Work, Energy and Power

Question1

An object moving along horizontal x-direction with kinetic energy 10J is displaced through $x = (3\hat{i})\text{m}$ by the force $\vec{F} = (-2\hat{i} + 3\hat{j})\text{N}$. The kinetic energy of the object at the end of the displacement x is

[NEET 2024 Re]

Options:

A.

10J

B.

16J

C.

4J

D.

6J

Answer: C

Solution:

Work energy theorem,

$W_{\text{all}} = \Delta K \cdot E\,(W_{\text{all}} = \text{ work done by all forces })$

$\Rightarrow K_f - K_i = \vec{F} \cdot \Delta \vec{x}$

$\Rightarrow K_f - 10 = (-2\hat{i} + 3\hat{j}) \cdot (3\hat{i})$

$K_f - 10 = -6$

$K_f = 4\text{J}$

Question2

An object falls from a height of 10m above the ground. After striking the ground it loses 50% of its kinetic energy. The height upto which the object can rebounce from the ground is:

[NEET 2024 Re]

Options:

A.

7.5m

B.

10m

C.

2.5m

D.

5m

Answer: D

Solution:

K.E. just before striking the ground $K_1 = mgh_1 = mg(10)$

K.E. just after striking the ground $= K_1 - \frac{50}{100}K_1 = \frac{50}{100}K_1 = \frac{K_1}{2} = K_2$

Now, $K_2 = mgh_2$

$\Rightarrow \frac{K_1}{2} = mgh_2$

$\Rightarrow \frac{mg(10)}{2} = mgh_2 \Rightarrow h_2 = 5\text{m}$

Question3

The potential energy of a long spring when stretched by 2cm is U. If the spring is stretched by 8cm, potential energy stored in it will be

[NEET 2023]

Options:

A.

4U

B.

8U

C.

16U

D.

2U

Answer: C

Solution:

Potential energy stored in spring $U = \frac{1}{2}Kx^2$

$$U = \frac{1}{2}K(2)^2 \text{ where } x = 2\text{ cm}$$

$$U = \frac{1}{2}(K)\cdot(4)$$

$$U = 2K$$

$$U' = \frac{1}{2}K(8)^2$$

$$U' = \frac{1}{2}K \times 64 = 32K$$

On dividing (i) by (ii)

$$\frac{U}{U'} = \frac{2K}{32K} = \frac{1}{16}$$

$$U' = 16U$$

Question4

At any instant of time t, the displacement of any particle is given by 2t − 1 (SI unit) under the influence of force of 5N. The value of instantaneous power is (in SI unit):

[NEET 2024]

Options:

A.

10

B.

5

C.

7

D.

6

Answer: A

Solution:

$x = 2t - 1$

$v = \frac{dx}{dt} = 2\text{m } s^{-1}$

$P = F \cdot v$

$= 2 \times 5 = 10\text{W}$

Question5

A bullet of mass m hits a block of mass M elastically.

The transfer of energy is the maximum, when :

[NEET 2023 mpr]

Options:

A.

M = m

B.

M = 2m

C.

M < < m

D.

M > > m

Answer: A

Solution:

Solution:

In elastic collision maximum energy is transfer when M = m

Question6

A particle moves with a velocity $(5\hat{i} - 3\hat{j} + 6\hat{k})\text{m } s^{-1}$ horizontally under the action of constant force $(10\hat{i} + 10\hat{j} + 20\hat{k})N$. The instantaneous power supplied to the particle is :

[NEET 2023 mpr]

Options:

A.

200W

B.

Zero

C.

100W

D.

140W

Answer: D

Solution:

$P = \vec{F} \cdot \vec{V}$

$P = \left(10\hat{i} + 10\hat{j} + 20\hat{k}\right) \cdot \left(5\hat{i} - 3\hat{j} + 6\hat{k}\right)$

$P = 50 - 30 + 120$

$P = 140W$

Question7

An electric lift with a maximum load of 2000kg (lift + passengers) is moving up with a constant speed of $1.5ms^{-1}$. The frictional force opposing the motion is 3000N . The minimum power delivered by the motor to the lift in watts is : ($g = 10ms^{-2}$)
[NEET-2022]

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Options:

A. 23000

B. 20000

C. 34500

D. 23500

Answer: C

Solution:

Solution :

$F_{up} = 2000g + 3000$

$= 23000N$

Minimum power $P_{min} = \vec{F} \cdot \vec{V}$

$P_{min} = Fv = 23000 \times \frac{3}{2}$

$= 34500W$

Question8

The energy that will be ideally radiated by a 100kW transmitter in 1 hour is
[NEET-2022]

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Options:

A. 36×10^7J

B. 36×10^4J

C. 36×10^5J

D. 1×10^5J

Answer: A

Solution:

Energy = Power × time

$E = 100 \times 10^3 \times 3600$

$= 36 \times 10^7 J$

Question9

The distance covered by a body of mass 5g having linear momentum 0.3 kg m / s in 5s is:
[NEET Re-2022]

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Options:

A. 0.3m

B. 300m

C. 30m

D. 3m

Answer: B

Solution:

$P = mv$

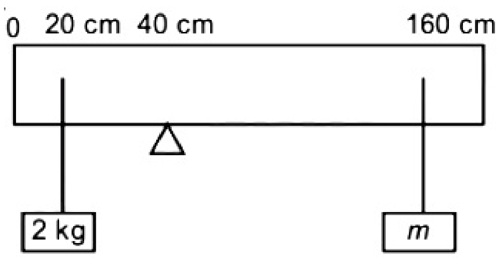
$0.3 = \dfrac{5}{1000} \times v \Rightarrow v = 60\mathrm{m/s}$

Distance travelled in $5s = 60 \times 5$

$= 300\mathrm{m}$

Question10

A uniform rod of length 200 cm and mass 500 g is balanced on a wedge placed at 40 cm mark. A mass of 2 kg is suspended from the rod at 20 cm and another unknown mass 'm' is suspended from the rod at 160 cm mark as shown in the figure. Find the value of 'm' such that the rod is in equilibrium. (g = 10 m/s^2)
[NEET 2021]



Options:

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

B. $\frac{1}{3}$kg

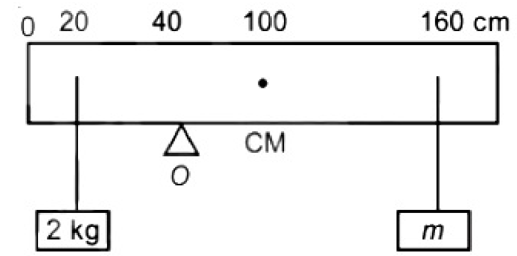
C. $\frac{1}{6}$kg

D. $\frac{1}{12}$kg

Answer: D

Solution:

Solution:
Given that
Mass of rod = 500 g; Length of rod = 200 cm



Rod will be in equilibrium, when net torque about point O will be zero.
Torque at point O due to 2 kg mass

$\vec{\tau} = \vec{r} \times \vec{F} = rF \sin\theta(\hat{n})$

$\tau_1 = 20 \times 20 \times 10^{-2} \times \sin 90°(\hat{k}) = 4N\,m(\hat{k})$

Torque due to mass of rod :

$\tau_2 = 5 \times 60 \times 10^{-2} \times \sin 90°(-\hat{k}) = 3N\,m(-\hat{k})$

Torque due to mass m

$\tau_3 = mg \times 120 \times 10^{-2} \times \sin 90°(-\hat{k}) = 12mN\,m(-\hat{k})$

Net torque about point O will be zero

So $\vec{\tau}_1 + \vec{\tau}_2 + \vec{\tau}_3 = 0$

$\Rightarrow 4 - 3 - 12m = 0$

$\Rightarrow 12m = 1$

$m = \frac{1}{12} kg$

Question11

A particle is released from height S from the surface of the Earth. At a certain height its kinetic energy is three times its potential energy. The height from the surface of earth and the speed of the particle at that instant are respectively [NEET 2021]

Options:

A. $\frac{S}{4}, \frac{3gS}{2}$

B. $\frac{S}{4}, \frac{\sqrt{3gS}}{2}$

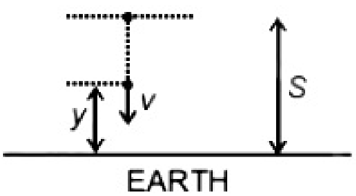
C. $\frac{S}{2}, \frac{\sqrt{3gS}}{2}$

D. $\frac{S}{4}, \sqrt{\frac{3gS}{2}}$

Answer: D

Solution:

Let required height of body is y.
When body from rest falls through height (S – y)
Then under constant acceleration



$v^2 = 0^2 + 2g(S - y)$
$v = \sqrt{2g(S - y)}$ ......(1)
When body is at height y above ground. Potential energy of body of mass m
U = mgy
As per given condition kinetic energy, K = 3U
$\frac{1}{2}m(v)^2 = 3 \times mg(y)$
$\frac{1}{2} \times m \times 2g(S - y) = 3 \times mgy$ (using (1))
$S - y = 3y$
$\therefore y = \frac{S}{4}$ ....(2)
$\therefore v = \sqrt{2 \times g\left(S - \frac{S}{4}\right)} = \sqrt{\frac{3gS}{2}}$ ....(3)

Question12

Water falls from a height of 60 m at the rate of 15 kg/s to operate a turbine. The losses due to frictional force are 10% of the input energy. How much power is generated by the turbine?
($g = 10\ m/s^2$)
[NEET 2021]

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Options:

