Work, Energy and Power

Question1

A constant force $\vec{F}=3\hat{i}-2\hat{j}-\hat{k}$ newton has a displacement $\vec{r}=2\hat{i}-3\hat{j}-3\hat{k}$ metre in 2 second. The work done and the power are respectively

MHT CET 2025 25th April Evening Shift

Options:

A. 20 joule, 10 watt

B. 15 joule, 7.5 watt

C. 13 joule, 6.5 watt

D. 10 joule, 5 watt

Answer: B

Solution:

$\text{Work done}=\vec{F}\cdot\vec{r}$

$\therefore\ \text{Work done}=(3\hat{i}-2\hat{j}-\hat{k})\cdot(2\hat{i}-3\hat{j}-3\hat{k})$

$\therefore\ \text{Work done}=(6+6+3)$

$\therefore\ \text{Work done}=15\text{ joule}$

$\text{Power}=\frac{\text{work done}}{\text{time}}$

$\therefore\ \text{Work done}=\frac{15}{2}$

$\therefore\ \text{Work done}=7.5\text{ watt.}$

Question2

A particle is displaced from point $\mathrm{P}(3\ \mathrm{m}, 4\ \mathrm{m}, 5\ \mathrm{m})$ to a point $\mathrm{Q}(2\ \mathrm{m}, 3\ \mathrm{m}, 4\ \mathrm{m})$ under a constant force $\overrightarrow{\mathrm{F}} = (3\hat{\mathrm{i}} + 4\hat{\mathrm{j}} + 5\hat{\mathrm{k}})\mathrm{N}$. The work done by the force in this process is

MHT CET 2025 23rd April Evening Shift

Options:

A. +10 J

B. +4 J

C. -8 J

D. -12 J

Answer: D

Solution:

$$
\begin{aligned}
\vec{s} &= \vec{Q} - \vec{P} \\
&= (2\hat{i} + 3\hat{j} + 4\hat{k})m - (3\hat{i} + 4\hat{j} + 5\hat{k})m \\
&= -1\hat{i} - 1\hat{j} - 1\hat{k} \\
W &= \vec{F} \cdot \vec{s} \\
&= (3\hat{i} + 4\hat{j} + 5\hat{k})\left(-1\hat{i} - 1\hat{j}\_1\hat{k}\right) \\
&= -3 - 4 - 5 = -12J
\end{aligned}
$$

Question3

A body of mass 1 kg begins to move under the action of a time dependent force $\overrightarrow{\mathrm{F}} = \left(\hat{\mathrm{t}} + 2t^2\hat{\mathrm{j}}\right)\mathrm{N}$, where $\hat{i}$ and $\hat{j}$ are unit vectors along x and y axis. The power developed by above force at time $\mathrm{t} = 3$ second will be

MHT CET 2025 22nd April Morning Shift

Options:

A. 337.5 W

B. 228.5 W

C. 422.5 W

D. 126.5 W

Answer: A

Solution:

Given Force:

The force is $\overrightarrow{\mathrm{F}} = (t\hat{i} + 2t^2\hat{j})$ N. This force acts on a body with mass 1 kg.

Step 1: Find Acceleration

The acceleration is found by dividing the force by mass: $\vec{a} = \frac{\vec{F}}{m} = (t\hat{i} + 2t^2\hat{j})$, because mass $m = 1$ kg.

Step 2: Write the Relationship Between Acceleration and Velocity

Acceleration is the rate of change of velocity: $\vec{a} = \frac{d\vec{v}}{dt}$.

Step 3: Find the Velocity by Integration

To get velocity, integrate acceleration over time:$\vec{v} = \int \vec{a}\, dt = \int (t\hat{i} + 2t^2\hat{j}) dt$

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

Step 4: Find the Power

Power is the dot product of force and velocity:$P = \vec{F} \cdot \vec{v}$So,$P = (t\hat{i} + 2t^2\hat{j}) \cdot \left(\frac{t^2}{2}\hat{i} + \frac{2t^3}{3}\hat{j}\right)$

Calculate the dot product:

- t times $\frac{t^2}{2} = \frac{t^3}{2}$ (from the x-components)
- $2t^2$ times $\frac{2t^3}{3} = \frac{4t^5}{3}$ (from the y-components)

So,$P = \frac{t^3}{2} + \frac{4t^5}{3}$

Step 5: Substitute $t = 3$ seconds

Put $t = 3$ into the formula:$P = \frac{3^3}{2} + \frac{4\times3^5}{3}$Calculate the values:

- $3^3 = 27$, so $\frac{27}{2} = 13.5$
- $3^5 = 243$, so $4 \times 243 = 972$, and $\frac{972}{3} = 324$

Add them: $13.5 + 324 = 337.5$

Final Answer:

Therefore, the power developed at $t = 3$ seconds is 337.5 W.

