JEE and NEET CRASH COURSE

PHYSICS

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Problem Solving Class

(Work, Energy and Power)

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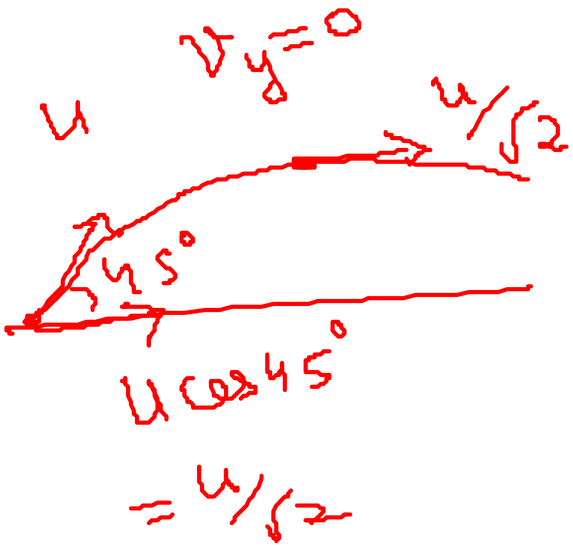
PQ4Q266

A ball whose kinetic energy is E, is projected at an angle of 45° to the horizontal. The kinetic energy of the ball at the highest point of its flight will be **AIEEE - 2002**

(A) E (B) $E/\sqrt{2}$

(C) E/2 (D) Zero



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

$E_{Top} = \frac{1}{2} m \left(\frac{u}{\sqrt{2}}\right)^2$

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

$= E/2$

PQ4S266

Ans [C]

Let us assume initial velocity of ball is u

Kinetic energy point of projection (E) $= \frac{1}{2} mu^2$

At highest point velocity = u cosθ

∴ Kinetic energy at highest point

$$= \frac{1}{2} m(u\cos\theta)^2$$

$$= \frac{1}{2} mu^2 \cos^2 45°$$

$$= \frac{E}{2}$$

Ball velocity when it reaches highest point is ucos45° because vertical component of velocity is 0.

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

$v = \frac{ds}{dt} = \frac{1}{3} \cdot 2t = \frac{2t}{3} = \frac{4}{3}$

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

$= \frac{1}{2} \times 3 \times \frac{16}{9} = \frac{8}{3}$ J

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

$a = \frac{dv}{dt} = \frac{2}{3}$

$W = F \cdot S = 2 \cdot \frac{t^2}{3}$

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

PQ4Q268

A spring of force constant 800 N/m has an extension of 5 cm. The work done in extending it from 5 cm to 15 cm is

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(A) 16 J

(B) 8 J

(C) 32 J

(D) 24 J

$$W_{ext} = -W_{spring\ force} = -(U_i - U_f)$$

$$= U_f - U_i$$

$$= \frac{1}{2}K(15\,cm)^2 - \frac{1}{2}K(5\,cm)^2$$

$$= \frac{1}{2} \times 800 \times 25 \times \frac{1}{10000}(9-1)$$

$$= 8\ J$$

PQ4S268

Ans [B]

$$W = \int_{x_1}^{x_2} kx \; dx = \int_{0.05}^{0.15} kx \; dx$$

$$\therefore \; W = \int_{0.05}^{0.15} 800x \; dx = \frac{800}{2} \, [x^2]_{0.05}^{0.15}$$

$$= \; 400 \, [(0.15)^2 \; - \; (0.05)^2]$$

or W = 8J.

- The work done is stored as elastic potential energy in the spring.

It is given by: after integration..

