PHYSICS

NEET and JEE Main- 2020- 45 Days Crash Course

Problem Solving Class

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P-Q730

A ball of mass m moving at a speed v collides with another ball of mass 3m at rest. The lighter block comes to rest after collision. The coefficient of restitution is

(A) $\frac{1}{2}$ (B) $\frac{2}{3}$

(C) $\frac{1}{4}$ (D) none of these

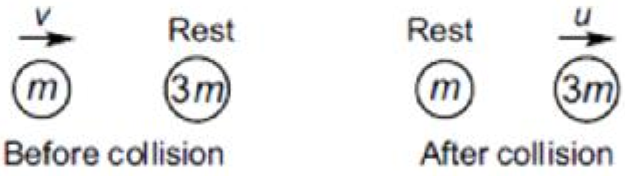
$\vec{p}$/c

$3mv' = mv \Rightarrow v' = \frac{v}{3}$

$e = \frac{v_{sep.}}{v_{app.}} = \frac{v/3}{v} = \frac{1}{3}$

P-Q730-Solution

Ans [D]



$$mv + 3m \cdot 0 = m \cdot 0 + 3u$$

The momentum will be conserved in this situation also, only the kinetic energy of the system will change

$$\therefore \quad u = \frac{v}{3}$$

$$e = \frac{\text{Velocity of separation}}{\text{Velocity of approach}}$$

$$= \frac{u - 0}{v - 0} = \frac{u}{v}$$

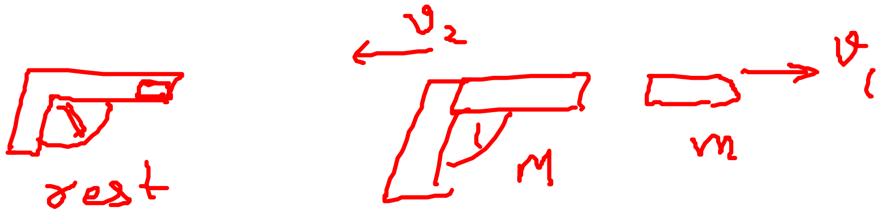
$$= \frac{1}{3}$$

P-Q747

A bullet of mass 5 g is shot from a gun of mass 5 kg. The muzzle velocity of the bullet is 500 m/s. The recoil velocity of the gun is

(a) 0.5 m/s (b) 0.25 m/s

(c) 1 m/s (d) Data is insufficient



$$mv_1 - Mv_2 = 0$$

$$v_2 = \frac{mv_1}{M}$$

P-Q747-Solution

Ans [A]

$$m_B v_B = m_a v_a$$

By the conservation of linear momentum

$$\Rightarrow v_G = \frac{m_B \times v_B}{m_G}$$

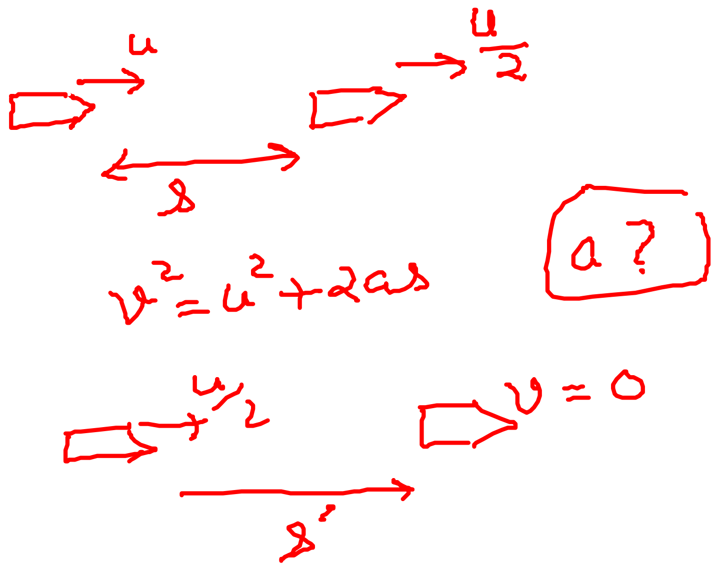
$$= \frac{5 \times 10^{-3} \times 500}{5} = 0.5\ m/s$$

P-Q184

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

(A) 1.5 *cm* (B) 1.0 *cm*

(C) 3.0 *cm* (D) 2.0 *cm*



P-Q184-Solution

Ans [B]