Question4

A stone is projected with kinetic energy E, making an angle θ with the horizontal. When it reaches a highest point, its kinetic energy is

MHT CET 2025 19th April Evening Shift

Options:

A. $\mathrm{E}^2 \sin^2 \theta$

B. $\mathrm{E} \sin \theta$

C. $E \cos^2 \theta$

D. $\mathrm{E} \cos \theta$

Answer: C

Solution:

Given:

- Initial kinetic energy of the stone = E
- Angle of projection with horizontal = θ

Step 1: Find the initial velocity using kinetic energy

Initial kinetic energy E is given by:

$E = \frac{1}{2} m u^2$

where u is the initial speed and m is the mass.

So,

$u = \sqrt{\frac{2E}{m}}$

Step 2: Break the velocity into horizontal and vertical components

- Horizontal component: $u_x = u \cos \theta$
- Vertical component: $u_y = u \sin \theta$

Step 3: At the highest point

At the highest point, the vertical component of velocity becomes zero ($v_y = 0$), but the horizontal component remains unchanged (u_x).

So, velocity at the highest point is:

$v_{\text{highest}} = u \cos \theta$

Step 4: Kinetic energy at the highest point

Only the horizontal component remains, so

Kinetic energy at highest point $= \frac{1}{2} m (u \cos \theta)^2 = \frac{1}{2} m u^2 \cos^2 \theta$

Recall from Step 1:

$\frac{1}{2} m u^2 = E$

So, kinetic energy at highest point:

$= E \cos^2 \theta$

Final Answer:

The correct option is **Option C:** $E \cos^2 \theta$

Question5

A stone of mass 1 kg tied to a light inextensible string of length $L = \frac{5}{3} m$ is rotating in a circular path of radius L in a vertical plane. If the ratio of maximum tension in the string to the minimum tension in the string is 3 , the speed of the stone at the highest point of the circle is ($\mathrm{g} =$ acceleration due to gravity)

MHT CET 2025 19th April Morning Shift

Options:

A. $\sqrt{\mathrm{gL}}$

B. $\sqrt{2gL}$

C. $\sqrt{4gL}$

D. $\sqrt{8gL}$

Answer: C

Solution:

Step 1: Tension at Highest and Lowest Points

At the **highest point**,

Let tension = T_H, speed = v_H.

For a body moving in a vertical circle:

$T_H + mg = \frac{mv_H^2}{L}$

So,

$T_H = \frac{mv_H^2}{L} - mg$

At the **lowest point**,

Let tension = T_L, speed = v_L.

$T_L - mg = \frac{mv_L^2}{L}$

So,

$T_L = \frac{mv_L^2}{L} + mg$

Step 2: Ratio of Maximum to Minimum Tension

Given:

$\frac{T_L}{T_H} = 3$

Step 3: Energy Conservation Between Highest and Lowest Point

Mechanical energy is conserved:

$\frac{1}{2}mv_L^2 = \frac{1}{2}mv_H^2 + mg(2L)$

$v_L^2 = v_H^2 + 4gL$

Step 4: Substitute Tensions

Plug in $m = 1$ (from question):

- $T_H = \frac{v_H^2}{L} - g$

- $T_L = \frac{v_L^2}{L} + g$

Given ratio:

$$\frac{T_L}{T_H} = \frac{\frac{v_L^2}{L}+g}{\frac{v_H^2}{L}-g} = 3$$

Step 5: Substitute $v_L^2 = v_H^2 + 4gL$

$$\frac{\frac{v_H^2+4gL}{L}+g}{\frac{v_H^2}{L}-g} = 3$$

Simplify numerator:

$$\frac{\frac{v_H^2}{L}+4g+g}{\frac{v_H^2}{L}-g} = 3$$

$$\frac{\frac{v_H^2}{L}+5g}{\frac{v_H^2}{L}-g} = 3$$

Step 6: Cross Multiply and Solve

$$\frac{v_H^2}{L} + 5g = 3\left(\frac{v_H^2}{L} - g\right)$$

$$\frac{v_H^2}{L} + 5g = 3\frac{v_H^2}{L} - 3g$$

Bring terms together:

$$5g + 3g = 3\frac{v_H^2}{L} - \frac{v_H^2}{L}$$

$$8g = 2\frac{v_H^2}{L}$$

$$\frac{v_H^2}{L} = 4g$$

$$v_H^2 = 4gL$$

$$v_H = \sqrt{4gL}$$

Step 7: Put the Value of $L = \frac{5}{3}$

$$v_H = \sqrt{4gL} = 2\sqrt{gL}$$

Final Answer:

$$\boxed{\sqrt{4gL}}$$

This matches **Option C**.