$W = 1/2 \times \; k \, (x_2{}^2 - x_1{}^2)$

PQ4Q 44

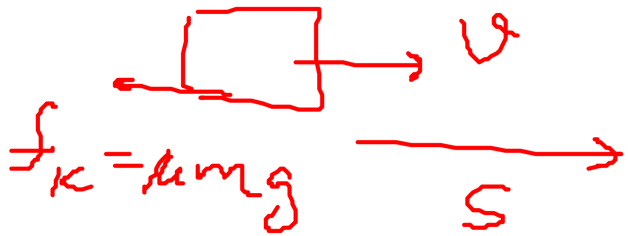
A vehicle of mass m is moving on a rough horizontal road with momentum P. If the coefficient of friction between the tyres and the road be m then the stopping distance is :

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

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

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

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



$$W_{friction} = K_f - K_i$$

$$-\mu mgS = 0 - \frac{P^2}{2m}$$

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

PQ4S44

Ans [D]

Using P = mv

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

We can write it using conservation of Energy also

PQ4Q269

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Consider the following two statements.

A. Linear momentum of a system of particles is zero.

B. Kinetic energy of a system of particles is zero.

Then

(A) A does not imply B and B does not imply A

(B) A implies B but B does not imply A

(C) A does not imply B but B implies A ✓

(D) A implies B and B implies A

For single particle

$K = \frac{p^2}{2m}$; $p = \sqrt{2mK}$

For system of particles

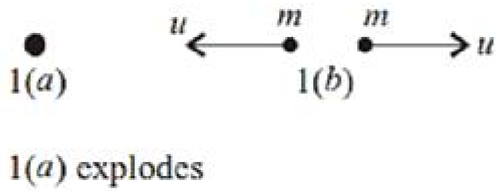
$K_{system} = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2 + \ldots$

$\vec{p}_{system} = m_1\vec{v}_1 + m_2\vec{v}_2 + \ldots$

PQ4S269

Ans [C]

A system of particles implies that one is discussing total momentum and total energy.



Total momentum = 0

But total kinetic energy $= 2\left(\frac{1}{2}\right) mu^2$

But if total kinetic energy = 0, velocities are zero. Here A is true, but B is not true.

A does not imply B, but B implies A

Linear momentum is a vector quantity linear momentum of a system of particle is zero does not means that momentum of each particle is zero.

● i.e each particle has momentum but thier vector sum is zero

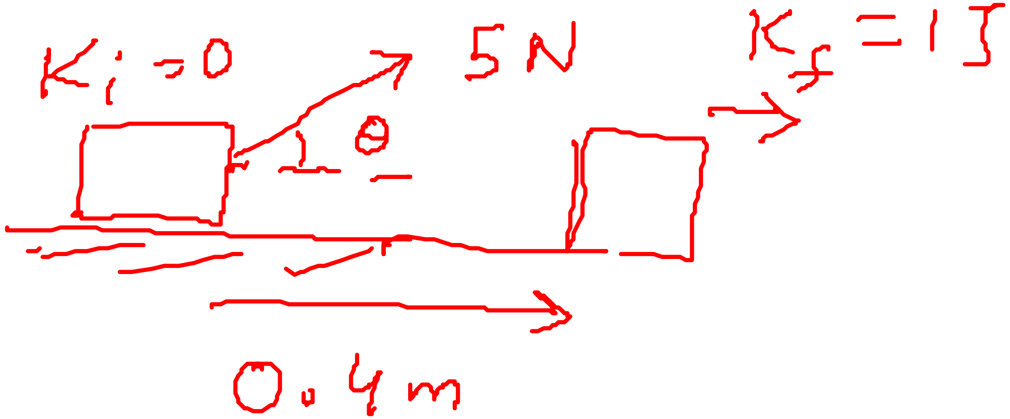
●If kinetic energy of system of particle is zero means kinetic enery of each particle is zero.

P-Q543

A force of 5 *N*, making an angle θ with the horizontal, acting on an object displaces it by 0.4*m* along the horizontal direction. If the object gains kinetic energy of 1*J*, the horizontal component of the force is

(a) 1.5 *N* (b) 2.5 *N*

(c) 3.5 *N* (d) 4.5 *N*



$$F \cos\theta = K_f - K_i$$

$$F_H S = 1 - 0$$

$$F_H = \frac{1}{0.4}$$

$$= \frac{10}{4}$$

$$F_H = 2.5\ N$$

P-Q543-Solution

Ans [B]