A. 10.2 kW

B. 8.1 kW

C. 12.3 kW

D. 7.0 kW

Answer: B

Solution:

Solution:
Incident power on turbine $= \frac{d(mgh)}{dt}$
$= gh\frac{dm}{dt}$
$= 10 \times 60 \times 15$
$= 9000$ W
Now, losses are 10%
$\therefore$ power generated $= \left(1 - \frac{10}{100}\right) \times 9000$
= 8100 W
= 8.1 kW

Question13

Body A of mass 4m moving with speed u collides with another body B of mass 2m, at rest. The collision is head on and elastic in nature. After

the collision the fraction of energy lost by the colliding body A is (NEET 2019)

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Options:

A. $\frac{5}{9}$

B. $\frac{1}{9}$

C. $\frac{8}{9}$

D. $\frac{4}{9}$

Answer: C

Solution:

Fractional loss of KE of colliding body,

$$\frac{\Delta KE}{KE} = \frac{4 \times (m_1 m_2)}{(m_1 + m_2)^2}$$

$$= \frac{4 \times (4m) \times 2m}{(4m + 2m)^2}$$

$$= \frac{32m^2}{36m^2} = \frac{8}{9}$$

Question14

A force F = 20 + 10y acts on a particle in y -direction where F is in newton and y in meter. Work done by this force to move the particle from y = 0 to y = 1m is
(NEET 2019)

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Options:

A. 20J

B. 30J

C. 5J

D. 25 J

Answer: D

Solution:

Work done by variable force

Work done, $W = \int_{yi}^{yf} F\,dy \Rightarrow \int_{y=0}^{yf=1} F \cdot dy$

where, $F = 20 + 10y$

$\therefore W = \int_0^1 (20 + 10y)dy$

$= \left[20y + \frac{10y^2}{2}\right]_0^1 = 25J$

Question15

A mass m is attached to a thin wire and whirled in a vertical circle. The wire is most likely to break when
(NEET 2019)

Options:

A. inclined at an angle of 60° from vertical

B. the mass is at the highest point

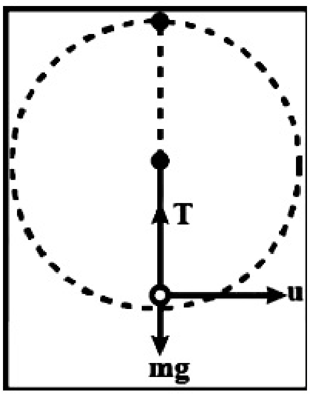
C. the wire is horizontal

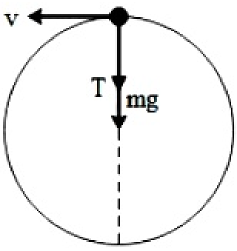
D. the mass is at the lowest point

Answer: D

Solution:

Solution:





We know that,

$T - mg = \frac{mu^2}{l}$

$\Longrightarrow T = mg + \frac{mu^2}{l}$

The tension is maximum at the lowest position of mass, so the chance of breaking is maximum.

Question16

A particle of mass 5m at rest suddenly breaks on its own into three fragments. Two fragments of mass m each move along mutually perpendicular direction with speed v each. The energy released during the process is
(OD NEET 2019)

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Options:

A. $\frac{3}{5}mv^2$

B. $\frac{5}{3}mv^2$

C. $\frac{3}{2}mv^2$

D. $\frac{4}{3}mv^2$

Answer: D

Solution:

$3m\vec{v} + mv\hat{i} + mv\hat{j} = 0$

$\Rightarrow \vec{v} = -\frac{v}{3}\hat{i} - \frac{v}{3}\hat{j}$

$\left|\vec{v}\right| = \frac{\sqrt{2}}{3}v$

Energy released

$= \frac{1}{2}mv^2 + \frac{1}{2}mv^2 + \frac{1}{2}(3m)\left(\frac{2}{9}\right)v^2$

$= \frac{4}{3}mv^2$

Question17

A moving block having mass m, collides with another stationary block having mass 4m. The lighter block comes to rest after collision. When the initial velocity of the lighter block is v, then the value of coefficient of restitution (e) will be
(2018)

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Options:

A. 0.5

B. 0.25

C. 0.8

D. 0.4

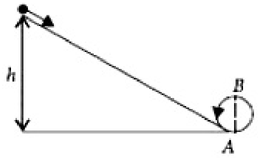
Answer: B

Solution:

Solution:
Coefficient of Restitution (e) -
$e = \frac{v_2 - v_1}{u_2 - u_1}$
Ratio of relative velocity after collision to relative velocity before collision.
Let velocity of $4m$ mass is v after collision
then $mv = 4mv$
$v = \frac{v}{4v}$
$e = \frac{\text{velocity of seperation}}{\text{velocity of approach}} = \frac{\frac{v}{4}}{v}$
$= \frac{1}{4}$
e = 0.25

Question18

A body initially rest and along a frictionless track from a height h (as shown in the figure) just completes a vertical circle of diameter AB = D. The height h is equal to



(2018)

Options:

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

B. D

C. $\frac{7}{5}D$

D. $\frac{5}{4}D$

Answer: D

Solution:

Solution:
Given: a body initially at rest and sliding along a frictionless track from a height h (as shown in the figure) just completes as vertical of diameter $AB = D$. To find the height h Solution:
Energy conservative forces $K + U = E$ Here E is constant
$\Delta K + \Delta U = 0$
$\Longrightarrow \Delta K = -\Delta U$

For particles to complete circle $V = \sqrt{5gR}$
$\Longrightarrow V = \sqrt{gh}$
$\Longrightarrow \sqrt{2gh} = \sqrt{\frac{5gD}{2}}$
$\Longrightarrow 2gh = \frac{5gD}{2}$
$\Longrightarrow h = \frac{5D}{4}$
is the height h.

Question19

Consider a drop of rain water having mass 1 g falling from a height of 1 km. It hits the ground with a speed of $50ms^{-1}$. Take 'g' constant with a value $10ms^{-2}$.The work don by the (i) gravitational force and the (ii) resistive force of air is
(2017 NEET)

Options:

A. (i) 1.25 J (ii) -8.25 J

B. (i) 100 J (ii) 8.75 J

C. (i) 10 J (ii) -8.75 J

D. (i) -10 J (ii) -8.25 J

Answer: C

Solution:

Solution:
Here
$m = 1\text{ g} = 10^{-3}\text{kg}, h = 1\text{ km} = 1000\text{m} . v = 50ms^{-1}, g = 10ms^{-2}$

(i) The work done by the gravitational force
$= mgh = 10^{-3} \times 10 \times 1000 = 10J$
(ii) The total work done by gravitational force and the resistive force of air is equal to change in kinetic energy of rain drop
$\therefore W_g + W_r = \frac{1}{2}mv^2 - 0$
$10 + W_r = \frac{1}{2} \times 10^{-3} \times 50 \times 50$ or $W_r = -8.75J$

Question20

A particle of mass 10 g moves along a circle of radius 6.4 cm with a constant tangential acceleration. What is the magnitude of this acceleration if the kinetic energy of the particle becomes equal to $8 \times 10^{-4}J$ by the end of the second revolution after the beginning of the motion ?
(2016 NEET Phase-I)

Options:

A. $0.18\frac{m}{s^2}$

B. $0.2\frac{m}{s^2}$

C. $0.1\frac{m}{s^2}$

D. $0.15\frac{m}{s^2}$

Answer: C

Solution:

Here,$m = 10g = 10^{-2}kg$
$R = 6.4cm = 6.4 \times 10^{-2}m$, $K_f = 8 \times 10^{-4}J$
$K_i = 0$, $a_t = ?$
Using work energy theorem,
Work done by all the forces = Change in KE
$W_{\text{tangential force}} + W_{\text{centripetal force}} = K_f - K_i$
$\Rightarrow F_t \times s + 0 = K_f - 0 \Rightarrow ma_t \times (2 \times 2\pi R) = K_f$
$\Rightarrow a_t = \frac{K_f}{4\pi Rm} = \frac{8 \times 10^{-4}}{4 \times \frac{22}{7} \times 6.4 \times 10^{-2} \times 10^{-2}}$
$= 0.099 \approx 0.1ms^{-2}$

Question21

A body of mass 1 kg begins to move under the action of time dependent force $\vec{F} = \left(2t\hat{i} + 3t^2\hat{j}\right)N$, where $\hat{i}$ and $\hat{j}$ are unit vectors along x and y axis. What power will developed by the force at the time t?
(2016 NEET Phase-I)

Options:

A. $(2t^3 + 3t^4)W$

B. $(2t^3 + 3t^5)W$

C. $(2t^2 + 3t^3)W$

D. $(2t^2 + 4t^4b)$

Answer: B

Solution:

$\vec{F} = \left(2t\hat{i} + 3t^2\hat{j}\right)N$, m = 1kg

Acceleration of the body, $\vec{a} = \frac{\vec{F}}{m} = \frac{\left(2t\hat{i} + 3t^2\hat{j}\right)N}{1kg}$

Velocity of the body at time t,

$\vec{v} = \int \vec{a}\,d\,t = \int \left(2t\hat{i} + 3t^2\hat{j}\right)d\,t = t^2\hat{i} + t^3\hat{j}ms^{-1}$

∴Power developed by the force at time t,

$P = \vec{F} \cdot \vec{v} = \left(2t\hat{i} + 3t^2\hat{j}\right) \cdot \left(t^2\hat{i} + t^3\hat{j}\right)W$