Question6

The power (P) is supplied to a rotating body having moment of inertia ' I ' and angular acceleration ' α '. Its instantaneous angular velocity ' ω ' is

MHT CET 2024 16th May Morning Shift

Options:

A. $\mathrm{P}(\mathrm{I}\alpha)^{-1}$

B. $\mathrm{P}^{-1}(\mathrm{I}\alpha)^{-1}$

C. $P\alpha^{-1}\mathrm{I}$

D. PIa

Answer: A

Solution:

$$\text{Power } = \frac{\text{Work done}}{\text{time}}$$

$$\mathrm{P} = \frac{\text{Torque } \times \text{ angular displacement}}{\text{time}} = \tau \times \omega$$

$\ldots\left[\because \omega = \frac{\theta}{t}\right] \quad \ldots(\because \tau = I\alpha)$

$$\therefore \quad \mathrm{P} = \mathrm{I}\alpha\omega$$

$$\therefore \quad \omega = \frac{\mathrm{P}}{\mathrm{I}\alpha} = \mathrm{P}(\mathrm{I}\alpha)^{-1}$$

Question7

A simple pendulum of length L has mass m and it oscillates freely with amplitude A. At extreme position, its potential energy is ($\mathrm{g} =$ acceleration due to gravity)

MHT CET 2024 16th May Morning Shift

Options:

A. $\frac{\mathrm{mgA}}{2 \mathrm{~L}}$

B. $\frac{\mathrm{mgA}^2}{\mathrm{~L}}$

C. $\frac{\mathrm{mgA}}{\mathrm{L}}$

D. $\frac{\mathrm{mgA}^2}{2 \mathrm{~L}}$

Answer: D

Solution:

Potential energy of particle at extreme position is, P.E. $=\frac{1}{2} m \omega^2 A^2$

$=\frac{1}{2} \mathrm{~m} \times \frac{\mathrm{g}}{\mathrm{L}} \times \mathrm{A}^2 \quad \ldots . .\left(\because \omega=\sqrt{\frac{\mathrm{g}}{l}}\right)$

Question8

If the work done in blowing a soap bubble of volume ' V ' is ' W ', then the work done in blowing a soap bubble of volume ' 2 V ' will be

MHT CET 2024 15th May Evening Shift

Options:

A. W

B. 2 W

C. $\mathrm{W} \sqrt{2}$

D. $\mathrm{W}(4)^{\frac{1}{3}}$

Answer: D

Solution:

The work done in blowing a soap bubble is related to the change in surface area, rather than volume. The surface area of a sphere of radius r is given by:

$A = 4\pi r^2$

The volume of the sphere is:

$V = \frac{4}{3}\pi r^3$

From the volume equation, the radius r can be expressed in terms of the volume V:

$r = \left(\frac{3V}{4\pi}\right)^{1/3}$

Substituting this into the surface area equation gives:

$A = 4\pi\left(\left(\frac{3V}{4\pi}\right)^{1/3}\right)^2 = 4\pi\left(\frac{3V}{4\pi}\right)^{2/3}$

The surface area of the bubble is proportional to $V^{2/3}$. The work done in blowing the bubble is proportional to the surface area, hence proportional to $V^{2/3}$.

If W is the work done for a volume V, then for a volume $2V$, the work done W' is given by:

$W' \propto (2V)^{2/3}$

Therefore, the ratio of work done from volume V to $2V$ is:

$\frac{W'}{W} = \frac{(2V)^{2/3}}{V^{2/3}} = 2^{2/3}$

Hence, the work done in blowing a soap bubble of volume $2V$ will be:

$W' = W \cdot 2^{2/3}$

Thus, the correct answer is:

Option D: $\mathrm{W}(4)^{\frac{1}{3}}$

Question9

A body of mass 1 kg starts from rest and moves with uniform acceleration. In 2 seconds, its velocity is $10\ \mathrm{m/s}$. The power exerted on the body in one second is

MHT CET 2024 15th May Morning Shift

Options:

A. 20 W

B. 25 W

C. 50 W

D. 100 W

Answer: B

Solution:

$$P = \frac{W}{t}$$
$$W = \text{ change in } KE$$
$$\therefore \quad W = \frac{1}{2} m \left(v^2 - u^2\right) = \frac{1}{2} \times 1 \times 10^2 = 50 J$$
$$\therefore \quad P = \frac{50}{2} = 25 \text{ W}$$

Question10

For a particle moving in vertical circle, the total energy at different positions along the path [The motion is under gravity]

MHT CET 2024 11th May Morning Shift

Options:

A. may increase or decrease.

B. decreases.

C. is conserved.

D. increases.

Answer: C

Solution:

Answer: Option C (is conserved)

Explanation:

For a particle moving in a vertical circle under the influence of gravity, assuming no non-conservative forces like air resistance or friction, the total mechanical energy (sum of kinetic energy and gravitational potential energy) remains constant throughout the motion.

At the lowest point, the particle has maximum kinetic energy and minimum potential energy.

At the highest point, it has minimum kinetic energy and maximum potential energy.

At intermediate points, the energy distribution between kinetic and potential energy changes, but the total remains constant.

Thus, the total energy is conserved.