Work done on the body = K.E. gained by the body

$$Fs\cos\theta = 1$$

$$\Rightarrow F\cos\theta = \frac{1}{s} = \frac{1}{0.4} = 2.5N$$

Horizontal component of force will be Fcosθ

PQ4Q270

A body is moved along a straight line by a machine delivering a constant power. The distance moved by the body in time t is proportional to

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(A) $t^{3/4}$

(B) $t^{3/2}$

(C) $t^{1/4}$

(D) $t^{1/2}$

$P = \text{const}$

$Fv = \text{const.}$

$m\frac{dv}{dt} \cdot v = \text{const}$

$\int v\,dv \propto \int dt$

$\frac{v^2}{2} \propto t$

$v \propto t^{1/2}$

$\frac{ds}{dt} \propto t^{1/2}$

$\int ds \propto \int t^{1/2}\,dt$

$s \propto \frac{t^{\frac{1}{2}+1}}{\frac{1}{2}+1}$

$s \propto t^{3/2}$

PQ4S270

Ans [B]

$$\text{Power} = \frac{\text{Work}}{\text{Time}} = \frac{\text{Force} \times \text{Distance}}{\text{Time}} = \text{Force} \times v$$

$$\text{Force} \times \text{velocity} = \text{constant (K)}$$

$$\text{or } (ma)(at) = K$$

$$\text{or } a = \left(\frac{K}{mt}\right)^{1/2}$$

$$\therefore s = \frac{1}{2}\left(\frac{K}{mt}\right)^{1/2} t^2 = \frac{1}{2}\left(\frac{K}{m}\right)^{1/2} t^{3/2}$$

or s is proportional to $t^{3/2}$.

- Power, $P = F.v.$
- force, $F = ma$
- velocity $= at$

$$s = \frac{1}{2} at^2$$

P-Q542

A force of 5 *N* acts on a 15 *kg* body initially at rest. The work done by the force during the first second of motion of the body is

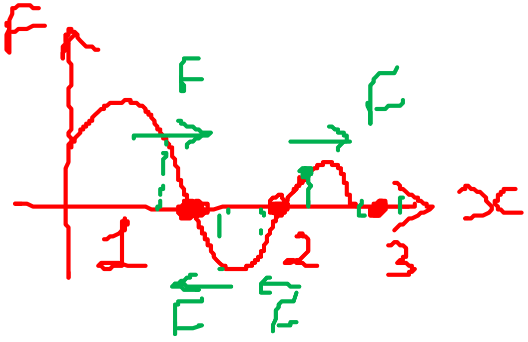
(a) 5 *J* (b) $\frac{5}{6}$ *J*

(c) 6 *J* (d) 75 *J*

$$a = \frac{F}{m} = \frac{5}{15} = \frac{1}{3}$$

$$S = \frac{1}{2}at^2 = \frac{1}{2} \times \frac{1}{3} \times 1^2 = \frac{1}{6}$$

$$W = F \cdot S = \frac{5}{6} J$$



Eq. point

F = 0 Neutral

1, 2, 3

Stable Unstabe

P-Q542-Solution

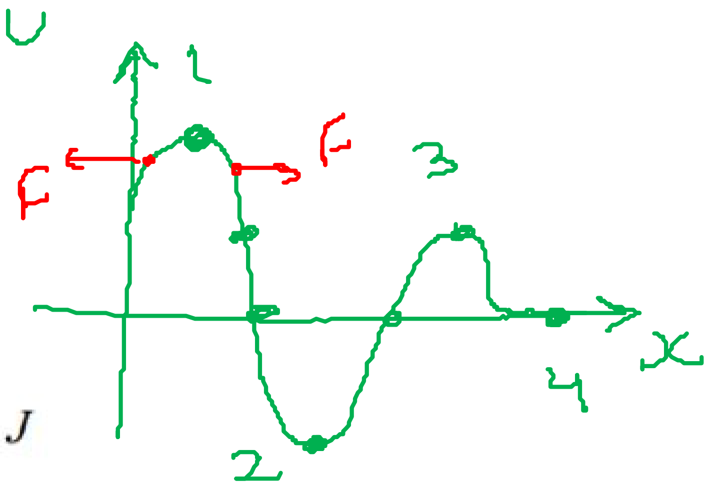
Ans [B]

