therefore W = \frac{1}{2} \times (3 + 2) \times (3 - 2) + 2 \times 2$
$= 2.5 + 4$
$= 6.5J$
Using work energy theorem,
Δ K.E = work done
$\therefore \Delta K.E = 6.5J$

Question143

A man (mass = 50kg) and his son (mass = 20kg) are standing on a frictionless surface facing each other. The man pushes his son so that he starts moving at a speed of $0.70ms^{-1}$ with respect to the man. The speed of the man with respect to the surface is :
[12 April 2019 I]

Options:

A. $0.28ms^{-1}$

B. $0.20ms^{-1}$

C. $0.47ms^{-1}$

D. $0.14ms^{-1}$

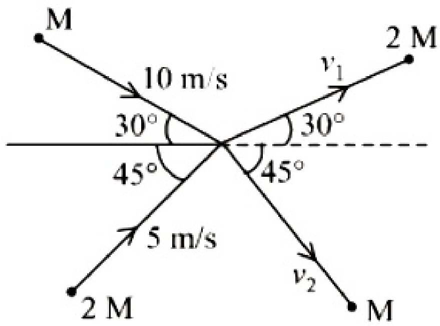
Answer: B

Solution:

Solution:
$P_i = P_f$
or $0 = 20(0.7 - v) = 50v$
or $v = 0.2m / s$

Question144

Two particles, of masses M and 2M , moving, as shown, with speeds of 10m / s and 5m / s, collide elastically at the origin. After the collision, they move along the indicated directions with speeds v_1 and v_2, respectively. The values of v_1 and v_2 are nearly:



[10 April 2019 I]

Options:

A. 6.5m / s and 6.3m / s

B. 3.2m / s and 6.3m / s

C. 6.5m / s and 3.2m / s

D. 3.2m / s and 12.6m / s

Answer: A

Solution:

Solution:
Apply concervation of linear momentum in X and Y direction for the system then
$M(10\cos 30°) + 2M(5\cos 45°) = 2M(v_1\cos 30°) + M(v_2\cos 45°)$

$5\sqrt{3} + 5\sqrt{2} = \sqrt{3}v_1 + \frac{v_2}{\sqrt{2}}$ ....(1)

Also
$2M(5\sin 45°) - M(10\sin 30°) = 2M v_1 \sin 30° - M v_2 \sin 45°$

$5\sqrt{2} - 5 = v_1 - \frac{v_2}{\sqrt{2}}$ ....(2)

Solving equation (1) and (2)
$(\sqrt{3}+1)v_1 = 5\sqrt{3} + 10\sqrt{2} - 5 \Rightarrow v_1 = 6.5m/s$
$v_2 = 6.3m/s$

Question145

A body of mass 2kg makes an elastic collision with a second body at rest and continues to move in the original direction but with one fourth of its original speed. What is the mass of the second body?
[9 April 2019 I]

Options:

A. 1.0kg

B. 1.5kg

C. 1.8kg

D. 1.2kg

Answer: B

Solution:

Solution:
$2u + 0 = 2\left(\frac{u}{4}\right) + mv_2$

and $\frac{1}{2} \times 2 \times u^2 + 0 = \frac{1}{2} \times 2 \times \left(\frac{u}{4}\right)^2 + \frac{1}{2}mv_2{}^2$

On solving, we get $m = 1.5kg$

Question146

A particle of mass ' m ' is moving with speed ' 2v ' and collides with a mass ' 2m ' moving with speed ' v ' in the same direction. After collision, the first mass is stopped completely while the second one splits into two particles each of mass ' m ', which move at angle 45° with respect to the original direction.
The speed of each of the moving particle will be:

Options:

A. $\sqrt{2}v$

B. $2\sqrt{2}v$

C. $\frac{v}{(2\sqrt{2})}$

D. $v / \sqrt{2}$

Answer: B

Solution:

Solution:
$m(2v) + 2mv = 0 + 2mv' \cos 45°$
or $v' = 2\sqrt{2}v$

Question147

A body of mass m_1 moving with an unknown velocity of $v_1\hat{i}$, undergoes a collinear collision with a body of massm_2 moving with a velocity $v_2\hat{i}$. After collision, m_1 and $m_2$move with velocities of $v_3\hat{i}$ and $v_4\hat{i}$, respectively. If $m_2 = 0.5m_1$ and $v_3 = 0.5v_1$, then v_1 is:
[8 April 2019 II]

Options:

A. $v_4 - \frac{v_2}{2}$

B. $v_4 - v_2$

C. $v_4 - \frac{v_2}{4}$

D. $v_4 + v_2$

Answer: B

Solution:

Solution:
$m_1v_1 + m_2v_2 = m_1v_2 + m_2v_1$
or $m_1v_1 + (0.5m_1)v_2 = m_1 0.5v_1 + (0.5m_1)v_4$
On solving, $v_1 = v_4 - v_2$

Question148

varies as $v = a\sqrt{s}$ where a is a constant s and is the distance covered by the body. The total work done by all the forces acting on the body in the first second after the start of the motion is:
[Online April 16, 2018]

Options:

A. $\frac{1}{8}ma^4t^2$

B. $4ma^4t^2$

C. $8ma^4t^2$

D. $\frac{1}{4}ma^4t^2$

Answer: A

Solution:

Solution:

From question, $v = a\sqrt{s} = \frac{ds}{dt}$

or, $2\sqrt{s} = at \Rightarrow S = \frac{a^2t^2}{4}$

$F = m \times \frac{a^2}{2}$

Work done $= \frac{ma^2}{2} \times \frac{a^2t^2}{4} = \frac{1}{8}ma^4t^2$

Question149

A particle is moving in a circular path of radius a under the action of an attractive potential $U = -\frac{k}{2r^2}$. Its total energyis:

[2018]

Options:

A. $-\frac{k}{4a^2}$

B. $\frac{k}{2a^2}$

C. zero

D. $-\frac{3}{2}\frac{k}{a^2}$

Answer: C

Solution:

Solution:

Since particle is moving in circular path

$F = \frac{mv^2}{r} = \frac{K}{r^3} \Rightarrow mv^2 = \frac{K}{r^2}$

$\therefore K.E. = \frac{1}{2}mv^2 = \frac{K}{2r^2}$

Total energy $= P.E. + K.E$

$= -\frac{K}{2r^2} + \frac{K}{2r^2} = \text{Zero} \left(\because P.E = -\frac{K}{2r^2} \text{given}\right)$

Question150

Two particles of the same mass m are moving in circular orbits because of force, given by $F(r) = \frac{-16}{r} - r^3$The first particle is at a distance r = 1, and the second, at r = 4. The best estimate for the ratio of kinetic energies of the first and the second particle is closest to [Online April 16, 2018]

Options:

A. 10^{-1}

B. 6×10^{-2}

C. 6×10^{2}

D. 3×10^{-3}

Answer: B

Solution:

Solution:

As the particles moving in circular orbits, So

$\frac{mv^2}{r} = \frac{16}{r} + r^2$

Kinetic energy, $KE_0 = \frac{1}{2}mv^2 = \frac{1}{2}[16 + r^4]$

For first particle, $r = 1$, $K_1 = \frac{1}{2}m(16 + 1)$

Similarly, for second particle, $r = 4$, $K_2 = \frac{1}{2}m(16 + 256)$

$\therefore \frac{K_1}{K_2} = \frac{\frac{16+1}{2}}{\frac{16+256}{2}} = \frac{17}{272} \simeq 6 \times 10^{-2}$

Question151

In a collinear collision, a particle with an initial speed v_0 strikes a stationary particle of the same mass. If the final total kinetic energy is 50% greater than the original kinetic energy, the magnitude of the relative velocity between the two particles, after collision, is: [2018]

Options:

A. $\frac{v_0}{4}$

B. $\sqrt{2}v_0$

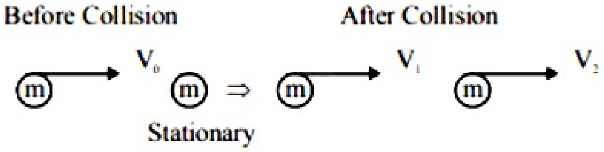
C. $\frac{v_0}{2}$

D. $\frac{v_0}{\sqrt{2}}$

Answer: B

Solution:

Solution:



$\frac{1}{2}mv_1^2 + \frac{1}{2}mv_2^2 = \frac{3}{2}\left(\frac{1}{2}mv_0^2\right)$

$\Rightarrow v_1^2 + v_2^2 = \frac{3}{2}v_0^2$ ......(i)

From momentum conservation

$mv_0 = m(v_1 + v_2)$ ......(ii)