Question11

If the momentum of a body of mass ' m ' is increased by 20% then its kinetic energy increases by

MHT CET 2024 10th May Morning Shift

Options:

A. 44%

B. 55%

C. 66%

D. 77%

Answer: A

Solution:

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

When momentum increases by 20%, new momentum is p'

$$\begin{aligned} \mathrm{p}' &= \mathrm{p} + 20\%\mathrm{p} \\ &= \mathrm{p} + 0.2\mathrm{p} = 1.2\mathrm{p} \end{aligned}$$

New kinetic energy,

$$\begin{aligned} \mathrm{K.E}' &= \frac{\mathrm{p}'^2}{2\,\mathrm{m}} \\ &= \frac{(1.2\mathrm{p})^2}{2\,\mathrm{m}} = \frac{1.44\mathrm{p}^2}{2\,\mathrm{m}} \\ \therefore \quad \mathrm{K.E}' &= 1.44\,\mathrm{K.E.} \end{aligned}$$

Increase in kinetic energy is calculated by change in kinetic energy.

$$\begin{aligned} \Delta \mathrm{KE} &= \left(\mathrm{K} \cdot \mathrm{E}' - \mathrm{K} \cdot \mathrm{E}\right) \\ &= (1.44\,\mathrm{K.E} - \mathrm{K} \cdot \mathrm{E}) \\ &= 0.44\,\mathrm{K.E.} \\ &\Rightarrow 44\% \end{aligned}$$

Question12

A lead bullet moving with velocity ' V ' strikes a wall and stops. If 75% of its energy is converted into heat, then the increase in temperature is ($\mathrm{s}=$ specific heat of lead, $\mathrm{J}=$ mechanical equivalent of heat)

MHT CET 2024 10th May Morning Shift

Options:

A. $\frac{3\,\mathrm{V}^2}{8\mathrm{Js}}$

B. $\frac{5\,\mathrm{V}^2}{8\mathrm{Js}}$

C. $\frac{3\,\mathrm{V}^2}{4\mathrm{Js}}$

D. $\frac{5\,\mathrm{V}^2}{4\mathrm{Js}}$

Answer: A

Solution:

The kinetic energy of the bullet before it strikes the wall can be expressed as:

$E_k = \frac{1}{2} m V^2$

where m is the mass of the bullet and V is the velocity.

Since 75% of the kinetic energy is converted into heat, the heat energy produced is:

$Q = 0.75 \times \frac{1}{2} m V^2 = \frac{3}{8} m V^2$

According to the mechanical equivalent of heat, the relationship between heat energy and temperature change is given by:

$Q = m s \Delta T$

where s is the specific heat capacity of lead, and ΔT is the change in temperature.

Substitute the expression for Q:

$\frac{3}{8} m V^2 = m s \Delta T$

Divide both sides by ms:

$\Delta T = \frac{3V^2}{8s}$

Since the conversion from mechanical energy to heat energy involves the mechanical equivalent of heat J, the formula should be adjusted to:

$\Delta T = \frac{3V^2}{8Js}$

This matches with the answer option A:

$\boxed{\frac{3\,V^2}{8Js}}$

Question13

The potential energy of a long spring when it is stretched by 3 cm is ' U '. If the spring is stretched by 9 cm , potential energy stored in it will be

MHT CET 2024 9th May Morning Shift

Options:

A. 3U

B. 4U

C. 5U

D. 9U

Answer: D

Solution:

The potential energy stored in a spring when it is stretched or compressed is given by the formula:

$U=\frac{1}{2} k x^2$

where:

U is the potential energy,

k is the spring constant,

x is the displacement from the equilibrium position.

Given that the potential energy is U when the spring is stretched by 3 cm, we have:

$U=\frac{1}{2} k(3)^2$

Now, if the spring is stretched by 9 cm, the potential energy $U^{\prime}$ becomes:

$U^{\prime}=\frac{1}{2} k(9)^2$

We can express $U^{\prime}$ in terms of U as follows:

Calculate $U^{\prime}$ based on the new displacement:

$U^{\prime}=\frac{1}{2} k(9)^2=\frac{1}{2} k \times 81$

Substitute $\frac{1}{2} k=\frac{U}{3^2}=\frac{U}{9}$:

$U^{\prime}=\frac{U}{9} \times 81=9 U$

Hence, when the spring is stretched by 9 cm, the potential energy stored in it is $9 U$. Therefore, the correct option is:

Option D: 9U

Question14

A carpet of mass ' M ' made of a material is rolled along its length in the form of a cylinder of radius ' R ' and kept above the rough floor. If the carpet is unrolled without sliding to a radius ' $R / 2$ '. The change in potential energy is ($\mathrm{g}=$ acceleration due to gravity)

MHT CET 2024 4th May Evening Shift

Options:

A. MgR

B. $\frac{7}{8}$MgR

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

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

Answer: B

Solution:

Density $(\rho = M/V)$ of carpet remains the same after it is unrolled,

$\rho_1 = \rho_2$

If M_2 and V_2 are mass and volume respectively of unrolled carpet,

$$\frac{M}{V} = \frac{M_2}{V_2}$$
$$M_2 = \frac{M}{\pi R^2 l} \times \pi R_2 l = \frac{M}{\pi R^2 l} \times \pi \left(\frac{R^2}{4}\right) l \quad \ldots (\because R_2 = R/2)$$
$$M_2 = \frac{M}{4} \quad \text{.... (i)}$$