$= (2t^3 + 3t^5)W$

Question22

What is the minimum velocity with which a body of mass m must enter a vertical loop of radius R so that can complete the loop?
(2016 NEET Phase-I)

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Options:

A. $\sqrt{3gR}$

B. $\sqrt{5gR}$

C. $\sqrt{gR}$

D. $\sqrt{2gR}$

Answer: B

Question23

A bullet of mass 10 g moving horizontally with a velocity of 400ms^{-1} strikes a wood block of mass 2 kg which is suspended by light in extensible string of length 5 m. As a result, the centre of gravity of the block found to rise a vertical distance of 10 cm. The speed of the bullet after it emerges out horizontally from the block will be
(2016 NEET Phase-II)

Options:

A. 100ms^{-1}

B. 80ms^{-1}

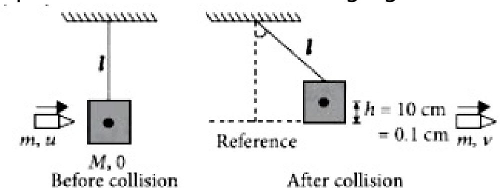
C. 120ms^{-1}

D. $160 ms^{-1}$

Answer: C

Solution:

Mass of bullet, $m = 10g = 0.01kg$
Initali speed of bullet, $u = 400ms^{-1}$
Mass of block, $M = 2kg$
Length of string, $l = 5m$
Speed of the block after collision $= v_1$
Speed of the bullet on emerging from block, v = ?



Using energy conservation principle for the block
$(KE + PE)_{Reference} = (KE + PE)_h$
$\Rightarrow \frac{1}{2} M v_1^2 = M gh$ or $v_1 = \sqrt{2gh}$
$v_1 = \sqrt{2 \times 10 \times 0.1} = \sqrt{2} ms^{-1}$
Using momentum conservation principle for block and bullet system,
$(M \times 0 + mu)_{Before\ collision} = (M \times v_1 + mv)_{After\ collision}$
$\Rightarrow 0.01 \times 400 = 2\sqrt{2} + 0.01 \times v$
$\Rightarrow v = \frac{4 - 2\sqrt{2}}{0.01} = 117.15 ms^{-1} \approx 120 ms^{-1}$

Question24

Two identical balls A and B having velocities of $0.5ms^{-1}$ and $0.3ms^{-1}$ respectively collide elastically in one dimension. The velocities of B and A after the collision respectively will be (2016 NEET Phase-II)

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Options:

A. $-0.5ms^{-1}$ and $0.3ms^{-1}$

B. $0.5ms^{-1}$ and $-0.3ms^{-1}$

C. $-0.3ms^{-1}$ and $0.5ms^{-1}$

D. $0.3ms^{-1}$ and $0.5ms^{-1}$

Answer: B

Solution:

Masses of the balls are same and collision is elastic, so their velocity will be interchanged after collision.
$\therefore v_a = +u_B = -0.3ms^{-1}$ and $v_B = v_A = 0.5ms^{-1}$

Question25

A particle moves from a point $\left(-2\hat{i} + 5\hat{j}\right)$ to $\left(4\hat{j} + 3\hat{k}\right)$ when a force of $\left(4\hat{i} + 3\hat{j}\right)$N is applied.How much work has been done by force ?
(2016 NEET Phase-II)

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Options:

A. 8 J

B. 11 J

C. 5 J

D. 2 J

Answer: C

Solution:

Here $\vec{r}_1 = \left(-2\hat{i} + 5\hat{j}\right)$m, $\vec{r}_2 = \left(4\hat{j} + 3\hat{k}\right)$m
$\vec{F} = \left(4\hat{i} + 3\hat{j}\right)$N , W = ?
Work done by force F in moving from $\vec{r}_1$ to $\vec{r}_2$
$W = \vec{F} \cdot \left(\vec{r}_2 - \vec{r}_1\right)$
$W = \left(4\hat{i} + 3\hat{j}\right) \cdot \left(4\hat{j} + 3\hat{k} + 2\hat{i} - 5\hat{j}\right)$
$\Rightarrow \left(4\hat{i} + 3\hat{j}\right) \cdot \left(2\hat{i} - \hat{j} + 3\hat{k}\right)$
$= 8 + (-3) = 5$J

Question26

Two particles A and B, move with constant velocities $\vec{v}_1$ and $\vec{v}_2$.At the initial moment their position vectors are $\vec{r}_1$ and $\vec{r}_2$ respectively. The condition for particles A and B for their collision is
(2015)

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Options:

A. $\vec{r}_1 \times \vec{v}_1 = \vec{r}_2 \times \vec{v}_2$

B. $\vec{r}_1 - \vec{r}_2 = \vec{v}_1 - \vec{v}_2$

C. $\frac{\vec{r}_1 - \vec{r}_2}{\left|\vec{r}_1 - \vec{r}_2\right|} = \frac{\vec{v}_2 - \vec{v}_1}{\left|\vec{v}_2 - \vec{v}_1\right|}$

D. $\vec{r}_1 \cdot \vec{v}_1 = \vec{r}_2 \cdot \vec{v}_2$

Answer: C

Solution:

Solution:
Let the particles A and B collide at time t. For their collision, the position vectors of both particles should be same at time t, i.e.
$\vec{r}_1 + \vec{v}_1 t = \vec{r}_2 + \vec{v}_2 t$
$\vec{r}_1 - \vec{r}_2 = \vec{v}_2 t - \vec{v}_1 t$
$= (\vec{v}_2 - \vec{v}_1) t$........(i)
Also, $|\vec{r}_1 - \vec{r}_2| = |\vec{v}_2 - \vec{v}_1| t$
or $t = \frac{|\vec{r}_1 - \vec{r}_2|}{|\vec{v}_2 - \vec{v}_1|}$
Substituting this value of t in eqn. (i), we get
$\frac{\vec{r}_1 - \vec{r}_2}{|\vec{r}_1 - \vec{r}_2|} = \frac{(\vec{v}_2 - \vec{v}_1)}{|\vec{v}_2 - \vec{v}_1|}$

Question27

The heart of a man pump s 5 litres of blood through the arteries per minute at a pressure of150 mm of mercury. If the density of mercury be 13. × $10^3 \frac{kg}{m^3}$ and g = $10 \frac{m}{s^2}$ then the power of heart in watt is (2015)

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Options:

A. 3.0

B. 1.50

C. 1.70

D. 2.35

Answer: C

Solution:

Here,Volume of blood pumped by man's heart,
$V = 5$ litres $= 5 \times 10^{-3} m^3$ ($\because$1 litre $= 10^{-3} m^3$)
Time in which this volume of blood pumps,
t = 1 min = 60 s
Pressure at which the blood pumps,
$P = 150mm$ of Hg=0.15 m of Hg
$= (0.15m)\left(13.6 \times 10^3 \frac{kg}{m^3}\right)\left(10 \frac{m}{s^2}\right)$
$(\because P = h\rho g)$
$= 20.4 \times 10^3 \frac{N}{m^2}$

$\therefore$ Power of the heart = $\frac{PV}{t}$

$$= \frac{\left(20.4 \times 10^3 \frac{N}{m^2}\right)(5 \times 10^{-3} m^3)}{60s} = 1.70W$$

Question28

A ball is thrown vertically downwards from a height of 20 m with an initial velocity v_0.It collides with the ground, loses 50 percent of its energy in collision and rebounds to the same height. The initial velocity v_0 is (Take $g = 10ms^{-2}$) (2015)

Options:

A. $28ms^{-1}$

B. $10ms^{-1}$

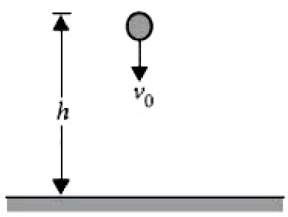
C. $14ms^{-1}$

D. $20ms^{-1}$

Answer: D

Solution:

Solution:
The situation is shown in the figure.



Let v be the velocity of the ball with which it collides with ground. Then according to the law of conservation of energy,Gain in kinetic energy = loss in potential energy

i . e$\frac{1}{2}mv^2 - \frac{1}{2}mv_0{}^2 = mgh$

(where m is the mass of the ball)

or $v^2 - v_0{}^2 = 2gh$ ....(i)

Now, when the ball collides with the ground, 50% of its energy is lost and it rebounds to the same height h

$\therefore \frac{50}{100}\left(\frac{1}{2}mv^2\right) = mgh$

$\frac{1}{4}v^2 = gh$ or $v^2 = 4gh$

Substituting this value of v^2 in eq (i),we get

$4gh - v_0{}^2 = 2gh$

or $v_0{}^2 = 4gh - 2gh = 2gh$ or $v_0 = \sqrt{2gh}$

Here, $g = 10ms^{-2}$ and $h = 20m$

$\therefore v_0 = \sqrt{2(10ms^{-2})(20m)} = 20ms^{-1}$

Question29

On a frictionless surface, a block of mass M moving at speed v collides elastically with another block of same mass M which is initially at rest. After collision the first block moves at an angle 0 to its initial direction and has a speed $\frac{v}{3.}$ The second block's speed after the collision (2015)

Options:

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

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

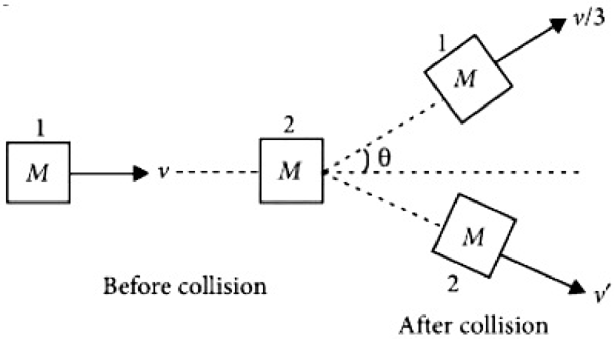
C. $\frac{2\sqrt{2}}{3}v$

D. $\frac{3}{4}v$

Answer: C

Solution:

Solution:
The situation is shown in the figure.