In this eq. u will be zero

$$W = Fs = F \times \frac{1}{2}at^2 \quad \left[\text{from } s = ut + \frac{1}{2}at^2\right]$$

$$\Rightarrow W = F\left[\frac{1}{2}\left(\frac{F}{m}\right)t^2\right] = \frac{F^2t^2}{2m} = \frac{25 \times (1)^2}{2 \times 15} = \frac{25}{30} = \frac{5}{6} J$$

$a = \frac{F}{m}$



Eqlm. (F = 0)

$F = -\frac{dU}{dx} = 0 \Rightarrow \frac{dU}{dx} = 0$

Eqlm. points is → 1, 2, 3, 4

1 → unstable; 2 → stable; 3 → unstable; 4 → neutral

PQ4Q272

A particle moves in a straight line with retardation proportional to its displacement. Its loss of kinetic energy for any displacement x is proportional to

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(A) x^2 ✓ (B) e^x

(C) x (D) $\log_e x$

$a \propto -x$

$v\frac{dv}{dx} \propto -x$

$\int_{v_i}^{v_f} v\,dv \propto -\int_0^x x\,dx$

$\left[\frac{v^2}{2}\right]_{v_i}^{v_f} \propto -\frac{x^2}{2}$

$\frac{v_f^2}{2} - \frac{v_i^2}{2} \propto -\frac{x^2}{2}$

Loss in K.E. $= K_i - K_f$

$= \frac{1}{2}mv_i^2 - \frac{1}{2}mv_f^2$

$\propto \left(\frac{m}{2}\right)x^2$

$\propto x^2$

PQ4S272

Ans [A]

Given : Retardation ∝ displacement

or $\frac{dv}{dt} = kx$

or $\left(\frac{dv}{dt}\right)\left(\frac{dx}{dt}\right) = kx$

or $dv\,(v) = kx\,dx$

- Acceleration $a = dv/dt$
- velocity $v = ds/dt$

or $\int_{v_1}^{v_2} v\ dv = k\int_0^x x\ dx$

or $\frac{v_2^2}{2} - \frac{v_1^2}{2} = \frac{kx^2}{2}$

or $\frac{mv_2^2}{2} - \frac{mv_1^2}{2} = \frac{mkx^2}{2}$

or $(K_2 - K_1) = \frac{mk}{2}\,x^2$

or Loss of kinetic energy is proportional to x^2.

P-Q5109

A pump motor is used to deliver water at a certain rate from a given pipe. To obtain twice as much water from the same pipe in the same time, power of the motor has to be increased to

(A) 16 times

(B) 4 times

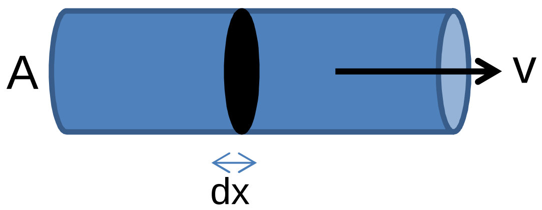
(C) 8 times

(D) 2 times

P-Q5109-Solution

Ans [C]

Change in kinetic energy work done



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

$$m = \rho.A.dx$$ ← Mass flow form small thickness dx

$$dW = \frac{1}{2}\rho.A.dx.v^2$$

$$Power\ is\ \frac{dW}{dt}$$

$$P = \frac{1}{2}\rho.A.v^2.\frac{dx}{dt}$$ ← $\frac{dx}{dt} = v$

$$Power\ of\ a\ pump = \frac{1}{2}\rho A v^3$$

Power $\propto v^3$ For pump

To get **twice** amount of water from same pipe ***v*** has to be made twice.

So power is to be made **8 times**.