Let initial velocity of the bullet = u

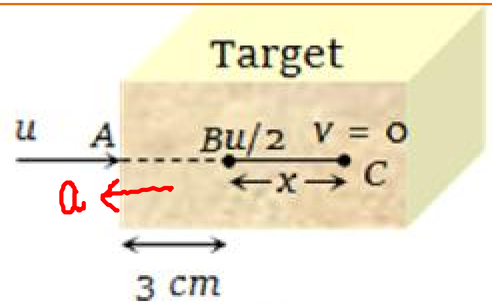
After penetrating 3 cm its velocity becomes $\frac{u}{2}$

Use motion equation

From $v^2 = u^2 - 2as$

$$\left(\frac{u}{2}\right)^2 = u^2 - 2a(3)$$

$$\Rightarrow 6a = \frac{3u^2}{4} \Rightarrow a = \frac{u^2}{8}$$



Let further it will penetrate through distance x and stops at point C.

For distance BC, $v = 0, u = u/2, s = x, a = u^2/8$

From $v^2 = u^2 - 2as \Rightarrow 0 = \left(\frac{u}{2}\right)^2 - 2\left(\frac{u^2}{8}\right).x$

$\Rightarrow x = 1$ cm.

Constant resistance means constant opposing force and since mass doesn't change acceleration will also be constant.

P-Q10001

A particle initially at rest at origin is moving according to law $\vec{a} = 6t\hat{i} + 8t\hat{j}\ m/s^2$, where a is acceleration. Find **1**. Path of particle **2.** velocity of particle at $t = 3\ s$:

a) Parabola, 45 m/s

b) Straight line, 45 m/s

c) Circle, 22 m/s

d) Straight line, 27 m/s

Path

If $\vec{a}$ = const

(1) st. line: $u = 0$, $\vec{u} \parallel \vec{a}$

(2) Parabola: $\vec{u} \nparallel \vec{a}$

$\vec{u} = 0$, $\vec{a}$ st. line

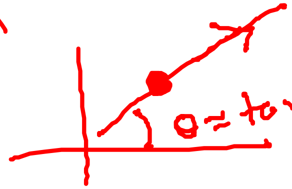
$\tan\theta = \frac{a_y}{a_x} = \frac{8t}{6t} = \frac{4}{3}$

$\vec{v} = \int \vec{a}\, dt = 6\frac{t^2}{2}\hat{i} + 8\frac{t^2}{2}\hat{j} = 3t^2\hat{i} + 4t^2\hat{j}$

At $t = 3\ s$

$\vec{v} = 3(3)^2\hat{i} + 4(3^2)\hat{j}$

$v = 9\sqrt{3^2+4^2} = 9\times 5 = 45\ m/s$



$\theta = \tan^{-1}(4/3)$

P-Q10001-Solution

Ans [B]

$a_x = 6t$ $\quad$ $a_y = 8t$

$\frac{dv_x}{dt} = 6t$ $\quad$ $\frac{dv_y}{dt} = 8t$

$\int dv_x = \int 6t\,dt$ $\quad$ $\int dv_y = \int 8t\,dt$

$v_x = \frac{6t^2}{2} = 27$ $\quad$ $v_y = \frac{8t^2}{2} = 36$ → (1)

$\frac{dx}{dt} = 27$ $\quad$ $\frac{dy}{dt} = 36$

$x = 27t$ $\quad$ $y = 36t$

$\frac{y}{x} = \frac{36}{27}$

$$v = \sqrt{v_x^2 + v_y^2} = \sqrt{27^2 + 36^2}$$

$$v = \sqrt{729 + 1296} = 45 \text{ m/s.}$$

← Velocity is constant irrespective of time

$x = 27t$ and $y = 36t$ ← From 1, $\frac{dy}{dt}$ and $\frac{dx}{dt}$ are constant

Eliminating t, $\mathbf{4x = 3y}$

Path is a straight line

Note: Motion in straight line can have variable acceleration

P-Q716

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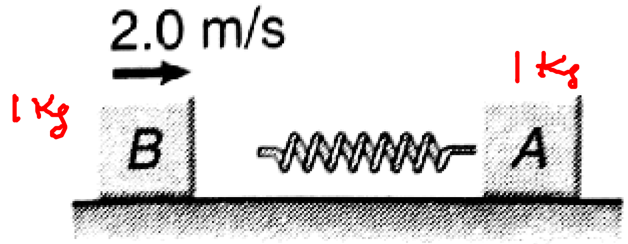
Two blocks **A** and **B** of equal mass $m = 1 \cdot 0\ kg$ are lying on a smooth horizontal surface as shown. A spring of force constant $k = 200 N/m$ is fixed at one end of block **A**. block **B** collides with block **A** with velocity $v_0 = 2.0 m/s$. Find the maximum compression of the spring.