Let V be speed of second block after the collision.
As the collision is elastic, so kinetic energy is conserved.
According to conservation of kinetic energy,

$$\frac{1}{2}M\,v^2 + 0 = \frac{1}{2}M\left(\frac{v}{3}\right)^2 + \frac{1}{2}M\,v'^2$$

$$v^2 = \frac{v^2}{9} + v'^2$$

or $v'^2 = v^2 - \frac{v^2}{9} = \frac{9v^2 - v^2}{9} = \frac{8}{9}v^2$

$$v' = \sqrt{\frac{8}{9}v^2} = \frac{\sqrt{8}}{3}v = \frac{2\sqrt{2}}{3}v$$

Question30

A particle of mass m is driven by a machine that delivers a constant power k watts. If the particle starts from rest the force on the particle at time t is (2015)

©

Options:

A. $\sqrt{2mkt}^{-\frac{1}{2}}$

B. $\frac{1}{2}\sqrt{mkt}^{-\frac{1}{2}}$

C. $\sqrt{\frac{mk}{2}}t^{-\frac{1}{2}}$

D. $\sqrt{mkt}^{-\frac{1}{2}}$

Answer: C

Solution:

Solution:
Constant power acting on the particle of mass m is k watt.
or P = k
$\frac{dW}{dt} = k; \; dW = kdt$
Integrating both sides, $\int_0^W dW = \int_0^t kdt$
$\Rightarrow W = kt$ ....(i)
Using work energy theorem,
$W = \frac{1}{2}mv^2 - \frac{1}{2}m(0)^2$
$kt = \frac{1}{2}mv^2$ [Using equation(i)]
$v = \sqrt{\frac{2kt}{m}}$
Acceleration of the particle, $a = \frac{dv}{dt}$
$a = \frac{1}{2}\sqrt{\frac{2k}{m}} = \frac{1}{\sqrt{t}} = \sqrt{\frac{k}{2mt}}$
Force on the particle,
$F = ma = \sqrt{\frac{mk}{2t}} = \sqrt{\frac{mk}{2}}t^{-\frac{1}{2}}$

Question31

Two particles of masses m_1, m_2 move with initial velocities u_1 and u_2.On collision, one of the particles get excited to higher level, after absorbing energy e. If final velocities of particles be v_1 and v_2 then we must have (2015)

©

Options:

A.

$\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 - \varepsilon = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$

B.

$\frac{1}{2}m_1^2u_1^2 + \frac{1}{2}m_2u_2^2 + \varepsilon = \frac{1}{2}m_1^2v_1^2 + \frac{1}{2}m_2^2v_2^2$

C.

$m_1^2u_1 + m_2^2u_2 - \varepsilon = m_1^2v_1 + m_2^2v_2$

D.

$\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2 - \varepsilon$

Answer: A

Question32

Two similar springs P and Q have spring constants K_P and K_Q such that $K_P > K_Q$.They They are stretched first by the same amount (case a), then by the same force (case b). The work done by the springs W_P and W_Q are related as, in case (a) and case (b) respectively (2015)

©

Options:

A. $W_P > W_Q$; $W_Q > W_P$

B. $W_P < W_Q$; $W_Q < W_P$

C. $W_P = W_Q$; $W_P > W_Q$

D. $W_P = W_Q$; $W_P = W_Q$

Answer: A

Solution:

Here $K_P > K_Q$
Case (a) : Elongation (x) in each spring is same.
$W_P = \frac{1}{2}K_Px^2$, $W_Q = \frac{1}{2}K_Qx^2$
$\therefore W_P > W_Q$
Case (b): Force of elongation is same.

So, $x_1 = \frac{F}{K_P}$ and $x_2 = \frac{F}{K_Q}$

$W_P = \frac{1}{2}K_P x_1^2 = \frac{1}{2}\frac{F^2}{K_P}$

$W_Q = \frac{1}{2}K_Q x_2^2 = \frac{1}{2}\frac{F^2}{K_Q}$ $\therefore W_P < W_Q$

Question33

A body of mass (4m) is lying in x-y plane at rest. It suddenly explodes into three pieces. Two pieces, each of mass (m) move perpendicular to each other with equal speeds (v). The total kinetic energy generated due to explosion is
(2014)

©

Options:

A. mv^2

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

C. $2mv^2$

D. $4mv^2$

Answer: B

Solution:

$p_i = p_f$

$0 = mvi + mv\hat{j} + 2m\vec{v}$

$\vec{v} = -\frac{v}{2}\hat{i} - \frac{v}{2}\hat{j}$

$|\vec{v}| = \frac{v}{\sqrt{2}}$

$$KE = \frac{1}{2}mv^2 + \frac{1}{2}mv^2 + \frac{1}{2}2m\left(\frac{v}{\sqrt{2}}\right)^2 = mv^2 + \frac{mv^2}{2} = \frac{3}{2}mv^2$$

Question34

A uniform force of $\left(3\hat{i} + \hat{j}\right)$ newton acts on a particle of mass 2 kg. Hence the particle is displaced from position $\left(2\hat{i} + \hat{k}\right)$ meter to position $\left(4\hat{i} + 3\hat{j} - \hat{k}\right)$ meter The work done by the force on the particle is
(2013 NEET)

©

Options:

A. 13 J

B. 15 J

C. 9 J

D. 6 J

Answer: C

Solution:

Here, $\vec{F} = \left(3\hat{i} + \hat{j}\right)N$
Initial position, $\vec{r}_1 = \left(2\hat{i} + \hat{k}\right)m$
Final position, $\vec{r}_2 = \left(4\hat{i} + 3\hat{j} - \hat{k}\right)m$
Displacement, $\vec{r} = \vec{r}_2 - \vec{r}_1$
$\vec{r} = \left(4\hat{i} + 3\hat{j} - \hat{k}\right)m - \left(2\hat{i} + \hat{k}\right)m = 2\hat{i} + 3\hat{j} - 2\hat{k}m$
Work done,
$W = \vec{F} \cdot \vec{r} = \left(3\hat{i} + \hat{j}\right) \cdot \left(2\hat{i} + 3\hat{j} - 2\hat{k}\right) = 6 + 3 = 6J$
$= 6 + 3 = 9J$

Question35

A particle with total energy E is moving in a potential energy region $U(x)$. Motion of the particle is restricted to the region when (KN NEET 2013)

Options:

A.

$U(x) < E$

B. $U(x) = 0$

C. $U(x) \leq E$

D. $U(x) > E$

Answer: A

Solution:

Solution:
As the particle is moving in a potential energy region.
$\therefore$ Kinetic energy > 0
And, total energy $E = K.E. + P.E. \Rightarrow U(x) < E$

Question36

One coolie takes 1 minute to raise asuitcase through a height of 2 mathrm m but the second coolie takes 30 s to raise the samesuitcase to the same height. The powers of two coolies are in the ratio (KN NEET 2013)

©

Options:

A. 1: 3

B. 2: 1

C. 3: 1

D. 1: 2

Answer: D

Solution:

Solution:

Power, $P = \frac{\text{Work done}}{\text{Time taken}}$

Here work done $(= mgh)$ is same in both cases.

$\therefore \frac{P_1}{P_2} = \frac{t_2}{t_1} = \frac{30s}{1min} = \frac{30s}{60s} = \frac{1}{2}$

Question37

The potential energy of a particle in a force field is

$$U = \frac{A}{r^2} - \frac{B}{r}$$

where A and B are positive constants and r is the distance of particle from the center of the field. For stable equilibrium, the distance of the particle is (2012)

©

Options:

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

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

C. $\frac{A}{B}$

D. $\frac{B}{A}$

Answer: B

Solution:

Here, $U = \frac{A}{r^2} - \frac{B}{r}$

For equilibrium, $\frac{dU}{dr} = 0$

$\therefore -\frac{2A}{r^3} + \frac{B}{r^2} = 0$ or $\frac{2A}{r^3} = \frac{B}{r^2}$ or $r = \frac{2A}{B}$

For stable equilibrium, $\frac{d^2U}{dr^2} > 0$

$\frac{d^2U}{dr^2} = \frac{6A}{r^4} - \frac{2B}{r^3}$

$\frac{d^2U}{dr^2}\Big|_{r=\frac{2A}{B}} = \frac{6AB^4}{16A^4} - \frac{2B^4}{8A^3} = \frac{B^4}{8A^3} > 0$

So for stable equilibrium, the distance of the particle is $\frac{2A}{B}$

Question38

A solid cylinder of mass 3 kg is rolling on a horizontal surface with velocity $4ms^{-1}$. It collides with a horizontal spring of force constant $200N\,m^{-1}$.The maximum compression produced in the spring will be (2012)

©

Options:

A. 0.5 m

B. 0.6 m

C. 0.7 m

D. 0.2 m

Answer: B

Solution:

Solution:
At maximum compression the solid cylinder will stop.
According to law of conservation of mechanical energy
Loss in kinetic energy = Gain in potential energy of spring of cylinder