P-Q5110

What average horsepower is developed by an **80 kg** man while climbing in **10*s*** a flight of stairs that rises **6 m** vertically

(A) 0.63 *HP* (B) 1.26 *HP*

(C) 1.8 *HP* (D) 2.1 *HP*

$$P_{avg} = \frac{W}{t} = \frac{mgh}{t} = \frac{80 \times 10 \times 6}{10}$$

$$= 480\text{ W}$$

$$= 480 \times \frac{1}{750}\text{ hp}$$

$$=$$

$1\text{ hp} = 746\text{ W} \approx 750\text{ W}$

$1\text{ W} \approx \frac{1}{750}\text{ hp}$

P-Q5110-Solution

Ans [A]

Work done against gravitational work

$$p = \frac{mgh}{t} = \frac{80 \times 9.8 \times 6}{10} W = \frac{470}{746} HP = 0.63\ HP$$

$$Power = \frac{Work\ done}{Time}$$

$$1Hp = 746Watt$$

PQ4Q273

A particle is acted upon by a force of constant magnitude which is always perpendicular to the velocity of the particle, the motion of the particle takes place in a plane. It follows that **AIEEE - 2004**

(A) Its velocity is constant

(B) Its acceleration is constant

(C) Its kinetic energy is constant

(D) It moves in a straight line.

$\vec{F} \perp \vec{ds}$

$W = 0$

$\Delta K = 0$

$K = \text{const}$

$\text{speed} = \text{constant}$

$\vec{v} \neq \text{constant}$

PQ4S273

Ans [C]

No work is done when a force of constant magnitude always acts at right angles to the velocity of a particle when the motion of the particle takes place in a plane. Hence kinetic energy of the particle remains constant.

- work done by the force in the direction of the velocity is zero. So the magnitude of velocity will not change due to the force.

So mass m and velocity v is constant
Therefor k.E is also constant

P-Q502

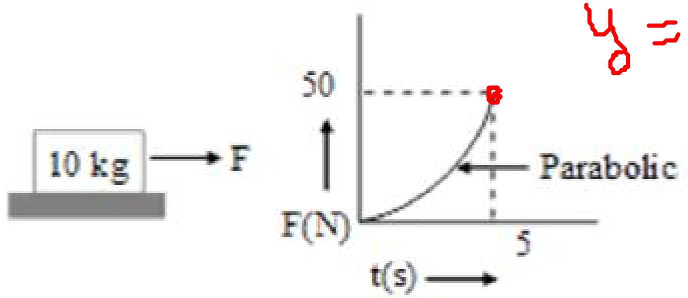
A force **F** is applied to the initially stationary cart. The variation of force with time is shown in the figure. The speed of cart at **t = 5** sec is -

(A) 10 m/s

(B) 8.33 m/s

C) 2 m/s

(D) zero



$y = Kx^2$

$F = Kt^2$

$50 = K5^2$

$K = 2$

$F = 2t^2$

$a = \frac{F}{m} = \frac{t^2}{5}$

$v = \int_0^t a\,dt = \int_0^t \frac{t^2}{5}\,dt = \frac{1}{5} \cdot \frac{t^3}{3}$

At $t = 5$ s

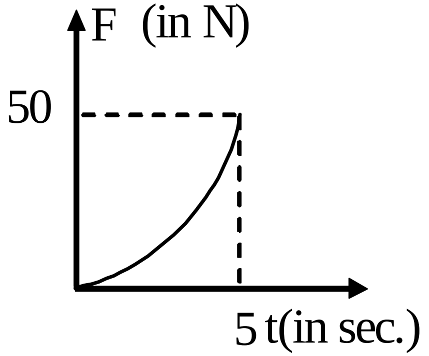
$v = \frac{1}{5} \times \frac{5^3}{3} = \frac{25}{3}$

$= 8.33$ m/s

$W = K_f - K_i$

P-Q502-Solution

Ans [B]



$t^2 = K \times F$; At t = 5 sec, F = 50 N

$\therefore \; 5^2 = K(50) \Rightarrow K = \dfrac{1}{2}$

Hence $t^2 = \dfrac{1}{2}F$ or $t^2 = \dfrac{1}{2}ma$

$F = ma$

Given function is Parabolic so

$y^2 = Kx$

From fig we put the values to find constant

$$\text{or } a = \frac{2t^2}{m} \text{ or } a = \frac{t^2}{5} \; [\because m = 10\text{kg}]$$

$$a = \frac{dv}{dt}$$

$$\text{or } \frac{dv}{dt} = \frac{t^2}{5} \text{ or } \int_0^v dv = \int_0^5 \frac{t^2}{5} dt \; \therefore \; v = 8.33 \text{ m/s}$$