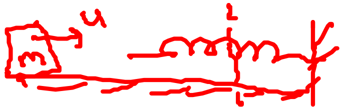
A) 1cm

B) 5cm

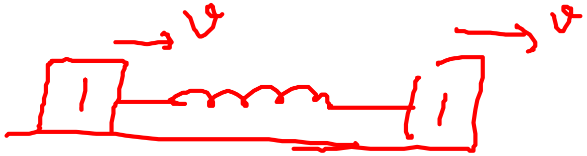
C) 10cm

D) 20cm





At max. compression, both will have same velocity



$\vec{P}$/C

$2v = 2$

$v = 1\ m/s$

$U_i + K_i = U_f + K_f$

$0 + \frac{1}{2}(1)(2)^2 = \frac{1}{2}Kx^2 + \frac{1}{2}(2)v^2$

P-Q716-Solution

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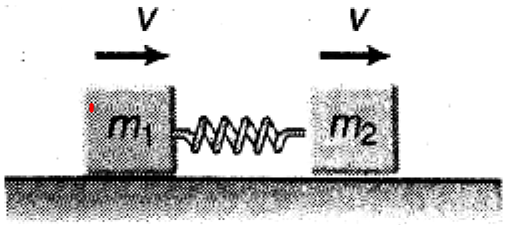
Ans [C]

At maximum compression velocity of both the blocks is same



Maximum compression = x_m

Conservation of momentum

$$(m_A + m_B)v = m_B v_0$$

$$(1.0 + 1.0)v = (1.0)\, v_0$$

$$v = \frac{v_0}{2} = \frac{2.0}{2} = 1.0\,\text{m/s}$$

Velocity at maximum compression

using conservation of mechanical energy

$$\frac{1}{2} m_B v_0^2 = \frac{1}{2}(m_A + m_B)v^2 + \frac{1}{2} k x_m^2$$

$$\frac{1}{2} \times (1) \times (2.0)^2 = \frac{1}{2} \times (1.0 + 1.0) \times (1.0)^2 + \frac{1}{2} \times (200) \times x_m^2$$

$$2 = 1.0 + 100 x_m^2 \quad \text{or} \quad x_m = 0.1\,\text{m} = 10.0\,\text{cm}$$

$2 = 1 + 100x^2$

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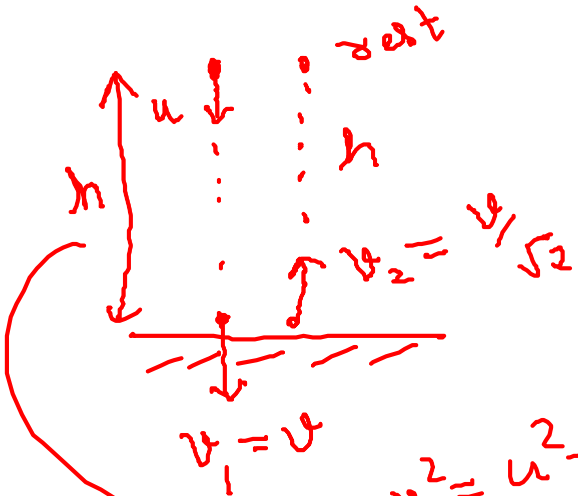
A ball is projected vertically down with an initial velocity from a height of **20 *m*** onto a horizontal floor. During the impact it loses **50%** of its energy and rebounds to the same height. The initial velocity of its projection is

(A) $20\ ms^{-1}$ (B) $15\ ms^{-1}$

(C) $10\ ms^{-1}$ (D) $5\ ms^{-1}$



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

$K_f = \frac{K}{2}$; $v_f = v/\sqrt{2}$

$h = \frac{(v/\sqrt{2})^2}{2g} = \frac{v^2}{4g}$

$v^2 = 4gh$

$v^2 = u^2 + 2as$

$4gh = u^2 + 2gh$

$u^2 = 2gh = 2 \times 10 \times 20 = 400$

$u = 20\ m/s$

Ans [A]

Ball risen up to same height. It is only possible when it has some initial kinetic energy with potential energy.