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

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

(∵v=Rω andd for solid cylinder,I=1/2mR^2)

$\frac{1}{2}mv^2 + \frac{1}{4}mv^2 = \frac{1}{2}kx^2$

$\frac{3}{4}mv^2 = \frac{1}{2}kx^2$ or $x^2 = \frac{3}{2}\frac{mv^2}{k}$

Here, $m = 3kg$, $v = 4ms^{-1}$, $k = 200N\,m^{-1}$

Substituting the given values, we get

$x^2 = \frac{3 \times 3 \times 4 \times 4}{2 \times 200}$

$x^2 = \frac{36}{100}$ or $x = 0.6m$

Question39

Two spheres A and B of masses m_1 and m_2 respectively collide. A is at rest initially and B is moving with velocity v and along x-axis. After collision B has a velocity $\frac{v}{2}$ in a direction perpendicular to the original direction. The mass A moves after collision in the direction (2012)

Options:

A. same as that of B

B. opposite to that of B

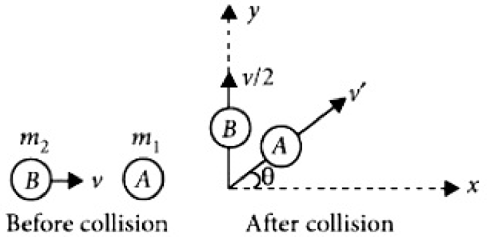
C. $\theta = \tan^{-1}\left(\frac{1}{2}\right)$ to the x-axis

D. $\theta = \tan^{-1}\left(-\frac{1}{2}\right)$ to the x-axis

Answer: D

Solution:

Solution:



According to law of conservation of linear momentum along x-axis, we get
$m_1 \times 0 + m_2 \times v = m_1 v' \cos\theta$
$m_2 v = m_1 v' \cos\theta$ ......(i)
or $\cos\theta = \frac{m_2 v}{m_1 v'}$
According to law of conservation of linear momentum long y-axis, we get
$m_1 \times 0 + m_2 \times 0 = m_1 v' \sin\theta + m_2 \frac{v}{2}$
$-m_2 \frac{v}{2} = m_1 v' \sin\theta$
$\sin\theta = -\frac{m_2 v}{2 m_1 v'}$ ....(ii)
Divide (ii) by (i),we get
$\tan\theta = -\frac{1}{2}$ or $\theta = \tan^{-1}\left(-\frac{1}{2}\right)$ to the x-axis

----

Question40

A car of mass m starts from rest and accelerates so that the instantaneous power delivered to the car has a constant magnitude P_0.The instantaneous velocity of the car is proportional to

(2012 Mains)

©

Options:

A. $t^2 P_0$

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

C. $t^{-\frac{1}{2}}$

D. $\frac{t}{\sqrt{m}}$

Answer: B

Solution:

$P_0 = F\,v \quad \because F = ma = m\frac{d\,v}{d\,t}$

$\therefore P_0 = mv\frac{d\,v}{d\,t}$ or $P_0 d\,t = mvd\,v$

Integrating both sides, we get $\int_0^t P_0 d\,t = m\int_0^v vd\,v$

$P_0 t = \frac{mv^2}{2}$, $v = \left(\frac{2P_0 t}{m}\right)^{\frac{1}{2}}$ or $v\sqrt{t}$

Question41

The potential energy of a system increases if work is done (2011)

©

Options:

A. upon the system by a nonconservative force

B. by the system against a conservative force

C. by the system against a nonconservative force

D. upon the system by a conservative force

Answer: B

Solution:

Solution:
When work is done upon a system by a conservative force then its potential energy increases.

Question42

A body projected vertically from the earth reaches a height equal to earth's radius before returning to the earth. The power exerted by the gravitational force is greatest
(2011)

©

Options:

A. at the highest position of the body

B. at the instant just before the body hits the earth

C. it remains constant all through

D. at the instant just after the body is projected

Answer: B

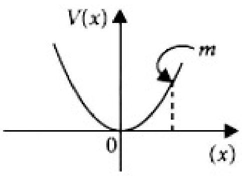
Solution:

Solution:
Power,P = $\vec{F} \cdot \vec{v} = F\,V \cos\theta$
Just before the earth θ = 0°.Hence,the power exerted by the gravitational force is greatest at the instant just before the body hits the earth

----

Question43

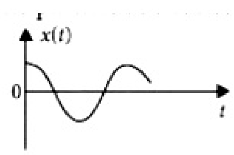
A particle of mass m is released from rest and follows a parabolic path as shown. Assuming that the displacement of the mass from the origin is small, which graph correctly depicts the position of the particle as a function of time?



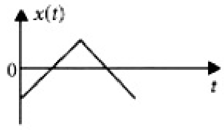
(2011)

Options:

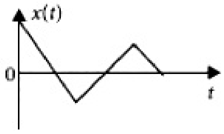
A.



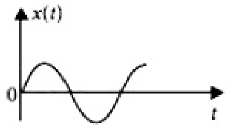
B.



C.



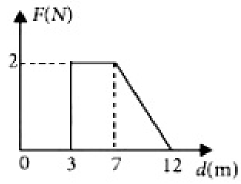
D.



Answer: A

Question44

Force F on a particle moving in a straight line varies with distance d as shown in figure. The work done on the particle during its displacement of 12 m is



(2011)

Options:

A. 18 J

B. 21 J

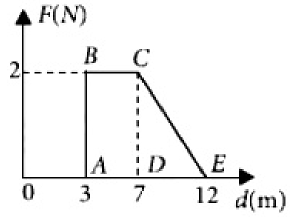
C. 26 J

D. 13 J

Answer: D

Solution:

Solution:



Work done = Area under (F-d) graph
= Area of rectangle ABCD + Area of triangle DCE
$= 2 \times (7-3) + \frac{1}{2} \times 2 \times (12-7) = 8 + 5 = 13J$

Question45

A mass m moving horizontally (along the x-axis) with velocity v collides and sticks to a mass of 3m moving vertically upward (along the y-axis) with velocity 2v.The final velocity of the combination is (2011 Mains)

Options:

A. $\frac{3}{2}v\hat{i} + \frac{1}{4}v\hat{j}$

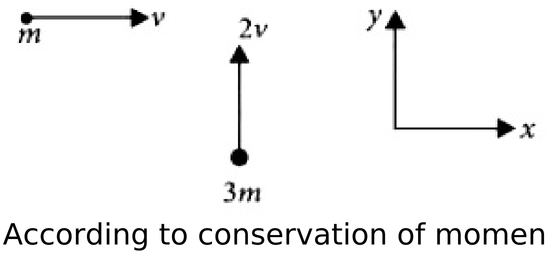
B. $\frac{1}{4}v\hat{i} + \frac{3}{2}v\hat{j}$

C. $\frac{1}{3}v\hat{i} + \frac{2}{3}\hat{j}$

D. $\frac{2}{3}v\hat{i} + \frac{1}{3}v\hat{j}$

Answer: B

Solution:



According to conservation of momentum, we get
$mv\hat{i} + (3m)2v\hat{j} = (m + 3m)v'$
where v′ is the final velocity after collision
$v' = \frac{1}{4}v\hat{i} + \frac{6}{4}v\hat{j} = \frac{1}{4}v\hat{i} + \frac{3}{2}\hat{j}$

Question46

A ball moving with velocity 2 m/s collides head on with another stationary ball of double the mass. If the coefficient of restitution is 0.5, then their velocities (in m/s) after collision will be (2010)

Options:

A. 0, 1

B. 1, 1

C. 1, 0.5

D. 0, 2

Answer: A

Solution:

Solution:
Here, $m_1 = m$, $m_2 = 2m$
$u_1 = 2\frac{m}{s}$, $u_2 = 0$
Coefficient of restitution, e = 0.5
Let v_1 and v_2 be their respective velocities after collision.
Applying the law of conservation of linear momentum, we get
$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$
$\therefore m \times 2 + 2m \times 0 = m \times v_1 + 2m \times v_2$
or $2m = mv_1 + 2mv_2$
or $2 = (v_1 + 2v_2)$.......(i)
By definition of coefficient of restitution,
$e = \frac{v_2 - v_1}{u_1 - u_2}$
or $e(u_1 - u_2) = v_2 - v_1$
$0.5(2 - 0) = v_2 - v_1$
$1 = v_2 - v_1$........(ii)
Solving equations (i) and (ii), we get
$v_1 = 0\frac{m}{s}$, $v_2 = 1\frac{m}{s}$

Question47

An engine pumps water through a hose pipe. Water passes through the pipe and leaves it with a velocity of 2 m/s. The mass per unit length of water in the pipe is 100 kg/m. What is the power of the engine? (2010)

Options:

A. 400 W

B. 200 W

C. 100 W

D. 800 W

Answer: D

Solution:

Here,
Mass per unit length of water, μ = 100 kg/m
Velocity of water, v=2 m/s
Power of the engine,P = $\mu v^3 = \left(100\frac{kg}{m}\right)\left(2\frac{m}{s}\right)^3 = 800W$

Question48

A particle of mass M, starting from rest, undergoes uniform acceleration. If the speed acquired in time T is V, the power delivered to the particle is
(2010 Mains)

©

Options:

A. $\frac{MV^2}{T}$

B. $\frac{1}{2}\frac{MV^2}{T}$

C. $\frac{MV^2}{T^2}$

D. $\frac{1}{2}\frac{MV^2}{T}$

Answer: D

Question49

A block of mass M is attached to the lower end of a vertical spring. The spring is hung from a ceiling and has force constant value k. The mass is released from rest with the spring initially upstretched. The maximum extension produced in the length of the spring will be
(2009)

©

Options:

A. 2Mg/k

B. 4Mg/k

C. Mg/2k

D. Mg/k

Answer: A

Solution:

When the mass attached to a spring fixed at the other end is allowed to fall suddenly, it extends the spring by x.
Potential energy lost by the mass is gained by the spring.
$M gx = \frac{1}{2}kx^2 \Rightarrow x = \frac{2M g}{k}$

Question50

A body of mass 1 kg is thrown upwards with a velocity 20 m/s. It momentarily comes to rest after attaining a height of 18 m. How much energy is lost due to air friction?