PQ4Q274

A uniform chain of length 2 m is kept on a table such that a length of 60 cm hangs freely from the edge of the table. The total mass of the chain is 4 kg. What is the work done in pulling the entire chain on the table?

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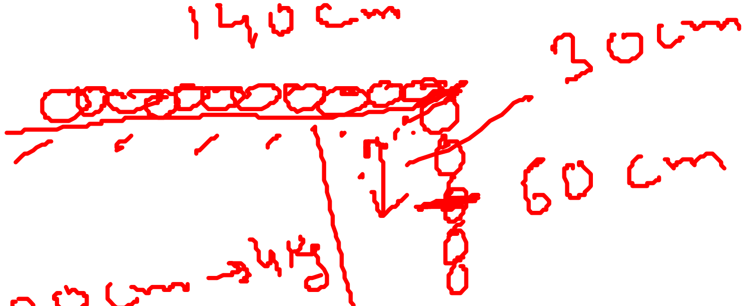
(A) 7.2 J

(B) 3.6 J

(C) 120 J

(D) 1200 J

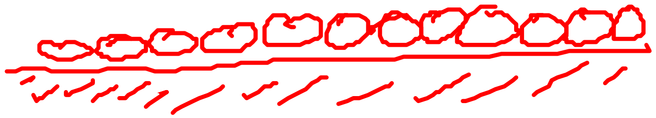


200 cm → 4 kg

1 cm → $\frac{4}{200}$

60 cm → $\frac{4}{200} \times 60$

= 1.2 kg



$W = mgh$

$= 1.2 \times 10 \times \frac{30}{100}$

$= 3.6$ J

PQ4S274

Ans [B]

The center of mass of the hanging part is at 0.3 m from table

Mass of hanging part $= \frac{4 \times 0.6}{2} = 1.2$ kg

$\therefore$ W = mgh

$= 1.2 \times 10 \times 0.3$

= 3.6 J

Mass per unit length of chain $= M/L = 4/2 = 2\,kg/m$

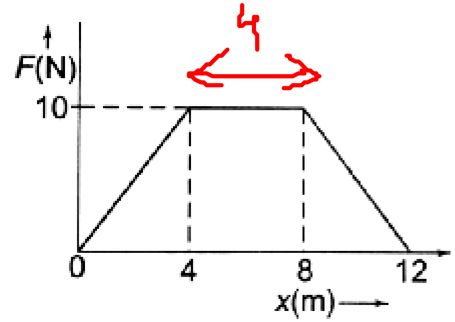
W= $F.x_{com} = mgh_{com}$

P-Q530

A particle of mass 0.1 Kg is subjected to a force which varies with distance as shown in figure. If starts its journey from rest at $x = 0$, its velocity at $x = 12\ m$ is

(a) zero (b) $20\sqrt{2}\ m/s$

(c) $20\sqrt{3}\ m/s$ (d) $40\ m/s$ ✓



$W = \text{Area} = K_f - K_i$

12

$\frac{1}{2}(12+4)\times 10 = \frac{1}{2}\times\frac{1}{10}v^2 - 0$

$160 = \frac{v^2}{10}$

$v^2 = 1600 \Rightarrow v = 40\ m/s$

P-Q530-Solution

Ans [D]

$Work\ done\ will\ be\ the\ area\ under\ the\ (F - x)\ graph$

$$= \frac{1}{2} \times 10 \times 4 + 10 \times 4 + \frac{1}{2} \times 10 \times 4 = 80\ J$$