Total energy at point $A = \frac{1}{2}mv^2 + mgh$

During collision loss of energy is **50%** and the ball rises up to same height.

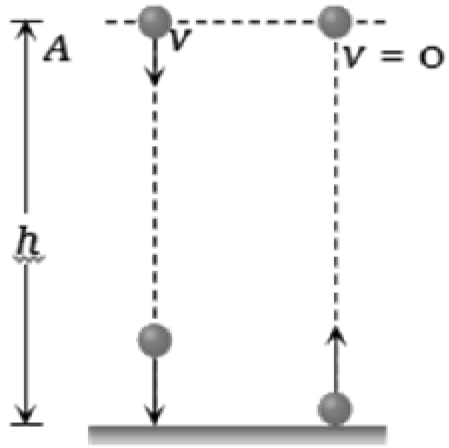
It means it possess only potential energy at same level.

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

$$\frac{1}{2}\left(\frac{1}{2}mv^2 + mgh\right) = mgh$$

$$v = \sqrt{2gh} = \sqrt{2 \times 10 \times 20}$$

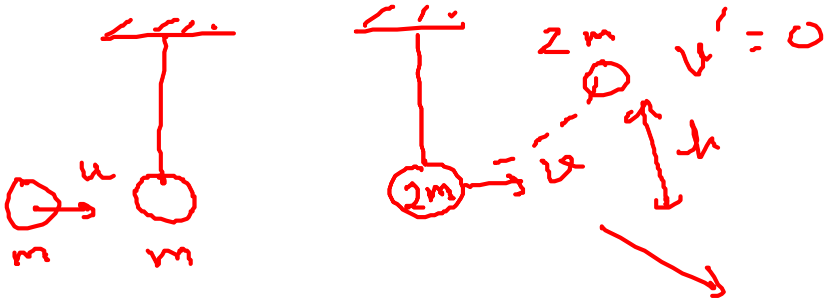
$$\therefore v = 20\ m/s$$



A mass of **10 *gm.*** moving with a velocity of **100 *cm/s*** strikes a pendulum bob of mass **10 *gm***. The two masses stick together. The maximum height reached by the system now is

(A) Zero (B) 5 *cm*

(C) 2.5 *cm* (D) 1.25 *cm*



E/C

$2mv = mu$

$v = \frac{u}{2}$

$\frac{1}{2} \cdot 2m v^2 = 2mgh$

$h = \frac{v^2}{2g} = \frac{u^2}{8g}$

$= \frac{1}{80} m$

$\frac{100}{80} cm$

1.25 cm

Ans [D]

Initially mass **10 gm**. moves with velocity **100 cm/s**

$\therefore$ Initial momentum = 10 × 100 = $1000 \frac{gm \times m}{\text{sec}}$

After collision system moves with velocity $v_{sys.}$ then

Final momentum = $(10+10) \times v_{sys.}$

Applying momentum conservation since no external force

$10000 = 20 \times v_{sys.} \Rightarrow v_{sys.} == 50\ cm/s$

If system rises up to height h then

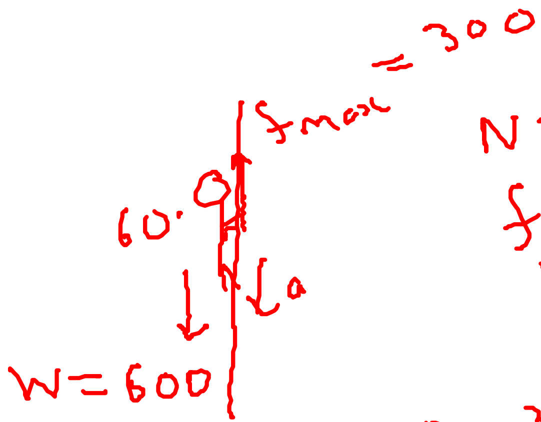
$$h = \frac{v_{sys.}^2}{2g} = \frac{50 \times 50}{2 \times 1000} = \frac{2.5}{2} = 1.25\ cm$$

PQ4Q 10

A fireman of mass 60 *kg* slides down a pole. He is pressing the pole with a force of 600 *N*. The coefficient of friction between the hands and the pole is 0.5, with what acceleration will the fireman slide down (g = 10 m/s^2)