$\left(\mathbf{g = 10}\frac{m}{s^2}\right)$

(2009)

©

Options:

A. 30 J

B. 40 J

C. 10 J

D. 20 J

Answer: D

Solution:

Initial velocity u = 20 m/s; m = 1 kg
Kinetic energy = maximum potential energy
Initial kinetic energy $= \frac{1}{2} \times 1 \times 20^2 = 200J$
$mgh(max) = 200J$
$\therefore h = 20m$
The height travelled by the body,h'=18m
∴ Loss of energy due to air friction $= mgh - mgh'$
⇒ Energy lost $= 200J - 1 \times 10 \times 18J = 20J$

Question51

An explosion blows a rock into three parts. Two parts go off at right angles to each other. These two are, 1 kg first part moving with a

velocity of $12ms^{-1}$ and 2 kg second part moving with a velocity $8ms^{-1}$.If the third part flies off with a velocity of $4ms^{-1}$,its mass would be (2009)

Options:

A. 7 kg

B. 17 kg

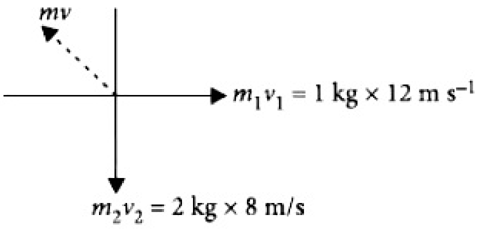
C. 3 kg

D. 5 kg

Answer: D

Solution:

Solution:



When an explosion breaks a rock, by the law of conservation of momentum, initial momentum is zero and for the three pieces,
Total momentum f the two pieces 1 kg an 2 kg
$= \sqrt{12^2 + 16^2} = 20kgms^{-1}$
The third piece has the same momentum and in the direction opposite to the resultant of these two momenta.
∴ Momentum of third piece $= 20kgms^{-1}$
Velocity $= 4m^{-1}$
∴ Mass of the 3rd piece $= \frac{mv}{V} = \frac{20}{4} = 5kg$

Question52

An engine pumps water continuously through a hose. Water leaves the hose with a velocity v and m is the mass per unit length of the water jet. What is the rate at which kinetic energy is imparted to water? (2009)

Options:

A. mv^3

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

C. $\frac{1}{2}m^2v^2$

D. $\frac{1}{2}mv^3$

Answer: D

Solution:

Velocity of water is v, mass flowing per unit length is m
∴ Mass flowing per second = mv
∴ Rate of kinetic energy or K.E. per second

$= \frac{1}{2}(mv)v^2 = \frac{1}{2}mv^3$

Question53

A shell of mass 200 gm is ejected from a gun of mass 4 kg by an explosion that generates 1.05 kJ of energy. The initial velocity of the shell is (2008)

©

Options:

A. $40ms^{-1}$

B. $120ms^{-1}$

C. $100ms^{-1}$

D. $80ms^{-1}$

Answer: C

Solution:

Solution:

$mv = Mv' \Rightarrow v' = \left(\frac{m}{M}\right)v$

Total K.E. of the bullet and gun $= \frac{1}{2}mv^2 + \frac{1}{2}Mv'^2$

Total K.E. $= \frac{1}{2}mv^2 + \frac{1}{2}M \cdot \frac{m^2}{M^2}v^2$

Total K.E. $= \frac{1}{2}mv^2\left\{1 + \frac{m}{M}\right\}$

$= \left\{\frac{1}{2} \times 0.2\right\}\left\{1 + \frac{0.2}{4}\right\}v^2 = 1.05 \times 1000J$

Question54

Water falls from a height of 60 m at the rate of 15 kg/s to operate a turbine. The losses due to frictional forces are 10% of energy. How much power is generated by the turbine ? ($g = 10m / s^2$) (2008)

©

Options:

A. 12.3 kW

B. 7.0 kW

C. 8..1 kW

D. 10.2 kW

Answer: C

Solution:

Mass of water falling/second = 15 kg/s
$h = 60m$
$g = 10m / s^2$,loss = 10%
i.e.,90% is used
Power generated $= 15 \times 10 \times 60 \times 0.9$
$= 8100W = 8.1kW$

Question55

A vertical spring with force constant k is fixed on a table. A ball of mass m at a height h above the free upper end of the spring falls vertically on the spring so that the spring is compressed by a distance d . The net work done in the process is (2007)

©

Options:

A. $mg(h + d) - \frac{1}{2}kd^2$

B. $mg(h - d) - \frac{1}{2}kd^2$

C. $mg(h - d) + \frac{1}{2}kd^2$

D. $mg(h + d) + \frac{1}{2}kd^2$

Answer: A

Solution:

Solution:
Net work done $= W_{mg} + W_{spring}$
$= mg(h + d) - \frac{1}{2}kd^2$

Question56

300 J of work is done in sliding a 2 kg block up an inclined plane of height 10m. Work done against friction is (Take $g = 10m / s^2$) (2006)

©

Options:

A. 1000J

B. 200J

C. 100J

D. zero.

Answer: C

Solution:

Solution:
Loss in potential energy $= mgh$
$= 2 \times 10 \times 10 = 200J$
Gain in kinetic energy = work done $= 300J$
$\therefore$ Work done against friction $= 300 - 200 = 100J$

Question57

The potential energy of a long spring when stretched by 2cm is U . If the spring is stretched by 8cm the potential energy stored in it is (2006)

©

Options:

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

B. 4U

C. 8U

D. 16U

Answer: D

Solution:

Solution:
Potential energy of a spring $= \frac{1}{2} \times$ force constant $\times (\text{extension})^2$
$\therefore$ Potential energy $\propto (\text{extension})^2$

or, $\frac{U_1}{U_2} = \left(\frac{x_1}{x_2}\right)^2$ or, $\frac{U_1}{U_2} = \left(\frac{2}{8}\right)^2$

or, $\frac{U_1}{U_2} = \frac{1}{16}$ or, $U_2 = 16U_1 = 16U$. $(\because U_1 = U)$

Question58

A body of mass 3kg is under a constant force which causes a displacement s in metres in it, given by the relation s = $\frac{1}{3}t^2$ where t is in seconds. Work done by the force in 2 seconds is
(2006)

©

Options:

A. $\frac{19}{5}$ J

B. $\frac{5}{19}$ J

C. $\frac{3}{8}$ J

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

Answer: D

Solution:

Solution:

$s = \frac{t^2}{3}; \frac{ds}{dt} = \frac{2t}{3}; \frac{d^2s}{dt^2} = \frac{2}{3}$

Work done, $W = \int F\,ds = \int m\frac{d^2s}{dt^2}ds$

$= \int m\frac{d^2s}{dt^2}\frac{ds}{dt}dt = \int_0^2 3 \times \frac{2}{3} \times \frac{2t}{3}dt = \frac{4}{3}\int_0^2 t\,dt$

$= \frac{4}{3}\left|\frac{t^2}{2}\right|_0^2 = \frac{4}{3} \times 2 = \frac{8}{3}J$

Question59

A bomb of mass 30kg at rest explodes into two pieces of masses 18kg and 12kg. The velocity of 18kg mass is 6ms^{-1}. The kinetic energy of the other mass is
(2005)

©

Options:

A. 324 J

B. 486 J

C. 256 J

D. 524 J.

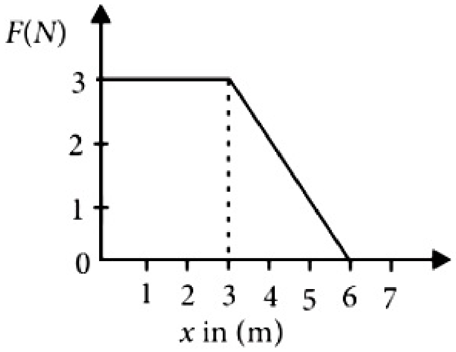
Answer: B

Solution:

Solution:
According to law of conservation of angular momentum, $30 \times 0 = 18 \times 6 + 12 \times v$
$\Rightarrow -108 = 12v \Rightarrow v = -9m / s$
Negative sign indicates that both fragments move in opposite direction.
K.E. of 12kg = $\frac{1}{2}mv^2 = \frac{1}{2} \times 12 \times 81 = 486J$

Question60

A force Facting on an object varies with distance x as shown here. The force is inN and x in m The work done by the force in moving the object from x = 0 to x = 6m is



(2005)

Options:

A. 18.0J

B. 13.5 J

C. 9.0J

D. 4.5J

Answer: B

Solution:

Work done = area under $F - x$ curve
= area of trapezium
$= 12 \times (6 + 3) \times 3 = \frac{9 \times 3}{2} = 13.5J$

Question61

A particle of mass m_1 is moving with a velocity v_1 and another particle of mass m_2 is moving with a velocity v_2. Both of them have the same momentum but their different kinetic energies are E_1 and E_2 respectively. If $m_1 > m_2$ then
(2004)

©

Options:

A.