Squarring both sides,

$(v_1 + v_2)^2 = v_0^2$

$\Rightarrow v_1^2 + v_2^2 + 2v_1v_2 = v_0^2$

$2v_1v_2 = -\frac{v_0^2}{2}$

$(v_1 - v_2)^2 = v_1^2 + v_2^2 - 2v_1v_2 = \frac{3}{2}v_0^2 + \frac{v_0^2}{2}$

Solving we get relative velocity between the two particles

$v_1 - v_2 = \sqrt{2}v_0$

Question152

The mass of a hydrogen molecule is 3.32×10^{-27}kg. If 10^{23} hydrogen molecules strike, per second, a fixed wall of area $2cm^2$ at an angle of 45° to the normal, and rebound elastically with a speed of $10^3 m / s$, then the pressure on the wall is nearly:
[2018]

Options:

A. $2.35 \times 10^3 N / m^2$

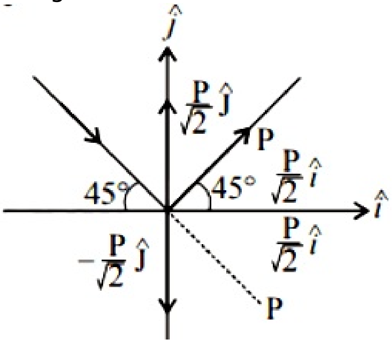
B. $4.70 \times 10^3 N / m^2$

D. $4.70 \times 10^2 N / m^2$

Answer: A

Solution:

Solution:
Change in momentum



$\Delta P = \frac{P}{\sqrt{2}}\hat{J} + \frac{P}{\sqrt{2}}\hat{J} + \frac{P}{\sqrt{2}}\hat{i} - \frac{P}{\sqrt{2}}\hat{i}$

$\Delta P = \frac{2P}{\sqrt{2}}\hat{J} = I_H$ molecule

$\Rightarrow I_{wall} = -\frac{2P}{\sqrt{2}}\hat{J}$

Pressure, P

$= \frac{F}{A} = \frac{\sqrt{2}P}{A} n(\because n =$ no. of particles)

$= \frac{\sqrt{2} \times 3.32 \times 10^{-27} \times 10^3 \times 10^{23}}{2 \times 10^{-4}} = 2.35 \times 10^3 N / m^2$

Question153

It is found that if a neutron suffers an elastic collinear collision with deuterium at rest, fractional loss of its energy is p_d; while for its similar collision with carbon nucleus at rest, fractional loss of energy is P_c. The values of P_d and P_c are respectively:
[2018]

Options:

A. (.89, .28)

B. (.28, .89)

C. (0,0)

D. (0,1)

Answer: A

Solution:

Solution:
For collision of neutron with deuterium:

Applying conservation of momentum :
$mv + 0 = mv_1 + 2mv_2$ ....(i)
$v_2 - v_1 = v$ ......(ii)
∵ Collision is elastic, e = 1
From eqn (i) and eqn (ii) $v_1 = -\frac{v}{3}$

$$P_d = \frac{\frac{1}{2}mv^2 - \frac{1}{2}m{v_1}^2}{\frac{1}{2}mv^2} = \frac{8}{9} = 0.89$$

Now, For collision of neutron with carbon nucleus

Applying Conservation of momentum
$mv + 0 = mv_1 + 12mv_2$ ....(iii)
$v = v_2 - v_1$ ....(iv)
From eqn (iii) and eqn (iv) $v_1 = -\frac{11}{13}v$

$$P_c = \frac{\frac{1}{2}mv^2 - \frac{1}{2}m\left(\frac{11}{13}v\right)^2}{\frac{1}{2}mv^2} = \frac{48}{169} \approx 0.28$$

Question154

A proton of mass m collides elastically with a particle of unknown mass at rest. After the collision, the proton and the unknown particle are seen moving at an angle of 90° with respect to each other. The mass of unknown particle is:
[Online April 15, 2018]

Options:

A. $\frac{m}{\sqrt{3}}$

B. $\frac{m}{2}$

C. 2m

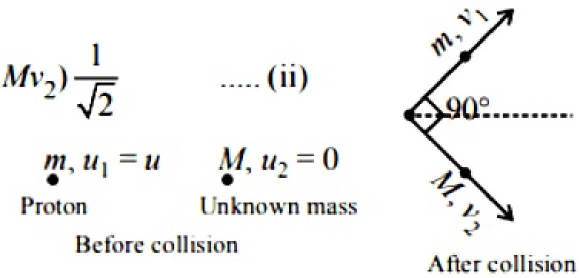
D. m

Answer: D

Solution:

Solution:
Apply principle of conservation of momentum along x-direction,
$mu = mv_1 \cos 45° + M v_2 \cos 45°$
$mu = \frac{1}{\sqrt{2}}(mv_1 + M v_2)$ ..... (i)
Along y -direction,
$o = mv_1 \sin 45° - M v_2 \sin 45°$

$o = (mv_1 - Mv_2)\frac{1}{\sqrt{2}}$ ..... (ii)



Coefficient of restution e = 1 = $\frac{v_2 - v_1 \cos 90}{u \cos 45}$ (∵ Collision is elastic)

$\Rightarrow \frac{v_2}{u\sqrt{2}} = 1$

$\Rightarrow u = \sqrt{2}v_2$..... (iii)

Solving eqs (i), (ii), & (iii), we get mass of unknown particle, M = m

----

Question155

A body of mass $m = 10^{-2}$kg is moving in a medium and experiences a frictional force $F = -kv^2$. Its intial speed is $v_0 = 10ms^{-1}$. If, after 10s, its energy is $\frac{1}{8}mv_0^2$, the value of k will be:
[2017]

Options:

A. $10^{-4}kgm^{-1}$

B. $10^{-1}kgm^{-1}s^{-1}$

C. $10^{-3}kgm^{-1}$

D. $10^{-3}kgs^{-1}$

Answer: A

Solution:

Solution:
Let V_f is the final speed of the body.
From questions,
$\frac{1}{2}mV_f^2 = \frac{1}{8}mV_0^2 \Rightarrow V_f = \frac{V_0}{2} = 5m/s$
$F = m\left(\frac{dV}{dt}\right) = -kV^2 \therefore (10^{-2})\frac{dV}{dt} = -kV^2$
$\int_{10}^{5}\frac{dV}{V^2} = -100K\int_0^{10}dt$
$\frac{1}{5} - \frac{1}{10} = 100K(10)$ or ,$K = 10^{-4}kgm^{-1}$

Question156

An object is dropped from a height h from the ground. Every time it hits the ground it looses 50% of its kinetic energy. The total distance

[Online April 8, 2017]

Options:

A. 3h

B. ∞

C. $\frac{5}{3}h$

D. $\frac{8}{3}h$

Answer: A

Solution:

Solution:

(K.E.)' = 50% of K.E. after hit i.e.,

$\frac{1}{2}mv^2 = \frac{50}{100} \times \frac{1}{2}mv^2 \Rightarrow v' = \frac{v}{\sqrt{2}}$

Coefficient of restitution $= \frac{1}{\sqrt{2}}$

Now, total distance travelled by object is

$H = h\left(\frac{1+e^2}{1-e^2}\right) = h\left(\frac{1+\frac{1}{2}}{1-12}\right) = 3h$

Question157

A time dependent force F = 6t acts on a particle of mass 1kg. If the particle starts from rest, the work done by the force during the first 1 second will be
[2017]

Options:

A. 9J

B. 18J

C. 4.5J

D. 22J

Answer: C

Solution:

Solution:

Using, $F = ma = m\frac{dV}{dt}$

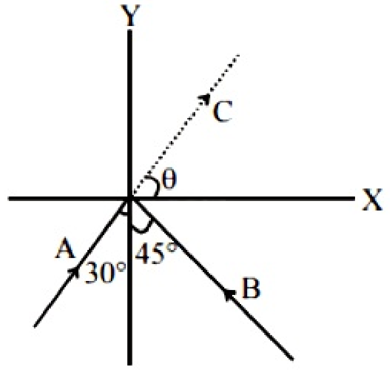
$6t = 1 \cdot \frac{dV}{dt}$[$\because m = 1kg$ given]

$\int_0^v dV = \int 6td\,tV = 6\left[\frac{t^2}{2}\right]_0^1 = 3ms^{-1}$ [$\because t = 1$ sec given]

$W = \Delta K E = \frac{1}{2}m(V^2 - u^2) = \frac{1}{2} \times 1 \times 9 = 4.5J$

Question158

Two particles A and B of equal mass M are moving with the same speed v as shown in the figure. They collide completely inelastically and move as a single particle C. The angle θ that the path of C makes with the X - axis is given by:



[Online April 9, 2017]

Options:

A. $\tan\theta = \frac{\sqrt{3}+\sqrt{2}}{1-\sqrt{2}}$

B. $\tan\theta = \frac{\sqrt{3}-\sqrt{2}}{1-\sqrt{2}}$

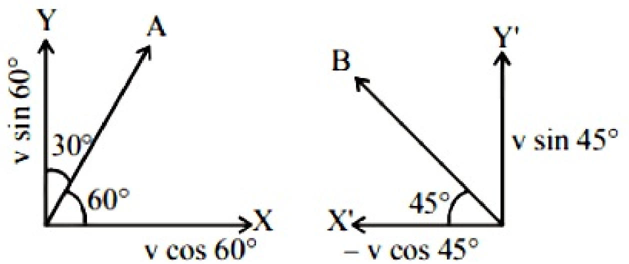
C. $\tan\theta = \frac{1-\sqrt{2}}{\sqrt{2}(1+\sqrt{3})}$

D. $\tan\theta = 1 - \sqrt{3}1 + \sqrt{2}$

Answer: A

Solution:

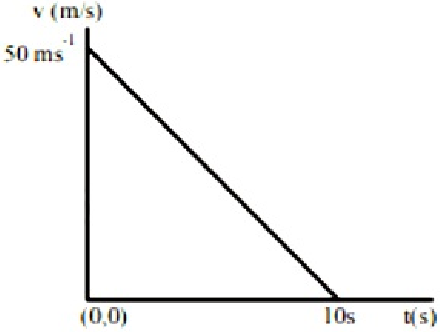
Solution:
For particle C,
According to law of conservation of linear momentum, verticle component,
2 mv' sin θ = mv sin 60° + mv sin 45°
$2mv' \sin\theta = \frac{mv}{\sqrt{2}} + \frac{mv\sqrt{3}}{2}$ ..... (i)
Horizontal component,
2 mv' cos θ = mv sin 60° – mv cos 45°
$2mv' \cos\theta = \frac{mv}{2} + \frac{mv}{\sqrt{2}}$ ...... (ii)



$$\tan\theta = \frac{\frac{1}{\sqrt{2}} + \frac{\sqrt{3}}{2}}{\frac{1}{2} - \frac{1}{\sqrt{2}}} = \frac{\sqrt{2} + \sqrt{3}}{1 - \sqrt{2}}$$

Question159

Velocity-time graph for a body of mass 10kg is shown in figure. Work-done on the body in first two seconds of the motion is :



[Online April 10, 2016]

Options:

A. -9300J

B. 12000J

C. -4500J

D. -12000J

Answer: C

Solution:

Solution:

Acceleration (a) $= \frac{v - 4}{t} = \frac{(0 - 50)}{(10 - 0)} = -5\text{m}/\text{s}^2$

$u = 50\text{m}/\text{s}$

$\therefore v = u + at = 50 - 5t$

Veocity in first two seconds $t = 2$

$v_{(\text{att} = 2)} = 40\text{m}/\text{s}$

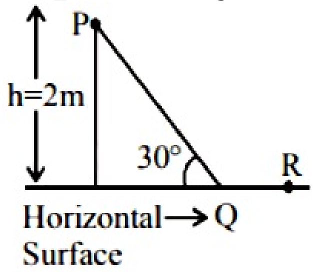
From work-energy theorem,

$\Delta K.E. = W = \frac{1}{2}(40^2 - 50^2) \times 10 = -4500\text{J}$

Question160

A point particle of mass m, moves long the uniformly rough track PQR as shown in the figure. The coefficient of friction, between the particle and the rough track equals μ. The particle is released, from rest from the point P and it comes to rest at a point R. The energies, lost by the ball, over the parts, PQ and QR, of the track, are equal to each other,

The value of the coefficient of friction μ and the distance x(= QR), are, respectively close to :



[2016]

Options:

A. 0.29 and 3.5m

B. 0.29 and 6.5m

C. 0.2 and 6.5m

D. 0.2 and 3.5m

Answer: A

Solution:

Solution:
Work done by friction at QR = μmgx
In triangle, $\sin 30^{\circ} = \frac{1}{2} = \frac{2}{PQ}$
$\Rightarrow PQ = 4m$
Work done by friction at PQ = $\mu mg \times \cos 30^{\circ} \times 4$
$= \mu mg \times \frac{\sqrt{3}}{2} \times 4 = 2\sqrt{3}\mu mg$
Since work done by friction on parts PQ and QR are equal, $\mu mgx = 2\sqrt{3}umg$
$\Rightarrow x = 2\sqrt{3} \cong 3.5m$
Using work energytheorem $mg \sin 30^{\circ} \times 4 = 2\sqrt{3}\mu mg + \mu mgx$
$\Rightarrow 2 = 4\sqrt{3}\mu$
$\Rightarrow \mu = 0.29$

Question161

A person trying to lose weight by burning fat lifts a mass of 10kg upto a height of 1m1000 times. Assume that the potential energy lost each time he lowers the mass is dissipated. How much fat will he use up considering the work done only when the weight is lifted up? Fat supplies $3.8 \text{ times } 10^{7} J$ of energy per kg which is converted to mechanical energy with a 20% efficiency rate. Take g = 9.8 ms^{-2}: [2016]

Options:

A. $9.89 \times 10^{-3} kg$

B. $12.89 \times 10^{-3} kg$

D. 6.45×10^{-3}kg

Answer: B

Solution:

Solution:

$n = \frac{W}{\text{input}} = \frac{mgh \times 1000}{\text{input}} = \frac{10 \times 9.8 \times 1 \times 1000}{\text{input}}$

Input $= \frac{98000}{0.2} = 49 \times 10^4 J$

Fat used $= \frac{49 \times 10^4}{3.8 \times 10^7} = 12.89 \times 10^{-3}$kg.

Question162

A particle of mass M is moving in a circle of fixed radius R in such a way that its centripetal acceleration at time t is given by n^2Rt^2 where n is a constant. The power delivered to the particle by the force acting on it, is:
[Online April 10, 2016]

Options:

A. $\frac{1}{2}M\,n^2R^2t^2$

B. $M\,n^2R^2t$

C. $M\,nR^2t^2$

D. $M\,nR^2\,t$

Answer: B

Solution:

Solution:
Centripetel acceleration
$a_c = n^2Rt^2$
$a_c = \frac{v^2}{R} = n^2Rt^2$
$v^2 = n^2R^2t^2$
$v = nRt$
$a_c = \frac{dv}{dt} = nR$
Power $= ma_tv = mnRnRt = M\,n^2R^2t$

Question163

A car of weight W is on an inclined road that rises by 100 m over a distance of 1Km and applies a constant frictionalforce $\frac{W}{\ }$ on the car.

While moving uphill on the road at a speed of $10ms^{-1}$, the car needs power P. If it needspower $\frac{P}{2}$ while moving downhill at speed v then value of v is:
[Online April 9, 2016]

Options:

A. $20ms^{-1}$

B. $5ms^{-1}$

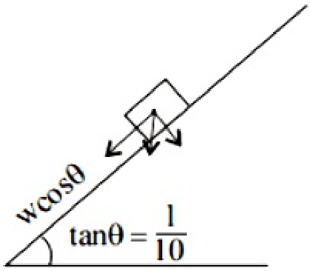
C. $15ms^{-1}$

D. $10ms^{-1}$

Answer: C

Solution:

Solution:



While moving downhill power

$P = \left(w \sin\theta + \frac{w}{20}\right) 10$

$P = \left(\frac{w}{10} + \frac{w}{20}\right) 10 = \frac{3w}{2}$

$\frac{P}{2} = \frac{3w}{4} = \left(\frac{w}{10} - \frac{w}{20}\right) V$

$\frac{3}{4} = \frac{v}{20} \Rightarrow v = 15m / s$

∴ Speed of car while moving downhill v = 15 m/s.

Question164

A neutron moving with a speed 'v' makes a head on collision with a stationary hydrogen atom in ground state.
The minimum kinetic energy of the neutron for which inelastic collision will take place is :
[Online April 10, 2016]

Options:

A. 20.4 eV

B. 10.2 eV

C. 12.1 eV

Answer: A

Solution:

Solution:

For inelastic collision $v' = \frac{m_1}{(m_1 + m_2)} v$

$= \frac{1}{(1+1)} v = \frac{v}{2}$

$n \to v(H)$ Before

$(n)(H) \to \frac{v}{2}$ After

Loss in K.E. $= \frac{1}{2} mv^2 - \frac{1}{2}(2m)\left(\frac{v}{2}\right)^2 = \frac{1}{4} mv^2$

K.E. lost is used to jump from 1 st orbit to 2 nd orbit

$\Delta K.E = 10.2 ev$

Minimum K.E. of neutron for inelastic collision

$\frac{1}{2} mv^2 = 2 \times 10.2 = 20.4 eV$

Question165

A particle is moving in a circle of radius r under the action of a force $F = \alpha r^2$ which is directed towards centre of the circle. Total mechanical energy (kinetic energy + potential energy) of the particle is (take potential energy = 0 for r = 0) :
[Online April 11, 2015]

Options:

A. $\frac{1}{2} \alpha r^3$

B. $\frac{5}{6} \alpha r^3$

C. $\frac{4}{3} \alpha r^3$

D. αr^3

Answer: B

Solution:

Solution:
As we know, dU = F.dr

$U = \int_0^r \alpha r^2 d r = \frac{ar^3}{3}$ ....(i)

As, $\frac{mv^2}{r} = \alpha r^2$

$m^2 v^2 = m\alpha r^3$

or, $2m(KE) = \frac{1}{2} \alpha r^3$ ......(ii)

Total energy = Potential energy + kinetic energy Now, from eqn (i) and (ii)
Total energy = K.E. + P.E.