(a) 1 m/s^2 (b) 2.5 m/s^2

(c) 10 m/s^2 (d) 5 m/s^2



$N = 600$

$f_{max} = \mu N = 300$

$600 - 300 = 60a$

$a = \frac{300}{60}$

$= 5 m/s^2$

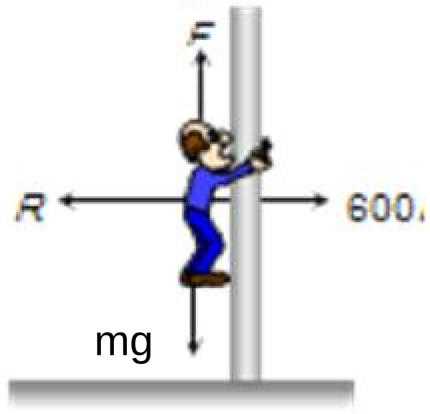
Ans [D]

Net downward acceleration $= \dfrac{\text{Weight - Frictionforce}}{\text{Mass}}$

$$= \frac{(mg - \mu R)}{m}$$

$$= \frac{60 \times 10 - 0.5 \times 600}{60}$$

$$= \frac{300}{60} = 5\ m/s^2$$



Friction force is acting in upward direction as the man is sliding downwards

PQ4Q 20

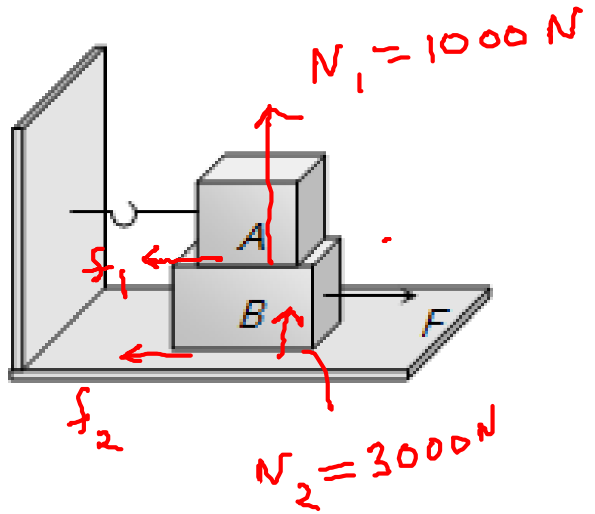
A block *A* with mass 100 *kg* is resting on another block *B* of mass 200 *kg*. As shown in figure a horizontal rope tied to a wall holds it. The coefficient of friction between *A* and *B* is 0.2 while coefficient of friction between *B* and the ground is 0.3. The minimum required force *F* to start moving *B* will be

(a) 900 *N*

(b) 100 *N*

(c) 1100 *N*

(d) 1200 *N*



$f_1 = 0.2 \times 1000 = 200\,N$

$f_2 = 0.3 \times 3000 = 900\,N$

$F = f_1 + f_2 = 1100\,N$

PQ4S20

Ans [C]

There are two friction forces acting on Block B

1. Due to Block A → f_{AB}
2. Due to Ground → f_{BG}

$$F = f_{AB} + f_{BG}$$

$$= \mu_{AB} m_a g + \mu_{BG}(m_A + m_B) g$$

$$= 0.2 \times 100 \times 10$$

$$+ 0.3(300) \times 10$$

$$= 200 + 900 = 1100 N$$

To bring a body into motion applied force should be at least equal to the maximum frictional force

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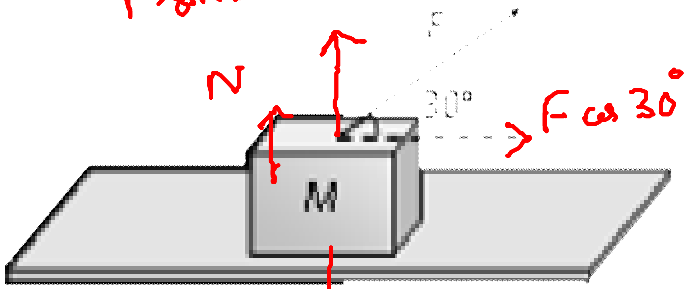
A block of mass 5 kg is resting on a rough horizontal surface for which the coefficient of friction is 0.2. When a force F = 40 N is applied, the acceleration of the block will be in $(\frac{m}{s^2})$:



(a) 5.73 ✓

(b) 8.0

(c) 3.17

(d) 10.0

$F\sin 30^\circ = 20$

$F\cos 30^\circ = 40 \times \frac{\sqrt{3}}{2} = 20\sqrt{3}$

20×1.73

34.6

N, 50

$N + 20 = 50$

$N = 30$

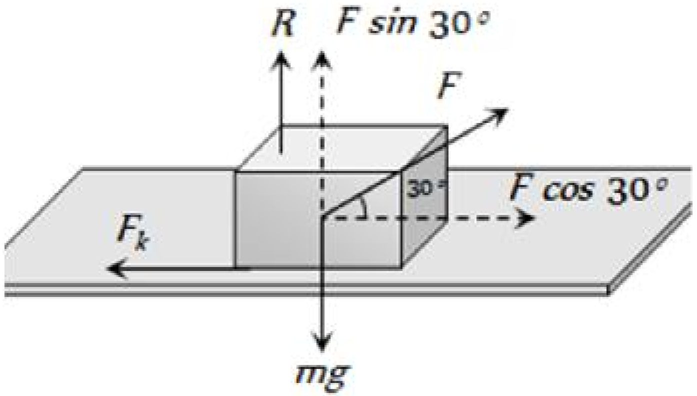
$f_{max} = \mu N = 0.2 \times 30 = 6\,N$

$a = \frac{20\sqrt{3} - 6}{5} = \frac{34.6 - 6}{5}$

$= \frac{28.6}{5} = 5.73$

PQ4S25

Ans [A]



Kinetic friction $= \mu_k R = 0.2(mg - F\sin 30^\circ)$

$$= 0.2\left(5 \times 10 - 40 \times \frac{1}{2}\right) = 0.2(50 - 20) = 6\ N$$

Acceleration of the block $= \dfrac{F\cos 30^\circ - \text{Kinetic friction}}{\text{Mass}}$

$$= \frac{40 \times \frac{\sqrt{3}}{2} - 6}{5} = 5.73\ m/s^2$$

In such cases always try to resolve the forces and write newton first law in x and y direction

PQ4Q 44

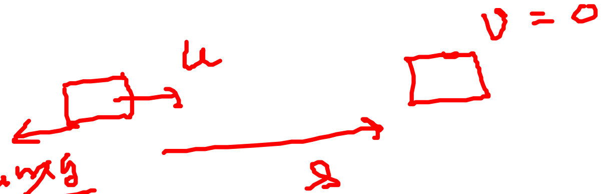
A vehicle of mass *m* is moving on a rough horizontal road with momentum *P*. If the coefficient of friction between the tyres and the road be *m*, then the stopping distance is :

(a) $\dfrac{P}{2\mu m g}$

(b) $\dfrac{P^2}{2\mu m g}$

(c) $\dfrac{P}{2\mu m^2 g}$

(d) $\dfrac{P^2}{2\mu m^2 g}$ ✓



$p = mu$

$a = \dfrac{\mu m g}{m}$

$v^2 = u^2 + 2as$

$0 = u^2 - 2\mu g s$

$s = \dfrac{u^2}{2\mu g} = \dfrac{m^2 u^2}{2\mu g m^2} = \dfrac{P^2}{2\mu g m^2}$

PQ4S44

Ans [D]

Using P = mv

$$S = \frac{u^2}{2\mu g} = \frac{m^2 u^2}{2\mu g m^2} = \frac{P^2}{2\mu m^2 g}$$

We can write it using conservation of Energy also

P-Q501

A body of mass **3 kg** acted upon by a constant force is displaced by **S** meter, given by relation $\boldsymbol{S} = \frac{1}{3}\boldsymbol{t}^2$ where $\boldsymbol{t}$ is in second. Work done by the force in 2 second is :

(A) $\frac{8}{3}$ J (B) $\frac{11}{3}$ J (C) $\frac{5}{3}$ J (D) $\frac{7}{3}$ J

$v = \frac{ds}{dt} = \frac{1}{3} \cdot 2t$

At $t = 2s$; $v = \frac{4}{3}$ m/s

$W_{all\ force} = \Delta K$

$= K_f - K_i$

$= \frac{1}{2}(3)\left(\frac{4}{3}\right)^2 - 0$

$= \frac{3}{2} \times \frac{16}{9} = \frac{8}{3}$ J

P-Q501-Solution

Ans [A]