Potential energy of rolled carpet,

$U_1 = MgR$

Potential energy of unrolled carpet,

$U_2 = M_2 g R_2 = \left(\frac{M}{4}\right) g \left(\frac{R}{2}\right)$ .... [From (i)]

Change in potential energy,

$$\Delta U = U_1 - U_2$$
$$\Delta U = MgR - \left(\frac{M}{4}\right) g \left(\frac{R}{2}\right)$$
$$\Delta U = \frac{7}{8} MgR$$

Question15

A ball ' A ' is projected vertically upwards with certain initial speed. Another ball 'B' of same mass is projected at an angle of 30° with

vertical with the same initial speed. At the highest point, the ratio of potential energy of ball A to that of ball B will be

$$\left(\sin 90^{\circ}=1, \sin 60^{\circ}=\cos 30^{\circ}=\frac{\sqrt{3}}{2}, \sin 30^{\circ}=\cos 60^{\circ}=\frac{1}{2}\right)$$

MHT CET 2024 3rd May Morning Shift

Options:

A. 4 : 3

B. 3 : 4

C. 4 : 1

D. 3 : 2

Answer: A

Solution:

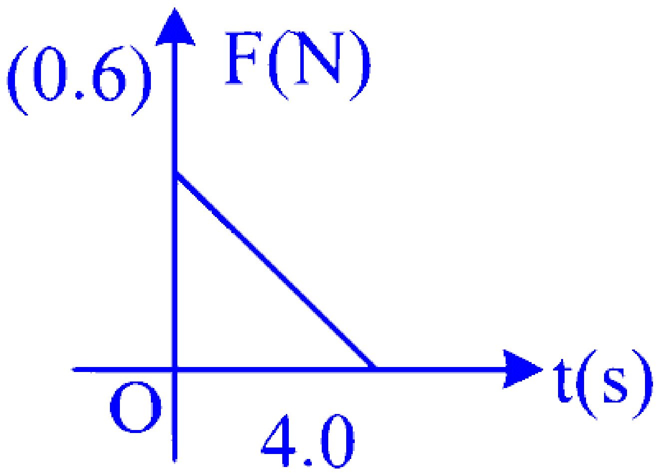
Maximum height attained by ball A, $h_1=\frac{u^2}{2 g}$

Maximum height attained by ball B,

$$\begin{aligned} h_2 & =\frac{u^2 \sin ^2\left(60^{\circ}\right)}{2 g} \quad \ldots\left(\because \theta=90^{\circ}-30^{\circ}=60^{\circ}\right) \\ & =\frac{3 u^2}{8 g} \\ \therefore \quad \frac{h_1}{h_2} & =\frac{u^2}{2 g} \times \frac{8 g}{3 u^2}=\frac{8}{6}=\frac{4}{3}\end{aligned}$$

Question16

Using variation of force and time given below, final velocity of a particle of mass 2 kg moving with initial velocity 6 m/s will be



MHT CET 2023 13th May Morning Shift

Options:

A. 10 m/s

B. 5 m/s

C. 12 m/s

D. 0 m/s

Answer: C

Solution:

Now, using the impulse-momentum theorem to find the final velocity

$12 = 2 \times (-6)$

$v - 6 = \frac{12}{2} = 6$

$v = 12 \mathrm{~m/s}$

So, with the given force-time data $(0, 6)$ and $(4, 0)$, the final velocity of the particle is $12 \mathrm{~m/s}$

Question17

A ball of mass 'm' is dropped from a height 's' on a horizontal platform fixed at the top of a vertical spring. The platform is depressed by a distance 'h'. The spring constant is ($g =$ acceleration due to gravity)

MHT CET 2023 10th May Evening Shift

Options:

A. $\frac{2mg(s-h)}{h^2}$

B. $\frac{2mg(s+h)}{h^2}$

C. $\frac{mg(s-h)}{h}$

D. $\frac{mg(s+h)}{h}$

Answer: B

Solution:

From the question, it can be understood that the total distance the ball falls is $(S+h)$

The spring is compressed through a length h

$\therefore$ Loss of P.E. by the ball $= mg(S+h)$

Work done on the spring $= \frac{1}{2}Kh^2$

Using law of conservation of energy,

$$\frac{1}{2}Kh^2 = mg(S+h)$$

$$\therefore \quad K = \frac{2mg(S+h)}{h^2}$$

Question18

If a lighter body of mass 'M_1' and velocity 'V_1' and a heavy body (mass M_2 and velocity V_2) have the same kinetic energy then

MHT CET 2023 10th May Morning Shift

Options:

A. $M_2V_2 < M_1 V_1$

B. $M_2V_2 = M_1V_1$

C. $M_2V_1 < M_1V_2$

D. $M_2V_2 > M_1V_1$

Answer: D

Solution:

$KE_1 = KE_2$

$KE = \frac{1}{2}mv^2 = \frac{p^2}{2\,m} \quad \ldots.(\because p = mv)$

$\therefore \quad p = \sqrt{2\,m(K \cdot E)}$

$\therefore \quad \frac{p_1}{p_2} = \frac{\sqrt{M_1}}{\sqrt{M_2}}$

But $M_2 > M_1$

$\therefore \quad p_2 > p_1$

i.e., $M_2\,V_2 > M_1\,V_1$

Question19

A stone is projected vertically upwards with speed 'v'. Another stone of same mass is projected at an angle of 60° with the vertical with the same speed 'v'. The ratio of their potential energies at the highest points of their journey is

$$\left[\sin 30^\circ = \cos 60^\circ = 0.5, \cos 30^\circ = \sin 60^\circ = \frac{\sqrt{3}}{2}\right]$$

MHT CET 2023 9th May Morning Shift

Options:

A. 4 : 1

B. 2 : 1

C. 3 : 2

D. 1 : 1

Answer: A

Solution:

P.E. of the stone projected vertically is,

P.E. = mgh

But $h=\frac{v^2}{2g}$

$$\therefore \quad P.E_1=mg\left(\frac{v^2}{2g}\right)$$

$$=\frac{\mathrm{mv}^2}{2} \quad \ldots\ldots \text{(i)}$$

For the second stone thrown at an angle $\theta_{\text{to the}}$ horizontal,

$$h=\frac{v^2\sin^2\theta}{2g}=\frac{v^2\sin^2 30^{\circ}}{2g}=\frac{v^2}{8g}$$

$$\therefore \quad \text{P.E. } 2=mg\left(\frac{v^2}{8g}\right)=\frac{mv^2}{8} \quad \ldots\ldots \text{(ii)}$$

Dividing equation (i) by equation (ii)

$$\frac{P.E_1}{P.E_2}=\frac{\left(\frac{mv^2}{2}\right)}{\left(\frac{m^2}{8}\right)}=4:1$$

Question20

The kinetic energy of a light body and a heavy body is same. Which one of them has greater momentum?

MHT CET 2021 24th September Evening Shift

Options:

A. A body having high velocity.

B. Heavy body.

C. Light body.

D. A body having large displacement.

Answer: B

Solution:

If k is the kinetic energy and p is the momentum then

$k=\frac{p^2}{2m} \quad \therefore p^2=2mk$

If k is constant, then $p^2 \propto m$

Question21

A stone is projected vertically upwards with velocity 'V. Another stone of same mass is projected at an angle fo 60° with the vertical with the same speed (V). The ratio of their potential energies at the highest points of their journey, is

$$\left[\sin 30^{\circ}=\cos 60^{\circ}=0.5, \cos 30^{\circ}=\sin 60^{\circ}=\frac{\sqrt{3}}{2}\right]$$

MHT CET 2021 24th September Morning Shift

Options:

A. 1 : 1

B. 4 : 1

C. 3 : 2

D. 2 : 1

Answer: B

Solution:

Maximum height $\mathrm{h}=\frac{\mathrm{u}^2 \sin ^2 \theta}{2 \mathrm{~g}}$

For the first stone $\theta=90^{\circ}, \sin 90^{\circ}=1$

$\therefore \mathrm{h}_1=\frac{\mathrm{u}^2}{2 \mathrm{~g}}=\frac{\mathrm{v}^2}{2 \mathrm{~g}}$

For the second stone $h_2=\frac{v^2 \sin ^2 30^{\circ}}{2 g}=\lambda$

$=\frac{\mathrm{v}^2}{2 \mathrm{~g}} \times \frac{1}{4}$

The masses are same. Hence ratio of potential energies

$\frac{\mathrm{p}_1}{\mathrm{p}_2}=4$

Question22

A car of mass 'm' moving with velocity 'u' on a straight road in a straight line, doubles its velocity in time t. The power delivered by the engine of a car for doubling the velocity is

MHT CET 2021 22th September Morning Shift

Options:

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

B. $\frac{m u^2}{2 t}$

C. $\frac{2 \mathrm{mu}^2}{\mathrm{t}}$

D. $\frac{3 \mathrm{mu}^2}{\mathrm{t}}$

Answer: A

Solution:

To determine the power delivered by the engine of a car for doubling its velocity, we need to analyze the work done and the time over which this work is performed.

Let's start with the given information:

- Initial velocity of the car: u
- Final velocity of the car: $2u$ (since the velocity is doubled)
- Time taken to double the velocity: t
- Mass of the car: m

First, we need to calculate the initial and final kinetic energy of the car:

The initial kinetic energy (KE_i) is given by:

$KE_i = \frac{1}{2}mu^2$

The final kinetic energy (KE_f) is given by:

$KE_f = \frac{1}{2}m(2u)^2 = \frac{1}{2}m \cdot 4u^2 = 2mu^2$

The work done by the engine to double the velocity is equal to the change in kinetic energy:

Work Done (W) $= KE_f - KE_i = 2mu^2 - \frac{1}{2}mu^2 = \frac{3}{2}mu^2$

Power is defined as the work done per unit time:

Power (P) $= \frac{\text{Work Done}}{\text{Time}} = \frac{\frac{3}{2}mu^2}{t} = \frac{3mu^2}{2t}$

Thus, the correct option is:

Option A: $\frac{3mu^2}{2t}$

Question23

A bob of a simple pendulum of mass 'm' is displaced through 90° from mean position and released. When the bob is at lowest position, the tension in the string is

MHT CET 2021 22th September Morning Shift

Options:

A. 4 mg

B. 2 mg

C. mg

D. 3 mg

Answer: D

Solution:

To determine the tension in the string when the bob is at the lowest position, we need to consider both gravitational forces and the centripetal forces acting on the bob of the pendulum.