$= \frac{\alpha r^3}{3} + \frac{\alpha r^3}{2} = \frac{5}{6} \alpha r^3$

Question166

A block of mass m = 0.1kg is connected to a spring of unknown spring constant k. It is compressed to a distance x from its equilibrium position and released from rest. After approaching half the distance $\left(\frac{x}{2}\right)$ from equilibrium position, it hits another block and comes to rest momentarily, while the other block moves with a velocity $3ms^{-1}$. The total initial energy of the spring is:
[Online April 10, 2015]

Options:

A. 0.3J

B. 0.6J

C. 0.8J

D. 1.5J

Answer: B

Solution:

Solution:
Applying momentum conservation
$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$
$0.1u + m(0) = 0.1(0) + m(3)$
$0.1u = 3m$
$\frac{1}{2}0.1u^2 = \frac{1}{2}m(3)^2$
Solving we get, $u = 3$
$\frac{1}{2}kx^2 = \frac{1}{2}K\left(\frac{x}{2}\right)^2 + \frac{1}{2}(0.1)3^2$
$\Rightarrow \frac{3}{4}kx^2 = 0.9$
$\Rightarrow \frac{3}{2} \times \frac{1}{2}kx^2 = 0.9$
$\therefore \frac{1}{2}Kx^2 = 0.6J$ (total initial energy of the spring)

Question167

A particle of mass m moving in the x direction with speed 2v is hit by another particle of mass 2m moving in the y direction with speed v. If the collision is perfectly inelastic, the percentage loss in the energy during the collision is close to :
[2015]

Options:

A. 56%

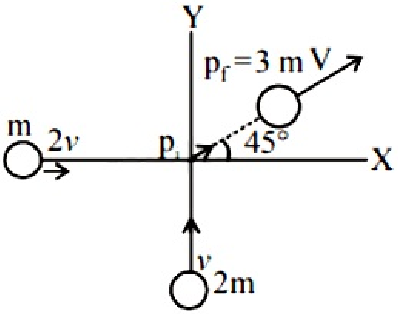
C. 44%

D. 50%

Answer: A

Solution:

Solution:



Initial momentum of the system

$p_i = \sqrt{[m(2V)^2 \times 2m(2V)^2]}$

$= \sqrt{2}m \times 2V$

Final momentum of the system $= 3mV$

By the law of conservation of momentum

$2\sqrt{2}mv = 3mV \Rightarrow \frac{2\sqrt{2}v}{3} = V_{combined}$

Loss in energy

$\Delta E = \frac{1}{2}m_1V_1{}^2 + \frac{1}{2}m_2V_2{}^2 - \frac{1}{2}(m_1 + m_2)V_{combined}{}^2$

$DE = 3mv^2 - \frac{4}{3}mv^2 = \frac{5}{3}mv^2 = 55.55\%$

Percentage loss in energy during the collision $\simeq 56\%$

Question168

When a rubber-band is stretched by a distance x, it exerts restoring force of magnitude $F = ax + bx^2$ where a and bare constants. The work done in stretching the unstretched rubber-band by L is: [2014]

Options:

A. $aL^2 + bL^3$

B. $\frac{1}{2}(aL^2 + bL^3)$

C. $\frac{aL^2}{2} + \frac{bL^3}{3}$

D. $\frac{1}{2}\left(\frac{aL^2}{2} + \frac{bL^3}{3}\right)$

Answer: C

Solution:

$dW = F\,dx = (ax + bx^2)dx$
Integrating both sides,
$W = \int_0^L axdx + \int_0^L bx^2 dx = \frac{aL^2}{2} + \frac{bL^3}{3}$

Question169

A bullet looses $\left(\frac{1}{n}\right)^{th}$ of its velocity passing through one plank. The number of such planks that are required to stop the bullet can be: [Online April 19, 2014]

Options:

A. $\frac{n^2}{2n-1}$

B. $\frac{2n^2}{n-1}$

C. infinite

D. n

Answer: A

Solution:

Solution:
Let u be the initial velocity of the bullet of mass m.
After passing through a plank of width x, its velocity decreases to v.
$\therefore u - v = \frac{4}{n}$ or, $v = u - \frac{4}{n} = \frac{u(n-1)}{n}$
If F be the retarding force applied by each plank, then using work – energy theorem,
$Fx = \frac{1}{2}mu^2 - \frac{1}{2}mv^2 = \frac{1}{2}mu^2 - \frac{1}{2}mu^2\frac{(n-1)^2}{n^2}$
$= \frac{1}{2}mu^2\left[\frac{1-(n-1)^2}{n^2}\right]$
$Fx = \frac{1}{2}mu^2\left(\frac{2n-1}{n^2}\right)$
Let P be the number of planks required to stop the bullet.
Total distance travelled by the bullet before coming to rest = Px
Using work-energy theorem again,
$F(Px) = \frac{1}{2}mu^2 - 0$
or, $P(Fx) = P\left[\frac{1}{2}mu^2\frac{(2n-1)}{n^2}\right] = \frac{1}{2}mu^2$
$\therefore P = \frac{n^2}{2n-1}$

Question170

A spring of unstretched length 1 has a mass m with one end fixed to a rigid support. Assuming spring to be made of a uniform wire, the kinetic energy possessed by it if its free end is pulled with uniform velocity v is:

Options:

A. $\frac{1}{2}mv^2$

B. mv^2

C. $\frac{1}{3}mv^2$

D. $\frac{1}{6}mv^2$

Answer: D

Solution:

Question171

A bullet of mass 4g is fired horizontally with a speed of 300 m/s into 0.8 kg block of wood at rest on a table. If the coefficient of friction between the block and the table is 0.3, how far will the block slide approximately?
[Online April 12, 2014]

Options:

A. 0.19 m

B. 0.379 m

C. 0.569 m

D. 0.758 m

Answer: B

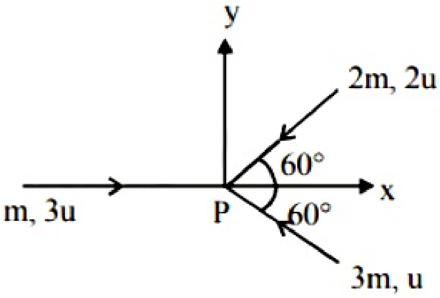
Solution:

Given, $m_1 = 4g, u_1 = 300m / s$
$m_2 = 0.8kg = 800, u_2 = 0m / s$
From law of conservation of momentum,
$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$
Let the velocity of combined system
$= v\ m / s$
then,
$4 \times 300 + 800 \times 0 = (800 + 4) \times v$
$v = \frac{1200}{804} = 1.49m / s$
Now, $\mu = 0.3$ (given)
$a = \mu ga = 0.3 \times 10$ (take $g = 10m / s^2$)
$= 3m / s^2$
then, from $v^2 = u^2 + 2$ as
$(1.49)^2 = 0 + 2 \times 3 \times s$
$s = \frac{(1.49)^2}{6}$

$s = \frac{2.22}{6}$
$= 0.379m$

Question172

Three masses m, 2m and 3m are moving in x-y plane with speed 3u, 2u and u respectively as shown in figure. The three masses collide at the same point at P and stick together. The velocity of resulting mass will be:



[Online April 12, 2014]

Options:

A. $\frac{u}{12}\left(\hat{i} + \sqrt{3}\hat{j}\right)$

B. $\frac{u}{12}\left(\hat{i} - \sqrt{3}\hat{j}\right)$

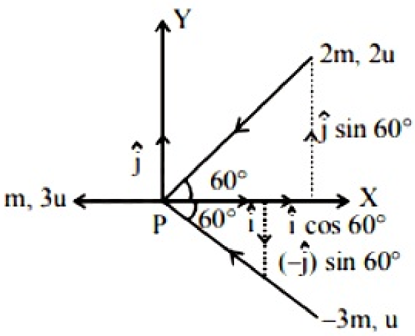
C. $\frac{u}{12}\left(-\hat{i} + \sqrt{3}\hat{j}\right)$

D. $\frac{u}{12}\left(-\hat{i} - \sqrt{3}\hat{j}\right)$

Answer: D

Solution:

Solution:
From the law of conservation of momentum we know that,
$m_1u_1 + m_2u_2 + \ldots\ldots = m_1v_1 + m_2v_2 + \ldots..$
Given $m_1 = m$, $m_2 = 2m$ and $m_3 = 3m$
and $u_1 = 3u$, $u_2 = 2u$ and $u_3 = u$
Let the velocity when they stick $= \vec{v}$
Then, according to question,



$m \times 3u\left(\hat{i}\right) + 2m \times 2u\left(-\hat{i}\cos 60° - \hat{j}\sin 60°\right) + 3m \times u\left(-\hat{i}\cos 60° + \hat{j}\sin 60°\right) = (m + 2m + 3m)\vec{v}$

$\Rightarrow 3mu\hat{i} - 4mu\frac{\hat{i}}{2} - 4mu\left(\frac{\sqrt{3}}{2}\hat{j}\right) - 3mu\frac{\hat{i}}{2} + 3mu\left(\frac{\sqrt{3}}{2}\hat{j}\right) = 6m\vec{v}$

$\Rightarrow mu\hat{i} - \frac{3}{2}mu\hat{i} - \frac{\sqrt{3}}{2}mu\hat{j} = 6m\vec{v}$

$\Rightarrow -\frac{1}{2}mu\hat{i} - \frac{\sqrt{3}}{2}mu\hat{j} = 6m\vec{v}$

$\Rightarrow \vec{v} = \frac{u}{12}\left(-\hat{i} - \sqrt{3}\hat{j}\right)$

Question173

Two springs of force constants 300N / m (Spring A) and 400N / m (Spring B) are joined together in series. The combination is compressed by 8.75cm. The ratio of energy stored in A and B is $\frac{E_A}{E_B}$. Then $\frac{E_A}{E_B}$ is equal to:
[Online April 9, 2013]

Options:

A. $\frac{4}{3}$

B. $\frac{16}{9}$

C. $\frac{3}{4}$

D. $\frac{9}{16}$

Answer: A

Solution:

Solution:
Given : $k_A = 300N / m$, $k_B = 400N / m$
Let when the combination of springs is compressed by force F. Spring A is compressed by x. Therefore compression in spring B
$x_B = (8.75 - x)cm$
$F = 300 \times x = 400(8.75 - x)$
Solving we get, $x = 5cm$
$x_B = 8.75 - 5 = 3.75cm$

$$\frac{E_A}{E_B} = \frac{\frac{1}{2}k_A(x_A)^2}{\frac{1}{2}k_B(x_B)^2} = \frac{300 \times (5)^2}{400 \times (3.75)^2} = \frac{4}{3}$$

Question174

A wind-powered generator converts wind energy into electrical energy. Assume that the generator converts a fixed fraction of the wind energy intercepted by its blades into electrical energy. For wind speed n, the electrical power output will be most likely proportional to

Options:

A. v^4

B. v^2

C. v

D. v

Answer: D

Solution:

Solution:

Question175

A 70kg man leaps vertically into the air from a crouching position. To take the leap the man pushes the ground with a constant force F to raise himself. The center of gravity rises by 0.5m before he leaps. After the leap the c.g. rises by another 1m. The maximum power delivered by the muscles is: (Take $g = 10ms^{-2}$)
[Online April 23, 2013]

Options:

A. 6.26×10^3 Watts at the start

B. 6.26×10^3 Watts at take off

C. 6.26×10^4 Watts at the start

D. 6.26×10^4 Watts at take off

Answer: B

Solution:

Solution:

Question176

This question has statement I and statement II. Of the four choices given after the statements, choose the one that best describes the two statements.
Statement - I: A point particle of mass m moving with speed υ collides with stationary point particle of mass M. If the maximum energy loss possible is given as $f\left(\frac{1}{2}mv^2\right)$ then $f = \left(\frac{m}{\ldots}\right)$

Statement - II: Maximum energy loss occurs when the particles get stuck together as a result of the collision.
[2013]

Options:

A. Statement - I is true, Statment - II is true, Statement - II is the correct explanation of Statement - I.

B. Statement-I is true, Statment - II is true, Statement - II is not the correct explanation of Statement - II.

C. Statement - I is true, Statment - II is false.

D. Statement - I is false, Statment - II is true.

Answer: D

Solution:

Solution:

Maximum energy loss $= \frac{P^2}{2m} - \frac{P^2}{2(m+M)}$ $\left[\because K.E. = \frac{P^2}{2m} = \frac{1}{2}mv^2\right]$

$= \frac{P^2}{2m}\left[\frac{M}{(m+M)}\right] = \frac{1}{2}mv^2\left\{\frac{M}{m+M}\right\}$

Statement II is a case of perfectly inelastic collision.

By comparing the equation given in statement I with above equation, we get\

$f = \left(\frac{M}{m+M}\right)$ instead of $\left(\frac{m}{M+m}\right)$

Hence statement I is wrong and statement II is correct.

Question177

A projectile of mass M is fired so that the horizontal range is 4 km. At the highest point the projectile explodes in two parts of masses M/4 and 3M/4 respectively and the heavier part starts falling down vertically with zero initial speed. The horizontal range (distance from point of firing) of the lighter part is :
[Online April 23, 2013]

Options:

A. 16 km

B. 1 km

C. 10 km

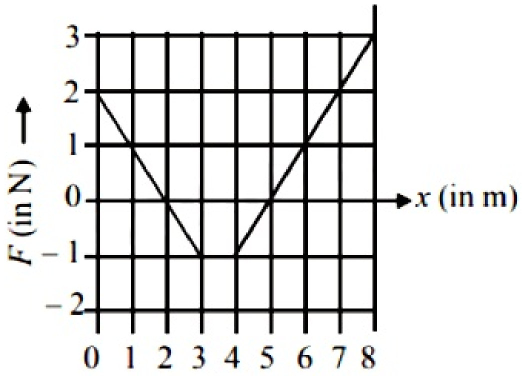
D. 2 km

Answer: C

Solution:

Question178

The force $\vec{F} = F\hat{i}$ on a particle of mass 2kg, moving along the x -axis is given in the figure as a function of its position x. The particle is moving with a velocity of 5m / s along the x -axis at x = 0. What is the kinetic energy of the particle at x = 8m?



[Online May 26, 2012]

Options:

A. 34J

B. 34.5J

C. 4.5J

D. 29.4J

Answer: D

Solution:

Solution:

Question179

A particle gets displaced by $\Delta\vec{r} = \left(2\hat{i} + 3\hat{j} + 4\hat{k}\right)$m under the action of a force$\vec{F} = \left(7\hat{i} + 4\hat{j} + 3\hat{k}\right)$. The change in its kinetic energy is [Online May 7, 2012]

Options:

A. 38J

B. 70J

C. 52.5J

D. 126J

Solution:

Solution:
According to work-energy theorem,
Change in kinetic energy = work done
$= \vec{F} \cdot \Delta\vec{r} = (7\hat{i} + 4\hat{j} + 3\hat{k}) \cdot (2\hat{i} + 3\hat{j} + 4\hat{k})$
$= 14 + 12 + 12 = 38J$

Question180

A moving particle of mass m, makes a head on elastic collision with another particle of mass 2m, which is initially at rest. The percentage loss in energy of the colliding particle on collision, is close to [Online May 19, 2012]

Options:

A. 33%

B. 67%

C. 90%

D. 10%

Answer: C

Solution:

Solution:
Fractional decrease in kinetic energy of mass m
$= 1 - \left(\frac{m_2 - m_1}{m_2 + m_1}\right)^2 = 1 - \left(\frac{2-1}{2+1}\right)^2$
$= 1 - \left(\frac{1}{3}\right)^2 = 1 - \frac{1}{9} = \frac{8}{9}$
Percentage loss in energy
$= \frac{8}{9} \times 100 \simeq 90\%$

Question181

Two bodies A and B of mass m and 2m respectively are placed on a smooth floor. They are connected by a spring of negligible mass. A third body C of mass m is placed on the floor. The body C moves with a velocity v_0 along the line joining A and B and collides elastically with A. At a certain time after the collision it is found that the instantaneous velocities of A and B are same and the compression of the spring is x_0. The spring constant k will be [Online May 12, 2012]

A. $m\frac{v_0^2}{x_0^2}$

B. $m\frac{v_0}{2x_0}$

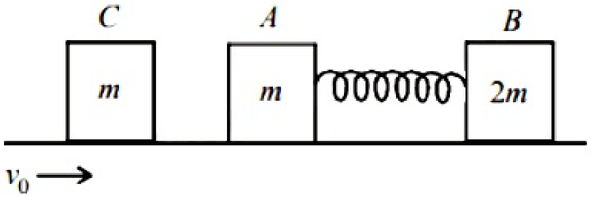
C. $2m\frac{v_0}{x_0}$

D. $\frac{2}{3}m\left(\frac{v_0}{x_0}\right)^2$

Answer: D

Solution:

Solution:



Initial momentum of the system block (C) $= mv_0$. After striking with A, the block C comes to rest and now both block A and B moves with velocity v when compression in spring is x_0.
By the law of conservation of linear momentum

$mv_0 = (m + 2m)v \Rightarrow v = \frac{v_0}{3}$

By the law of conservation of energy
K.E. of block C = K.E. of system + P.E. of system

$\frac{1}{2}mv_0^2 = \frac{1}{2}(3m)\left(\frac{v_0}{3}\right)^2 + \frac{1}{2}kx_0^2$

$\Rightarrow \frac{1}{2}mv_0^2 = \frac{1}{6}mv_0^2 + \frac{1}{2}kx_0^2$

$\Rightarrow \frac{1}{2}kx_0^2 = \frac{1}{2}mv_0^2 - \frac{1}{6}mv_0^2 = \frac{mv_0^2}{3}$

$\therefore k = \frac{2}{3}m\left(\frac{v_0}{x_0}\right)^2$

Question182

A projectile moving vertically upwards with a velocity of $200ms^{-1}$ breaks into two equal parts at a height of 490m. One part starts moving vertically upwards with a velocity of $400ms^{-1}$. How much time it will take, after the break up with the other part to hit the ground? [Online May 12, 2012]

Options:

A. $2\sqrt{10}s$

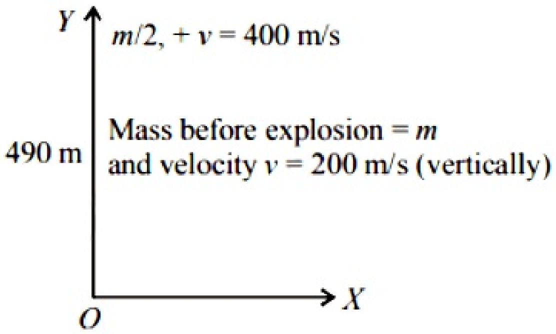
B. 5s

C. 10s

Answer: C

Solution:

Solution:



Momentum before explosion = Momentum after explosion

$m \times 200\hat{j} = \frac{m}{2} \times 400\hat{j} + \frac{m}{2}v$

$= \frac{m}{2}\left(400\hat{j} + v\right)$

$\Rightarrow 400\hat{j} - 400\hat{j} = v$

$\therefore v = 0$

i.e., the velocity of the other part of the mass, v = 0

Let time taken to reach the earth by this part be t

Applying formula, $h = ut + \frac{1}{2}gt^2$

$490 = 0 + 12 \times 9.8 \times t^2$

$\Rightarrow t^2 = \frac{980}{9.8} = 100$

$\therefore t = \sqrt{100} = 10\,\text{sec}$

Question183

At time t = 0 a particle starts moving along the x -axis. If its kinetic energy increases uniformly with time ' t ', the net force acting on it must be proportional to
[2011 RS]

Options:

A. constant

B. t

C. $\frac{1}{\sqrt{t}}$

D. $\sqrt{t}$

Answer: C

Solution:

Solution:

$K.E \propto t$

K.E. = ct [Here ,c = constant]

1 2 .

$\Rightarrow \frac{(mv)^2}{2m} = ct$

$\Rightarrow \frac{p^2}{2m} = ct (\because p = mv)$

$\Rightarrow p = \sqrt{2ctm}$

$\Rightarrow F = \frac{dp}{dt} = \frac{d(\sqrt{2ctm})}{dt}$

$\Rightarrow F = \sqrt{2cm} \times \frac{1}{2\sqrt{t}}$

$\Rightarrow F \propto \frac{1}{\sqrt{t}}$

Question184

The potential energy function for the force between two atoms in a diatomic molecule is approximately given by $U(x) = \frac{a}{x^{12}} - \frac{b}{x^6}$, where a and b are constants and x is the distance between the atoms. If the dissociation energy of the molecule is $D = [U(x = \infty) - U_{\text{at equilibrium}}]$, D is

[2010]

Options:

A. $\frac{b^2}{2a}$

B. $\frac{b^2}{12a}$

C. $\frac{b^2}{4a}$

D. $\frac{b^2}{6a}$

Answer: D

Solution:

Solution:

At equilibrium : $F = \frac{-dU(x)}{dx}$

$\Rightarrow F = \frac{-d}{dx}\left[\frac{a}{x^{12}} - \frac{b}{x^6}\right]$

$\Rightarrow F = -\left[\frac{12a}{x^{13}} + \frac{6b}{x^7}\right]$

$\Rightarrow \frac{12a}{x^{13}} = \frac{6b}{x^7} \Rightarrow x = \left(\frac{2a}{b}\right)^{\frac{1}{6}}$

$\therefore U_{\text{at equilibrium}} = \frac{a}{\left(\frac{2a}{b}\right)^2} - \frac{b}{\left(\frac{2a}{b}\right)} = -\frac{b^2}{4a}$ and $U_{(x = \infty)} = 0$

$\therefore D = 0 - \left(-\frac{b^2}{4a}\right) = \frac{b^2}{4a}$

Statement -1: Two particles moving in the same direction do not lose all their energy in a completely inelastic collision.
Statement -2 : Principle of conservation of momentum holds true for all kinds of collisions.
[2010]

Options:

A. Statement -1 is true, Statement -2 is true ; Statement -2 is the correct explanation of Statement -1.

B. Statement -1 is true, Statement -2 is true; Statement -2 is not the correct explanation of Statement -1

C. Statement -1 is false, Statement -2 is true.

D. Statement -1 is true, Statement -2 is false.

Answer: A

Solution:

Solution:
In completely inelastic collision, all initial kinetic energy is not lost but loss in kinetic energy 15 as large as it can be. Linear momentum remain conserved in all types of collision. Statement -2 explains statement -1 correctly because applying the principle of conservation of momentum, we can get the common velocity and hence the kinetic energy of the combined body.

Question186

An athlete in the olympic games covers a distance of 100 m in 10s. His kinetic energy can be estimated to be in the range [2008]

Options:

A. $200\text{J} - 500\text{J}$

B. $2 \times 10^5\text{J} - 3 \times 10^5\text{J}$

C. $20,000\text{J} - 50,000\text{J}$

D. $2,000\text{J} - 5,000\text{J}$

Answer: D

Solution:

Solution:
The average speed of the athelete
$v = \frac{5}{t} = \frac{100}{10} = 10\text{m/s}$
$\therefore K.E. = \frac{1}{2}mv^2$
Assuming the mass of athelet to 40 kg his average K.E would be

Assuming mass to 100kg average kinetic energy
$K.E. = \frac{1}{2} \times 100 \times (10)^2 = 5000J$

Question187

A block of mass 0.50 kg is moving with a speed of 2.00 ms^{-1} on a smooth surface. It strikes another mass of 1.00 kg and then they move together as a single body. The energy loss during the collision is
[2008]

Options:

A. 0.16 J

B. 1.00 J

C. 0.67 J

D. 0.34 J

Answer: C

Solution:

Solution:
Initial kinetic energy of the system
$K.E_i = \frac{1}{2}mu^2 + \frac{1}{2}M(0)^2$
$= \frac{1}{2} \times 0.5 \times 2 \times 2 + 0 = 1J$
Momentum before collision = Momentum after collision
$m_1u_1 + m_2u_2 = (m + M) \times v$
$\therefore 0.5 \times 2 + 1 \times 0 = (0.5 + 1) \times v \Rightarrow v = \frac{2}{3}m/s$
Final kinetic energy of the system is
$K.E_f = \frac{1}{2}(m + M)v^2$
$= \frac{1}{2}(0.5 + 1) \times \frac{2}{3} \times \frac{2}{3} = \frac{1}{3}J$
$\therefore$ Energy loss during collision $= \left(1 - \frac{1}{3}\right)J = 0.67J$

Question188

A 2 kg block slides on a horizontal floor with a speed of 4m/s. It strikes a uncompressed spring, and compresses it till the block is motionless. The kinetic friction force is 15N and spring constant is 10, 000N / m. The spring compresses by
[2007]

Options:

A. 8.5cm

C. 2.5cm

D. 11.0cm

Answer: B

Solution:

Solution:
Suppose the spring gets compressed by x before stopping.
kinetic energy of the block = P.E. stored in the spring + work done against friction.