$E_1 < E_2$

B. $\frac{E_1}{E_2} = \frac{m_1}{m_2}$

C. $E_1 > E_2$

D. $E_1 = E_2$

Answer: A

Solution:

Kinetic energy $= \frac{p^2}{2m}$

$\therefore \frac{E_1}{E_2} = \frac{\frac{p_1^2}{2} m_1}{\frac{p_2^2}{2} m_2} \Rightarrow \frac{E_1}{E_2} = \frac{m_2}{m_1}$

$\therefore E_1 < E_2$

Question62

A ball of mass 2kg and another of mass 4kg are dropped together from a 60 feet tall building. After a fall of 30 feet each towards earth, their respective kinetic energies will be in the ratio of
(2004)

©

Options:

A. $\sqrt{2} : 1$

B. 1: 4

C. 1: 2

D. $1 : \sqrt{2}$

Answer: C

Solution:

Solution:
Ratio of their kinetic energy is givenas

$$\frac{KE_1}{KE_2} = \frac{\left(\frac{1}{2}\right) m_1 {v_1}^2}{\left(\frac{1}{2}\right) m_2 {v_2}^2}$$

$\Rightarrow v^2 = 2gs$ (zero initial velocity)
which is same for both

$$\therefore \frac{KE_1}{KE_2} = \frac{m_1}{m_2} = \frac{2}{4} = \frac{1}{2}$$

Question63

A mass of 0.5 kg moving with a speed of 1.5m / s on a horizontal smooth surface, collides with a nearly weightless spring of force constant k = 50N / m. The maximum compression of the spring would be

(2004)

Options:

A. 0.15m

B. 0.12m

C. 1.m

D. 0.5m

Answer: A

Solution:

Solution:
The kinetic energy of mass is converted into energy required to compress a spring which is given by

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

$$\Rightarrow x = \sqrt{\frac{mv^2}{k}} = \sqrt{\frac{0.5 \times (1.5)^2}{50}} = 0.15\text{m}$$

Question64

When a long spring is stretched by 2cm its potential energy is U . If the spring is stretched by 10cm, the potential energy stored in it will be (2003)

©

Options:

A. $\frac{U}{5}$

B. 5U

C. 10U

D. 25U

Answer: D

Solution:

Solution:
$U = -kx^2$, $k =$ Spring constant
$\frac{U_1}{U_2} = \frac{x_1^{\ 2}}{x_2^{\ 2}} = \frac{4}{100} \Rightarrow U_2 = 25U_1$

Question65

A stationary particle explodes into two particles of masses m_1 and m_2 which move in opposite directions with velocities v_1 and v_2 . The ratio of their kinetic energies $\frac{E_1}{E_2}$ is
(2003)

©

Options:

A. $\frac{m_2}{m_1}$

B. $\frac{m_1}{m_2}$

C. 1

D. $m_1 \frac{v_2}{m_2} v_1$

Answer: A

Solution:

Solution:
$m_1 v_1 = m_2 v_2$
(conservation of linear momentum)

$$\frac{E_1}{E_2} = \frac{\left(\frac{1}{2}\right) m_1 v_1^2}{\left(\frac{1}{2}\right) m_2 v_2^2} = \frac{m_1^2 v_1^2}{m_2^2 v_2^2} \cdot \frac{m_2}{m_1} = \frac{m_2}{m_1}$$

Question66

If kinetic energy of a body is increased by 300% then percentage change in momentum will be (2002)

©

Options:

A. 100%

B. 150%

C. 265%

D. 73.2%.

Answer: A

Solution:

Solution:
Let m be the mass of the body and v_1 and v_2 be the initial and final velocities of the body respectively.

$\therefore$ Initial kinetic energy $= \frac{1}{2} m v_1^2$

Final kinetic energy $= \frac{1}{2} m v_2^2$

Initial kinetic energy is increased 300% to get the final kinetic energy.

$\therefore \frac{1}{2} m v_2^2 = \frac{1}{2}\left(1 + \frac{300}{100}\right) m v_1^2$

$\Rightarrow v_2 = 2v_1$ or $\frac{v_2}{v_1} = 2$ .....(i)

Initial momentum $= p_1 = mv_1$

Final momentum $= p_2 = mv_2$

$\therefore \frac{p_2}{p_1} = \frac{mv_2}{mv_1} = \frac{v_2}{v_1} = 2$

$\therefore p_2 = 2p_1 = \left(1 + \frac{100}{100}\right) p_1$

So momentum has increased 100%.

Question67

A child is sitting on a swing. Its minimum and maximum heights from the ground 0.75m and 2m respectively, its maximum speed will be (2001)

©

Options:

A. 10 m / s

B. 5 m / s

C. 8 m / s

D. 15 m / s

Answer: B

Solution:

Solution:
Maximum drop in P.E. = maximumgain in K.E.
$mg(2-0.75)=\frac{1}{2}mv^2 \Rightarrow v=\sqrt{2g(1.25)}=5m/s$

Question68

Two springs A and B having spring constant K_A and $K_B(K_A = 2K_B)$ are stretched by applying force of equal magnitude. If energy stored in spring A is E_A then energy stored in B will be
(2001)

©

Options:

A. $2E_A$

B. $\frac{E_A}{4}$

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

D. $4E_A$

Answer: A

Solution:

Solution:
Energy $=\frac{1}{2}Kx^2=\frac{1}{2}\frac{F^2}{K}$
$\frac{K_A}{K_B}=2$
$\therefore\frac{E_A}{E_B}=\frac{1}{2}$ or $E_B=2E_A$

Question69

A particle is projected making an angle of 45° with horizontal having kinetic energyK. The kinetic energy at highest point will be (2001,1997)

©

Options:

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

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

C. 2K

D. K

Answer: B

Solution:

Solution:
Kinetic energy of the ball $= K$ and angle of projection $(\theta) = 45°$.
Velocity of the ball at the highest point $= v \cos \theta$
$= v \cos 45° = \frac{v}{\sqrt{2}}$
Therefore kinetic energy of the ball
$\frac{1}{2} m \times \left(\frac{v}{\sqrt{2}}\right)^2 = \frac{1}{4} m v^2 = \frac{K}{2}$.

Question70

If $\vec{F} = \left(60\hat{i} + 15\hat{j} - 3\hat{k}\right)N$ and $\vec{v} = \left(2\hat{i} - 4\hat{j} + 5\hat{k}\right) m/s$, then instantaneous power is (2000)

©

Options:

A. 195 watt

B. 45 watt

C. 75 watt

D. 100 watt

Answer: B

Solution:

Solution:
$P = \vec{F}\vec{v} = \left(60\hat{i} + 15\hat{j} - 3\hat{k}\right).\left(2\hat{i} - 4\hat{j} + 5\hat{k}\right)$
$= 120 - 60 - 15 = 45$ watts.

Question71

A mass of 1kg is thrown up with a velocity of 100m / s. After 5 seconds, it explodes into two parts. One part of mass 400g comes down with a velocity 25m / s. The velocity of other part is (Take left . $g = 10ms^{-2}$) (2000)

©

Options:

A. 40 m / s

B. 80 m / s

C. 100 m / s

D. 60 m / s

Answer: C

Solution:

Velocity after 5s, $v = u - gt$
$= 100 - 10 \times 5 = 50m / s$
By conservation of momentum
$1 \times 50 = 0.4 \times (-25) + 0.6 \times v'$
$60 = 0.6 \times v' \Rightarrow v' = 100m / s$ upwards

Question72

Two bodies with kinetic energies in the ratio of 4: 1 are moving with equal linear momentum. The ratio of their masses is (1999)

©

Options:

A. 4: 1

B. 1: 1

C. 1: 2

D. 1: 4 .

Answer: D

Solution:

K.E. $= \frac{p^2}{2m} \Rightarrow \frac{K.E._1}{K.E._2} = \frac{m_2}{m_1} = \frac{4}{1}$

or $\frac{m_1}{m_2} = \frac{1}{4}$

Question73

Two equal masses m_1 and m_2 moving along the same straight line with velocities $+3$ m / s and -5 m / s respectively collide elastically. Their velocities after the collision will be respectively (1998)

©

Options:

A. -4 m / s and $+4$ m / ss

B. $+4$ m / s for both

C. -3 m / s and $+5$ m / s

D. -5 m / s and $+3$ m / s

Answer: D

Solution:

Solution:
Equal masses after elastic collision interchange their velocities.
-5 m / s and $+3$ m / s.