When the bob is displaced through 90° from the mean position and released, it will swing down to the lowest point. At the lowest position, the bob will have kinetic energy due to its motion, in addition to the gravitational force acting on it.

The forces acting on the bob at the lowest point are:

- The weight of the bob, which is mg downward.
- The tension T in the string, which acts upward through the string.

At the lowest position, the bob's speed will be at its maximum. The centripetal force required to keep the bob moving in a circular path is provided by the tension in the string. The centripetal force is given by:

$F_c = \frac{mv^2}{L}$

where

- m is the mass of the bob,
- v is the velocity at the lowest point,
- and L is the length of the pendulum.

When the pendulum bob is released from the horizontal position (displaced 90°), it falls a distance L (the length of the string) to reach the lowest point. The potential energy at the displaced position is converted into kinetic energy at the lowest point. Using the principle of conservation of energy:

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

Here, h is the vertical height the bob falls, which is equal to the length of the pendulum L because it was displaced horizontally:

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

$v^2 = 2gL$

Now, substituting this value into the expression for the centripetal force:

$T - mg = \frac{mv^2}{L}$

$T - mg = \frac{m(2gL)}{L}$

$T - mg = 2mg$

$T = 3mg$

Therefore, the tension in the string at the lowest position is:

Option D: 3 mg

Question24

Three bodies P, Q and R have masses 'm' kg, '2m' kg and '3m' kg respectively. If all the bodies have equal kinetic energy, then greater momentum will be for body/bodies.

MHT CET 2021 21th September Evening Shift

Options:

A. Q

B. R

C. P and Q

D. P

Answer: B

Solution:

To address this question, we need to understand the relationship between kinetic energy and momentum. The kinetic energy (KE) of a body is given by the formula:

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

where *m* is mass and *v* is velocity. The momentum (p) of a body, on the other hand, is given by

$p = mv$

Given that the bodies P, Q, and R have masses *m*, *2m*, and *3m* respectively, and all have the same kinetic energy, let us find a relationship between their momenta.

Since their kinetic energies are the same, we can write

$\frac{1}{2}mv_p^2 = \frac{1}{2}(2m)v_q^2 = \frac{1}{2}(3m)v_r^2$

where v_p, v_q, and v_r are the velocities of P, Q, and R, respectively. Simplifying this,

$mv_p^2 = 2mv_q^2 = 3mv_r^2$

We can remove the factor of *m* from each side, as it's common, which simplifies to:

$v_p^2 = 2v_q^2 = 3v_r^2$

Let's express the velocities of Q and R in terms of P's velocity to see the relation clearly:

$v_q^2 = \frac{v_p^2}{2} \quad \text{and} \quad v_r^2 = \frac{v_p^2}{3}$

Now, we find the square roots of both sides to get the actual velocities:

$v_q = v_p/\sqrt{2}$ and $v_r = v_p/\sqrt{3}$

Since the momentum $p = mv$, we can substitute these velocity relationships into the equation for momentum:

$p_p = mv_p$

$p_q = 2m(v_p/\sqrt{2}) = \sqrt{2}mv_p$

$p_r = 3m(v_p/\sqrt{3}) = \sqrt{3}mv_p$

Comparing the momenta:

p_p refers to the momentum of P with a factor of mv_p.

p_q has a factor of $\sqrt{2}mv_p$, which indicates that the momentum of Q is greater than that of P because $\sqrt{2} > 1$.

p_r has a factor of $\sqrt{3}mv_p$, which indicates that the momentum of R is greater than both P and Q since $\sqrt{3} > \sqrt{2}$.