$\Rightarrow \frac{1}{2} \times 2 \times (4)^2 = \frac{1}{2} \times 10,000 \times x^2 + 15 \times x$

$\Rightarrow 10,000x^2 + 30x - 32 = 0$

$\Rightarrow 5000x^2 + 15x - 16 = 0$

$\therefore x = \frac{-15 \pm \sqrt{(15)^2 - 4 \times (5000)(-16)}}{2 \times 5000}$

$= 0.055m = 5.5cm.$

Question189

A particle is projected at 60° to the horizontal with a kinetic energy K. The kinetic energy at the highest point is [2007]

Options:

A. K / 2

B. K

C. Zero

D. K / 4

Answer: D

Solution:

Solution:
Let u be the velocity with which the particle is thrown and m be the mass of the particle. Then

$K = \frac{1}{2}mu^2$ ......(1)

At the highest point the velocity is u cos 60° (only the horizontal component remains, the vertical component being zero at the top-most point). Therefore kinetic energy at the highest point.

$K' = \frac{1}{2}m(u \cos 60°)^2 = \frac{1}{2}mu^2\cos^2 60° = \frac{K}{4}$ [From 1]

Question190

A particle of mass 100g is thrown vertically upwards with a speed of 5m / s. The work done by the force of gravity during the time the particle goes up is

Options:

A. $-0.5J$

B. $-1.25J$

C. $1.25J$

D. $0.5J$

Answer: B

Solution:

Solution:
Given, Mass of the particle, m = 100g
Initial speed of the particle, μ = 5 m/s
Final speed of the particle, v = 0
Work done by the force of gravity
= Loss in kinetic energy of the body.

$= \frac{1}{2}m(v^2 - u^2) = \frac{1}{2} \times \frac{100}{1000}(0^2 - 5^2)$

$= -1.25J$

Question191

The potential energy of a 1kg particle free to move along the x -axis is given by $V(x) = \left(\frac{x^4}{4} - \frac{x^2}{2}\right)J$.
The total mechanical energy of the particle is 2J . Then, the maximum speed (in m / s) is
[2006]

Options:

A. $\frac{3}{\sqrt{2}}$

B. $\sqrt{2}$

C. $\frac{1}{\sqrt{2}}$

D. 2

Answer: A

Solution:

Solution:
Potential energy

$V(x) = \frac{x^4}{4} - \frac{x^2}{2}$ joule

For maxima of minima

$\frac{dV}{dx} = 0 \Rightarrow x^3 - x = 0 \Rightarrow x = \pm 1$

K.E. $_{(max.)}$ + P.E $_{(min.)}$ =2(Given)

$\therefore K.E_{.(max.)} = 2 + \frac{1}{4} = \frac{9}{4}$

$K.E_{max} = \frac{1}{2} m v_{max}^{2}$

$\Rightarrow \frac{1}{2} \times 1 \times v_{max}^{2} = \frac{9}{4} \Rightarrow v_{max.} = \frac{3}{\sqrt{2}}$

Question192

A mass of M kg is suspended by a weightless string. The horizontal force that is required to displace it until the string makes an angle of 45° with the initial vertical direction is
[2006]

Options:

A. $Mg(\sqrt{2}+1)$

B. $Mg\sqrt{2}$

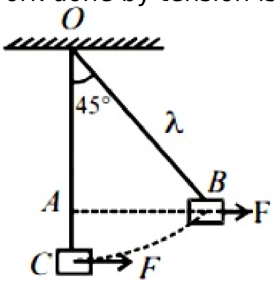
C. $\frac{Mg}{\sqrt{2}}$

D. $Mg(\sqrt{2}-1)$

Answer: D

Solution:

Solution:
Work done by tension + Work done by force (applied) + Work done by gravitational force = change in kinetic energy
Work done by tension is zero



$\Rightarrow 0 + F \times AB - Mg \times AC = 0$

$\Rightarrow F = Mg\left(\frac{AC}{AB}\right) = Mg\left[\frac{1-\frac{1}{\sqrt{2}}}{\frac{1}{\sqrt{2}}}\right]$

$[\because AB = l\sin 45° = \frac{l}{\sqrt{2}}$ and $AC = OC - OA = l - l\cos 45° = l\left(1-\frac{1}{\sqrt{2}}\right)$

where $l =$ length of the string.]

$\Rightarrow F = Mg(\sqrt{2}-1)$

Question193

A bomb of mass 16kg at rest explodes into two pieces of masses 4kg and

other mass is
[2006]

Options:

A. 144J

B. 288J

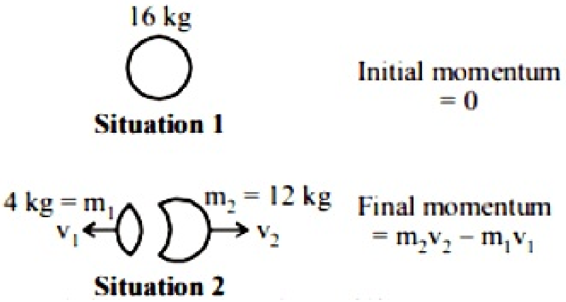
C. 192J

D. 96J

Answer: B

Solution:

Let the velocity and mass of 4kg piece be v_1 and m_1 and that of 12kg piece be v_2 and m_2.



Applying conservation of linear momentum

$16 \times 0 = 4 \times v_1 + 12 \times 4$

$\Rightarrow v_1 = -\frac{12 \times 4}{4} = -12 ms^{-1}$

Kinetic energy of 4kg mass

$\therefore K.E. = \frac{1}{2} m_1 v_1^2 = \frac{1}{2} \times 4 \times 144 = 288J$

Question194

A spherical ball of mass 20 kg is stationary at the top of a hill of height 100 m. It rolls down a smooth surface to the ground, then climbs up another hill of height 30 m and finally rolls down to a horizontal base at a height of 20 m above the ground. The velocity attained by the ball is [2005]

Options:

A. 20 m/s

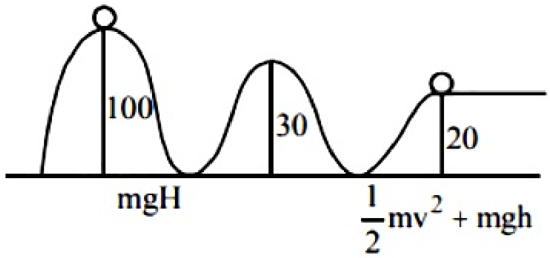
B. 40 m/s

C. $10\sqrt{30}$ m/s

D. 10 m/s

Answer: B

Solution:



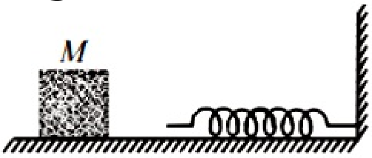
Using conservation of energy,
Total energy at 100 m height
= Total energy at 20m height

$m(10 \times 100) = m\left(\frac{1}{2}v^2 + 10 \times 20\right)$

or $\frac{1}{2}v^2 = 800$ or $v = \sqrt{1600} = 40 m / s$

Question195

The block of mass M moving on the frictionless horizontal surface collides with the spring of spring constant k and compresses it by length L. The maximum momentum of the block after collision is



[2005]

Options:

A. $\frac{kL^2}{2M}$

B. $\sqrt{Mk}L$

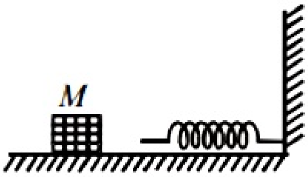
C. $\frac{ML^2}{k}$

D. zero

Answer: B

Solution:

Solution:
When the spring gets compressed by length L.
K.E. lost by mass M = P.E. stored in the compressed spring.



$\frac{1}{2}Mv^2 = \frac{1}{2}kL^2$

$\Rightarrow v = \sqrt{\frac{k}{M}} . L$

Momentum of the block, $= M \times v$

Question196

A mass 'm' moves with a velocity 'v' and collides inelastically with another identical mass. After collision the 1st mass moves with velocity $\frac{v}{\sqrt{3}}$ in a direction perpendicular to the initial direction of motion. Find the speed of the 2nd mass after collision.
[2005]

Options:

A. $\sqrt{3}v$

B. v

C. $\frac{v}{\sqrt{3}}$

D. $\frac{2}{\sqrt{3}}v$

Answer: D

Solution:

Solution:
Considering conservation of momentum along x-direction,
$mv = mv_1 \cos\theta$ ......(1)
where v_1 is the velocity of second mass
In y-direction,
$0 = \frac{mv}{\sqrt{3}} - mv_1 \sin\theta$
or $m_1 v_1 \sin\theta = \frac{mv}{\sqrt{3}}$ ...(2)
Squaring and adding eqns. (1) and (2) we get
$v_1{}^2 = v^2 + \frac{v^2}{\sqrt{3}} \Rightarrow v_1 = \frac{2}{\sqrt{3}}v$

Question197

A uniform chain of length 2m is kept on a table such that a length of 60cm hangs freely from the edge of the table. The total mass of the chain is 4kg. What is the work done in pulling the entire chain on the table?
[2004]

Options:

A. 12J

B. 3.6J

C. 7.2J

D. 1200J

Answer: B

Solution:

Solution:
Mass of over hanging part of the chain
$m' = \frac{4}{2} \times (0.6)\text{kg} = 1.2\text{kg}$
Weight of hanging part of the chain
$= 1.2 \times 10 = 12\text{N}$
C.M. of hanging part $= 0.3\text{m}$ below the table
Workdone in putting the entire cha in on the table $= 12 \times 0.30 = 3.6\text{J}$

Question198

A force $\vec{F} = \left(5\vec{i} + 3\vec{j} + 2\vec{k}\right)\text{N}$ is applied over a particle which displaces it from its origin to the point $\vec{r} = \left(2\vec{i} - \vec{j}\right)\text{m}$. The work done on the particle in joules is
[2004]

Options:

A. +10

B. +7

C. -7

D. +13

Answer: B

Solution:

Solution:
Given, Force, $\vec{F} = \left(5\hat{i} + 3\hat{j} + 2\hat{k}\right)$
Displacement, $x = \left(2\hat{i} - \hat{j}\right)$
Work done,
$W = \vec{F} \cdot \vec{x} = \left(5\hat{i} + 3\hat{j} + 2\hat{k}\right) \cdot \left(2\hat{i} - \hat{j}\right)$
$= 10 - 3 = 7\text{joules}$

Question199

A particle moves in a straight line with retardation proportional to its displacement. Its loss of kinetic energy for any displacement x is proportional to
[2004]

A. x

B. e^x

C. x^2

D. $\log_e x$

Answer: C

Solution:

Solution:
Given : retardation propto displacement
i.e., $a = -kx$[Here ,$k =$ constant]
But $a = v\frac{dv}{dx}$
$\therefore \frac{vdv}{dx} = -kx \Rightarrow \int_{v_1}^{v_2} vdv = -\int_0^x kxdx$
$\Rightarrow \left[\frac{v^2}{2}\right]_{v_1}^{v_2} = -k\left[\frac{x^2}{2}\right]_0^x$
$\Rightarrow (v_2{}^2 - v_1{}^2) = -\frac{kx^2}{2}$
$\Rightarrow \frac{1}{2}m(v_2{}^2 - v_1{}^2) = \frac{1}{2}m\left(\frac{-kx^2}{2}\right)$
$\therefore$ Loss in kinetic energy ,$\therefore \Delta K \propto x^2$

Question200

A particle is acted upon by a force of constant magnitude which is always perpendicular to the velocity of the particle, the motion of the particles takes place in a plane. It follows that [2004]

Options:

A. its kinetic energy is constant

B. its acceleration is constant

C. its velocity is constant

D. it moves in a straight line

Answer: A

Solution:

Solution:
Work done by such force is always zero since force is acting in a direction perpendicular to velocity.
$\therefore$ From work-energy theorem $= \Delta K = 0$
K remains constant.

A body of mass ' m ', accelerates uniformly from rest to ' v_1 ' in time ' t_1 '. The instantaneous power delivered to the body as a function of time ' t ' is
[2004]

Options:

A. $\frac{mv_1t^2}{t_1}$

B. $\frac{mv_1^{2}t}{t_1^{2}}$

C. $\frac{mv_1t}{t_1}$

D. $\frac{mv_1^{2}t}{t_1}$

Answer: B

Solution:

Solution:
Let a be the acceleration of body
Using, $v = u + at$
$v_1 = 0 + at_1 \Rightarrow a = \frac{v_1}{t_1}$
Velocity of the body at instant t $v = at$
$\Rightarrow v = \frac{v_1 t}{t_1}$
Instantaneous powr, $P = \vec{F} \cdot \vec{v} = (m\vec{a}) \cdot \vec{v}$
$= \left(\frac{mv_1}{t_1}\right)\left(\frac{v_1 t}{t_1}\right) = m\left(\frac{v_1}{t_1}\right)^2 t$

Question202

A spring of spring constant $5 \times 10^3 N / m$ is stretched initially by 5cm from the unstretched position. Then the work required to stretch it further by another 5cm is
[2003]

Options:

A. $12.50N - m$

B. $18.75N - m$

C. $25.00N - m$

D. $6.25N - m$

Answer: B

Solution:
Spring constant, $k = 5 \times 10^3 N / m$
Let x_1 and x_2 be the initial and final stretched position of the spring, then
Work done, $W = \frac{1}{2}k(x_2^2 - x_1^2)$
$= \frac{1}{2} \times 5 \times 10^3[(0.1)^2 - (0.05)^2]$
$= \frac{5000}{2} \times 0.15 \times 0.05 = 18.75 N m$

Question203

A wire suspended vertically from one of its ends is stretched by attaching a weight of 200N to the lower end.
The weight stretches the wire by 1 mm. Then the elastic energy stored in the wire is
[2003]

Options:

A. 0.2 J

B. 10 J

C. 20 J

D. 0.1 J

Answer: D

Solution:

Solution:
The elastic potential energy
$= \frac{1}{2} \times$ Force $\times$ extension
$= \frac{1}{2} \times F \times x$
$= \frac{1}{2} \times 200 \times 0.001 = 0.1 J$

Question204

A body is moved along a straight line by a machine delivering a constant power. The distance moved by the body in time ' t ' is proportional to
[2003]

Options:

A. $t^{3/4}$

B. $t^{3/2}$

D. $t^{1/2}$

Answer: B

Solution:

Solution:
Power, $P = Fv = ma.v$

$\Rightarrow P = \frac{m\,dv}{dt}v = c = $ contant $\left(\because F = ma = \frac{m\,dv}{dt}\right)$

$mv_0 v = c\,dt$

Integrating both sides, we get

$m\int_0^v v\,dv = c\int_0^t dt$

$\Rightarrow \frac{1}{2}mv^2 = ct$

$\Rightarrow \frac{v^2}{2} = \frac{c.t}{m}$

$\Rightarrow v_2 = \frac{2c.t}{m}$

$\Rightarrow v = \sqrt{\frac{2c}{m}} \times t^{1/2}$

$\Rightarrow \frac{dx}{dt} = \sqrt{\frac{2c}{m}} \times t^{1/2}$ where $v = \frac{dx}{dt}$

$\Rightarrow \int_e^x dx = \sqrt{\frac{2c}{m}} \times \int_0^t t^{1/2}dt$

$\Rightarrow x = \sqrt{\frac{2c}{m}} \times \frac{2t^{3/2}}{3} \Rightarrow x \propto t^{3/2}$

Question205

Consider the following two statements:
A. Linear momentum of a system of particles is zero
B. Kinetic energy of a system of particles is zero. Then [2003]

Options:

A. A does not imply B and B does not imply A

B. A implies B but B does not imply A

C. A does not imply B but B implies A

D. A implies B and B implies A

Answer: C

Solution:

Solution:
Kinetic energy of a system of particle is zero only when the speed of each particles is zero. This implies momentum of each particle is zero, thus linear momentum of the system of particle has to be zero.
Also if linear momentum of the system is zero it does not mean linear momentum of each particle is zero. This is because linear momentum is a vector quantity. In this case the kinetic energy of the system of particles will not be zero.
∴ Adoes not imply B but B implies A.
Given, force, F = 200N, extension of wire, x = 1mm

Question206

A spring of force constant 800N / m has an extension of 5cm. The work done in extending it from 5cm to 15cm is [2002]

Options:

A. 16J

B. 8J

C. 32J

D. 24J

Answer: B

Solution:

Solution:
Small amount of work done in extending the spring by dx is
$dW = kx\,dx$
$\therefore W = k\int_{0.05}^{0.15} x\,dx$
$= \frac{800}{2}[(0.15)^2 - (0.05)^2]$
$= 400[(0.15 + 0.05)(0.15 - 0.05)]$
$= 400 \times 0.2 \times 0.1 = 8J$

Question207

A ball whose kinetic energy is E, is projected at an angle of 45° to the horizontal. The kinetic energy of the ball at the highest point of its flight will be [2002]

Options:

A. E

B. $E / \sqrt{2}$

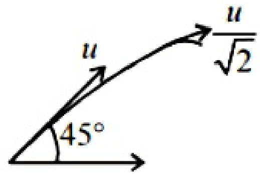
C. E/2

D. zero

Answer: C

Solution:

Solution:
Let u be the speed with which the ball of mass m is projected. Then the kinetic energy (E) at the point of projection is



$E = \frac{1}{2}mu^2$ ....(i)

When the ball is at the highest point of its flight, the speed of the ball is $\frac{u}{\sqrt{2}}$ (Remember that the horizontal component of velocity does not change during a projectile motion).

∴ The kinetic energy at the highest point

$= \frac{1}{2}m\left(\frac{u}{\sqrt{2}}\right)^2 = \frac{1}{2}\frac{mu^2}{2} = \frac{E}{2}$ [From (i)]