Question74

A force acts on a 3 g particle in such a way that the position of the particle as a function of time is given by $x = 3t - 4t^2 + t^3$, where x is in metres and t is in seconds. The work done during the first 4 second is (1998)

©

Options:

A. 490mJ

B. 450mJ

C. 576mJ

D. 530mJ

Answer: C

Solution:

$x = 3t - 4t^2 + t^3$ or $, \frac{d^2x}{dt^2} = -8 + 6t$

or $\left.\frac{d^2x}{dt^2}\right|_{t=4} = 16$ and $x|_{t=4} = 12$

Work done $= F \times s = mas = 3 \times 10^{-3} \times 16 \times 12$
$= 576 mJ$

Question75

A shell, in flight, explodes into four unequal parts. Which of the following is conserved?
(1998)

©

Options:

A. Potential energy

B. Momentum

C. Kinetic energy

D. Both (a) and (c).

Answer: B

Question76

Two bodies of masses m and 4m are moving with equal kinetic energies. The ratio of their linear momenta is
(1998, 1997, 1989)

Options:

A. 1: 2

B. 1: 4

C. 4: 1

D. 1: 1 .

Answer: A

Solution:

Mass of first body $= m$;
Mass of second body $= 4m$ and $KE_1 = KE_2$
. Linear momentum of a body
$p = \sqrt{2mE} \propto \sqrt{m}$
Therefore $\frac{p_1}{p_2} = \sqrt{\frac{m_1}{m_2}} = \sqrt{\frac{m}{4m}} = \sqrt{\frac{1}{4}} = \frac{1}{2}$
or $p_1 : p_2 = 1 : 2$

Question77

A metal ball of mass 2kg moving with speed of 36km / h has a head on collision with a stationary ball of mass 3kg. If after collision, both the balls move as a single mass, then the loss in K.E. due to collision is (1997)

©

Options:

A. 100J

B. 140J

C. 40J

D. 60J .

Answer: D

Solution:

Solution:
Mass of metal ball $= 2kg$;
Speed of metal ball $(v_1) = 36km / h = 10m / s$ andmass of stationary ball $= 3.$ kg.
Applying law of conservation of momentum,
$m_1v_1 + m_2v_2 = (m_1 + m_2)v$
or, $v = \frac{m_1v_1 + m_2v_2}{m_1 + m_2} = \frac{(2 \times 10) + (3 \times 0)}{2 + 3} = \frac{20}{5}$
Therefore loss of energy $= \left[\frac{1}{2}m_1{v_1}^2 + \frac{1}{2}m_2{v_2}^2\right] - \frac{1}{2} \times (m_1 + m_2)v^2$
$= \left[\frac{1}{2} \times 2 \times (10)^2 + \frac{1}{2} \times 3(0)^2\right] - \frac{1}{2} \times (2 + 3) \times (4)^2$
$= 100 - 40 = 60J$

Question78

A body moves a distance of 10m along a straight line under the action of a 5N force. If the work done is 25J , then angle between the force and direction of motion of the body is (1997)

©

Options:

A. 60°

B. 75°

C. 30°

D. 45°

Answer: A

Solution:

Solution:
Distance (s) = 10m; Force $(F) = 5\text{N}$ and work done $(W) = 25\text{J}$.
.Work done $(W) = F s \cos\theta = 25$
$\therefore 25 = 5 \times 10 \cos\theta = 50 \cos\theta$
or $\cos\theta = \frac{25}{50} = 0.5$ or $\theta = 60°$.

Question79

A moving body of mass m and velocity 3 km / hour collides with a body at rest of mass 2m and sticks to it. Now the combined mass starts to move. What will be the combined velocity?
(1996)

©

Options:

A. 3 km/ hour

B. 4 km/ hour

C. 1 km/ hour

D. 2 km/ hour

Answer: C

Solution:

Solution:
Mass of body $(m_1) = m$; Velocity of first body $(u_1) = 3\text{km/ hour}$; Mass of second body at rest $(m_2) = 2m$ and velocity of second body$(u_2) = 0$.
After combination, mass of the body
$M = m + 2m = 3m$
From the law of conservation of momentum, weget
$M v = m_1 u_1 + m_2 u_2$
or $3mv = (m \times 3) + (2m \times 0) = 3m$
or $v = 1$ km/ hour.

Question80

The potential energy between two atoms, in a molecule, is given by $U(x) = \frac{a}{x^{12}} - \frac{b}{x^6}$ where a and b are positive constants and x is the distance between the atoms. Theatom is in stable equilibrium, when
(1995)

©

Options:

A. $x = \left(\frac{2a}{b}\right)^{\frac{1}{6}}$

B. $x = \left(\frac{11a}{5b}\right)^{\frac{1}{6}}$

C. $x = 0$

D. $x = \left(\frac{a}{2b}\right)^{\frac{1}{6}}$

Answer: A

Solution:

Solution:
$U(x) = \frac{a}{x^{12}} - \frac{b}{x^6}$ or $-\frac{12a}{x^{13}} - \frac{-6b}{x^7} = 0$

or $x^6 = \frac{2a}{b}$. Therefore $x = \left(\frac{2a}{b}\right)^{\frac{1}{6}}$

Question81

A body, constrained to move in y -direction, is subjected to a force given by $\vec{F} = \left(-2\hat{i} + 15\hat{j} + 6\hat{k}\right)$N . The work doneby this force in moving the body through a distance of $10\hat{j}$m along y -axis, is
(1994)

©

Options:

A. 150 J

B. 20 J

C. 190 J

D. 160 J

Answer: A

Solution:

Force $\vec{F} = (-2\hat{i} + 15\hat{j} + 6\hat{k})$N and distance $(d) = 10\hat{j}$ m
Work done, $W = \vec{F} \cdot \vec{d}$
$= (-2\hat{i} + 15\hat{j} + 6\hat{k}) \cdot (10\hat{j}) = 150N - m = 150J$

Question82

The kinetic energy acquired by a mass m in travelling distance d , starting from rest, under the action of a constant force is directly proportional to
(1994)

©

Options:

A. m

B. m^0

C. $\sqrt{m}$

D. $\frac{1}{\sqrt{m}}$

Answer: B

Solution:

Solution:
$v^2 = u^2 + 2as$ or $v^2 - u^2 = 2as$
or $v^2 - (0)^2 = 2 \times \frac{F}{m} \times s$ or $v^2 = \frac{2Fs}{m}$
and $K.E. = \frac{1}{2}mv^2 = \frac{1}{2}m \times \frac{2Fs}{m} = Fs$
Thus K.E. is the independent of m or directly proportional to m^0.

Question83

A position dependent force, $F = (7 - 2x + 3x^2)$N acts on a small body of mass 2 kg and displaces it from x = 0 to x = 5m. The work done in joule is
(1994, 1992)

©

Options:

A. 135

B. 270

C. 35

D. 70

Answer: A

Solution:

Solution:
Force $(F) = 7 - 2x + 3x^2$
Mass $(m) = 2\,kg$ and displacement $(d) = 5m$
Therefore work done
$(W) = \int F\,dx = \int_0^5 (7 - 2x + 3x^2)dx = (7x - x^2 + x^3)_0^5$
$= (7 \times 5) - (5)^2 + (5)^3 = 35 - 25 + 125 = 135J$

Question84

When a body moves with a constant speed along a circle (1994)

©

Options:

A. no work is done on it

B. no acceleration is produced in it

C. its velocity remains constant

D. no force acts on it.

Answer: A

Solution:

Solution:

Question85

Two masses of 1g and 9g are moving with equal kinetic energies. The ratio of the magnitudes of their respective linear momenta is (1993)

©

Options:

A. 1 : 9

B. 9 : 1

C. 1 : 3

D. 3 : 1

Answer: C

Solution:

Solution:

$$\frac{K_1}{K_2} = \frac{p_1^2}{p_2^2} \times \frac{M_2^2}{M_1^2}$$

when $K_1 = K_2$

$$\frac{p_1}{p_2} = \sqrt{\frac{M_1}{M_2}} = \sqrt{\frac{1}{9}} = \frac{1}{3}$$

$\therefore p_1 : p_2 = 1 : 3$

Question86

A particle of mass M is moving in a horizontal circle of radius R with uniform speed v. When it moves from one point to a diametrically opposite point, its (1992)

©

Options:

A. kinetic energy change by $\frac{Mv^2}{4}$

B. momentum does not change

C. momentum change by $2\,Mv$

D. kinetic energy changes by Mv^2

Answer: C

Solution:

Solution:

On the diametrically opposite points, the velocities have same magnitude but opposite directions. Therefore change in momentum is

$Mv - (-Mv) = 2\,Mv$

Question87

How much water a pump of $2\,kW$ can raise in one minute to a height of $10m$? (take $g = 10m / s^2$) (1990)

©

Options:

A. 1000 litres

B. 1200 litres

C. 100 litres

D. 2000 litres

Answer: B

Solution:

Solution:

Power $= \frac{\text{work done}}{\text{time taken}} = \frac{W}{t}$

$\therefore P = \frac{M \times g \times h}{t}$

$M = \frac{p \times t}{g \times h} = \frac{2000 \times 60}{10 \times 10} = 1200\,\text{kg}$

i.e., 1200 litres as one litre has a mass of 1 kg.

Question88

A bullet of mass 10g leaves a rifle at an initial velocity of 1000m / s and strikes the earth at the same level with a velocity of 500m / s. The work done in joule for overcoming the resistance of air will be (1989)

©

Options:

A. 375

B. 3750

C. 5000

D. 500

Answer: B

Solution:

Solution:

Work done = change in kinetic energy of the body

$W = \frac{1}{2} \times 0.01[(1000)^2 - (500)^2] = 3750$ joule

----

Question89

The coefficient of restitution e for a perfectly elastic collision is (1988)

Options:

A. 1

B. 0

C. ∞

D. -1

Answer: A

Solution:

Solution:
Coefficient of restitution or resilience of two bodies is defined as the constant ratio of relative velocity after impact to the relative velocity of the bodies before impact when the two bodies collide head on. Their velocities are in the opposite directions.

Thus $\frac{v_1 - v_2}{u_1 - u_2} = \text{ constant } = -e$

The constant e is known as coefficient of restitution or resilience of two bodies. For a perfectly elastic collision, $e = 1$ and for a perfectly inelastic collision, $e = 0$. Thus $0 \leq e \leq 1$