$s = t^2/3$

$v = \frac{ds}{dt} = \frac{2}{3}t$

Differentiating distance function with time gives velocity

$at\ t = 0\ ;\ v_1 = 0;$

$t = 2s\ ;\ v_2 = \frac{4}{3}\ m/s$

$W = \frac{1}{2}m({v_1}^2 - {v_2}^2) = \frac{1}{2}(3)\left(\frac{16}{9} - 0\right)$

Change in energy give work done

$= \frac{8}{3}\ J$

P-Q506

A particle is released from a height **H**. At certain height its kinetic energy is two times its potential energy. Height and speed of particle at that instant are

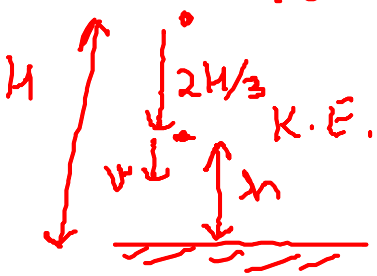
A) $\frac{5H}{7}, \sqrt{\frac{2gH}{7}}$ ✗

B) $\frac{H}{3}, 2\sqrt{\frac{gH}{3}}$

C) $\frac{2H}{3}, \sqrt{\frac{gH}{3}}$ ✗

D) $\frac{H}{3}, \sqrt{2gH}$

$M.E = mgH$



$K.E. = 2P.E$

$K.E. + P.E. = M.E$

$2mgh + mgh = mgH$

$3mgh = mgH$

$h = \frac{H}{3}$

$v = \sqrt{2g \cdot \frac{2H}{3}} = 2\sqrt{\frac{gH}{3}}$

$v^2 - u^2 = 2as$

P-Q506-Solution

Ans [B]

Conservation of energy

$$\therefore K + U = mgH \ \ \& \ K = 2U$$

$$\therefore 2U + U = mgH$$

Point at KE is 2PE

$$\Rightarrow U = \frac{mgH}{3} \Rightarrow mgh = \frac{mgH}{3} \Rightarrow h = H/3$$

$$\therefore \frac{1}{2} mv^2 = 2U = \frac{2mgH}{3} \Rightarrow v = 2\sqrt{\frac{gH}{3}}$$

P-Q507

The potential energy of a particle under a conservative force field is given by **$U = 10 + (x - 4)^2$**, where **x** is in meter. At **x = 6 m**, K.E. of particle is **10 J**. Calculate the maximum kinetic energy of particle.

A) 24 J B) 10 J C) 7 J D) 14 J

At $x = 6$

$U = 10 + (6-4)^2 = 10 + 4 = 14$

$K = 10$

$M.E. = U + K = 24\ J = \text{const.}$

$U_{min.} = 10\ J$

$U + K = 24$

$K_{max} = 24 - 10 = 14\ J$

P-Q507-Solution

Ans [D]

$U = 10 + (x - 4)^2$

$0 = 2(x - 4)$

For maximum value $\frac{dU}{dx} = 0$

Minimum potential energy $at\ x = 4\ is\ 10\ J$

At x = 6

When KE = 10 J

$U = 10 + (6 - 4)^2 = 14\ J$ ← Putting the x = 6 in PE equation

TME = KE + PE ← Conservation of energy

= (10 + 14) J = 24 J

When KE is maximum PE is minimum

$TME = KE_{max} + PE_{min}$

$24 = KE_{max} + 10$ ← Minimum potential energy at x = 4

$KE_{max} = 14\ J$

P-Q528

A position dependent force $F = 7 - 2x + 3x^2$ newton acts on a body of mass 2 Kg and displaces it from $x = 0$ to $x = 5m$. The work done in joules is

(a) 70 (b) 270 (c) 35 (d) 135 ✓

$W = \int F\,dx$

$= \left[7x - x^2 + x^3\right]_0^5$

$= 35 - 25 + 125$

$= 135\ J$

P-Q528-Solution

Ans [D]

Work done is

$$W = \int_0^5 F\,dx = \int_0^5 (7 - 2x + 3x^2)\,dx$$

We can find the work done by integrating F wrt x

$$= |7x - x^2 + x^3|_0^5$$

$$= 7 \times 5 - (5)^2 + (5)^3 = 135\ J$$