Therefore, the body with the greatest momentum is body R, making the correct option:

Option B: R

Question25

A sphere of mass 25 gram is placed on a vertical spring. It is compressed by $0.2 \mathrm{~m}$ using a force $5 \mathrm{~N}$. When the spring is released, the sphere will reach a height of $\left(\mathrm{g}=10 \mathrm{~m/s}^2\right) 2 \mathrm{~m}$

MHT CET 2021 21th September Morning Shift

Options:

A. 6 cm

B. 8 cm

C. 10 cm

D. 2 m

Answer: D

Solution:

Gravitational potential energy gained by the ball = Elastic potential energy in the spring

$$\begin{aligned} \mathrm{mgh} &= \frac{1}{2}\mathrm{Fx} \\ \therefore \quad \mathrm{h} &= \frac{\mathrm{Fx}}{2\mathrm{mg}} \\ &= \frac{5 \times 0.2}{2 \times 25 \times 10^{-3} \times 10} \\ &= 2 \mathrm{~m} \end{aligned}$$

Question26

A vehicle of mass m is moving with momentum p on a rough horizontal road. The coefficient of friction between the tyres and the horizontal road is μ. The stopping distance is ($g =$ acceleration due to gravity)

MHT CET 2020 16th October Morning Shift

Options:

A. $\frac{p^2}{2\mu m^2}$

B. $\frac{p^2}{2\mu g m^2}$

C. $\frac{p^2}{\mu g m^2}$

D. $\frac{p^2}{2\mu g}$

Answer: B

Solution:

To find the stopping distance of the vehicle, we begin by recognizing that the work done by friction to stop the vehicle is equal to the kinetic energy possessed by the vehicle.

The momentum p of the vehicle is given by $p = mv$, where m is the mass and v is the velocity of the vehicle.

The kinetic energy E_k of the vehicle can be found by the formula $E_k = \frac{1}{2}mv^2$.

Substituting $v = \frac{p}{m}$ into the kinetic energy equation gives us:

$E_k = \frac{1}{2}m\left(\frac{p}{m}\right)^2$

Simplifying, this gives:

$E_k = \frac{p^2}{2m}$

The work done by friction (which is equal to the kinetic energy to stop the vehicle) is calculated by the product of the friction force and the stopping distance d that we want to find. The maximum friction force available is $F_{\text{friction}} = \mu mg$, where μ is the coefficient of friction and g is the acceleration due to gravity.

So, the work done by friction is:

$W = F_{\text{friction}} \cdot d = \mu mgd$

Equating the work done by friction to the kinetic energy of the vehicle gives us:

$\mu mgd = \frac{p^2}{2m}$

Solving for d:

$d = \frac{p^2}{2\mu gm^2}$

Therefore, the correct option that represents the stopping distance d of the vehicle is:

Option B: $\frac{p^2}{2\mu gm^2}$

Question27

If the radius of the circular path and frequency of revolution of a particle of mass m are doubled, then the change in its kinetic energy will be $\left(E_i\right.$ and E_1 are the initial and final kinetic energies of the particle respectively,)

MHT CET 2019 3rd May Morning Shift

Options:

A. 12 E_f

B. 13 E_i

C. 8 E_f

D. 15 E_i

Answer: D

Solution:

Initial kinetic energy of body,

$$E_i = \frac{1}{2}mv^2 = \frac{1}{2}m\left(\frac{2\pi r_1}{T_1}\right)^2 \left[\because v = \frac{2\pi r}{T}\right]$$
$$E_i = 2\pi^2 m r_1^2 f_1^2 \quad \text{.... (i)}$$

Where, $f_1 =$ frequency of revolution of the body.

When, $r_2 = 2r_1$ and $f_2 = 2f_1$, then

$$\begin{aligned} E_f &= 2\pi^2 m \cdot r_2^2 \cdot f_2^2 \\ &= 2\pi^2 m(2r_1)^2(2f_1)^2 \\ E_f &= 32\pi^2 m r_1^2 f_1^2 = 16 \cdot 2\pi^2 m r_1^2 f_1^2 \\ E_f &= 16E_i \end{aligned}$$

$\therefore$ Change in kinetic energy,

$$\begin{aligned} \Delta E &= E_i - E_i \\ &= 16E_i - E_i = 15E_i \end{aligned}$$

Question28

A force $(F) = -5\hat{\mathbf{i}} - 7\hat{\mathbf{j}} + 3\hat{\mathbf{k}}$ acting on a particle causes a displacement $(s) = 3\hat{\mathbf{i}} - 2\hat{\mathbf{j}} + a\hat{\mathbf{k}}$ in its own direction. If the work done is 14 J , then the value of ' a ' is

MHT CET 2019 2nd May Evening Shift

Options:

A. 0

B. 5

C. 15

D. 1

Answer: B

Solution:

Given,

$$\mathbf{F} = -5\hat{\mathbf{i}} - 7\hat{\mathbf{j}} + 3\hat{\mathbf{k}}$$
$$\mathbf{s} = 3\hat{\mathbf{i}} - 2\hat{\mathbf{j}} + a\hat{\mathbf{k}}$$

and $W = 14$ J

The work done by a force in displacing a particle through a distance is given by

$W = \mathbf{F} \cdot \mathbf{s}$ .... (i)

Substituting above values in Eq. (i), we get

$$14 = (-5\hat{\mathbf{i}} - 7\hat{\mathbf{j}} + 3\hat{\mathbf{k}}) \cdot (3\hat{\mathbf{i}} - 2\hat{\mathbf{j}} + a\hat{\mathbf{k}})$$
$$\Rightarrow \quad 14 = -15 + 14 + 3a$$
$$\Rightarrow \quad a = \frac{15}{3} = 5$$