$Now, work\ done = increase\ in\ kinetic\ energy\ . If\ v\ is\ the\ velocity$

$at\ x = 12\ m, then\ increase\ in\ K.E = \frac{1}{2}\ mv^2.$

$Therefore,$

$$\frac{1}{2}\ mv^2 = 80\ or\ v^2 = \frac{80 \times 2}{m} = \frac{80 \times 2}{0.1} = 1600$$

$$or \quad v = 40\ ms^{-1}$$

PQ4Q275

A force $\vec{F} = \left(5\hat{i} + 3\hat{j} + 2\hat{k}\right)$ is applied over a particle which displaces it from its origin to the point $\vec{r} = (2\hat{i} - \hat{j})$. The work done on the particle in joule is **AIEEE - 2004**

(A) –7 (B) +7

(C) +10 (D) +13

$W = \vec{F}\cdot\vec{r} = 10 - 3 + 0 = 7\ J$

PQ4S275

Ans [B]

$$\text{Work done} = \vec{F}\,.\,\vec{r}$$

or work done = $\left(5\hat{i} + 3\hat{j} + 2\hat{k}\right) . (2\hat{i} - \hat{j})$

or work done = 10 – 3 = 7 J

PQ4Q276

A body of mass m, accelerates uniformly from rest to v_1 in time t_1. The instantaneous power delivered to the body as a function of time t is **AIEEE - 2004**

(A) $\dfrac{mv_1 t}{t_1}$ (B) $\dfrac{mv_1^2 t}{t_1^2}$

(C) $\dfrac{mv_1 t^2}{t_1}$ (D) $\dfrac{mv_1^2 t}{t_1}$

$v = u + at$

$v_1 = 0 + at_1$

$a = \dfrac{v_1}{t_1}$

At time t

$v = u + at$

$= 0 + \dfrac{v_1}{t_1} t$

$P = F \cdot v$

$= ma \cdot v$

$= m \dfrac{v_1}{t_1} \cdot \dfrac{v_1}{t_1} \cdot t$

$= \dfrac{mv_1^2}{t_1^2} \cdot t$

PQ4S276

Ans [B]

Acceleration $a = \frac{v_1}{t_1}$

$\therefore$ velocity (v) $= 0 + at = \frac{v_1}{t_1} t$

$\therefore$ Power P $=$ Force $\times$ velocity $=$ mav

or $P = m\left(\frac{v_1}{t_1}\right) \times \left(\frac{v_1 t}{t_1}\right) = \frac{m v_1^2 t}{t_1^2}$

- Þ v=u+at
- Þ v1=0+at1
- Þ a=v1/t1

Power at any instance is = mav

P-Q529

If momentum is increased by 20% ,then kinetic energy increases by

(a) 44% (b) 55% (c) 66% (d) 77%

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

$K \propto p^2$

$K_f \propto p_f^2$

$\propto 1.44 p^2$

$K_f \propto 1.44 K$

$p_f = \left(1 + \frac{20}{100}\right) p$

$= 1.2 p$

$\% \text{ change} = \frac{K_f - K_i}{K_i} \times 100$

$= \frac{1.44K - K}{K} \times 100$

$= 44\%$

P-Q529-Solution

Ans [A]

$$Momentum\ p = mv\ or\ p^2 = m^2v^2\ or\ \frac{1}{2}\frac{p^2}{m} = \frac{1}{2}mv^2.$$

$Thus\ the\ kinetic\ energy\ is$

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

Think like this: we need to find K when P is given

So develop a relation between both

$If\ p\ increases\ by\ 20\%,\ the\ new\ momentum\ is\ p' = 1.2\ p.$

$$K' = \frac{(1.2)^2}{2m} = 1.44\ \frac{p^2}{2m} = 1.44\ K$$

The new Kinetic energy will be this

$$i.e, K\ increases\ by\ 0.44\ K. The\ percentage\ increase\ in\ K\ is\ \frac{0.44}{K}K \times 100 = 44\%$$

PQ4Q277

A spherical ball of mass 20 kg is stationary at the top of a hill of height 100 m. It rolls down a smooth surface to the ground, then climbs up another hill of height 30 m and finally rolls down to a horizontal base at a height of 20 m above the ground. The velocity attained by the ball is

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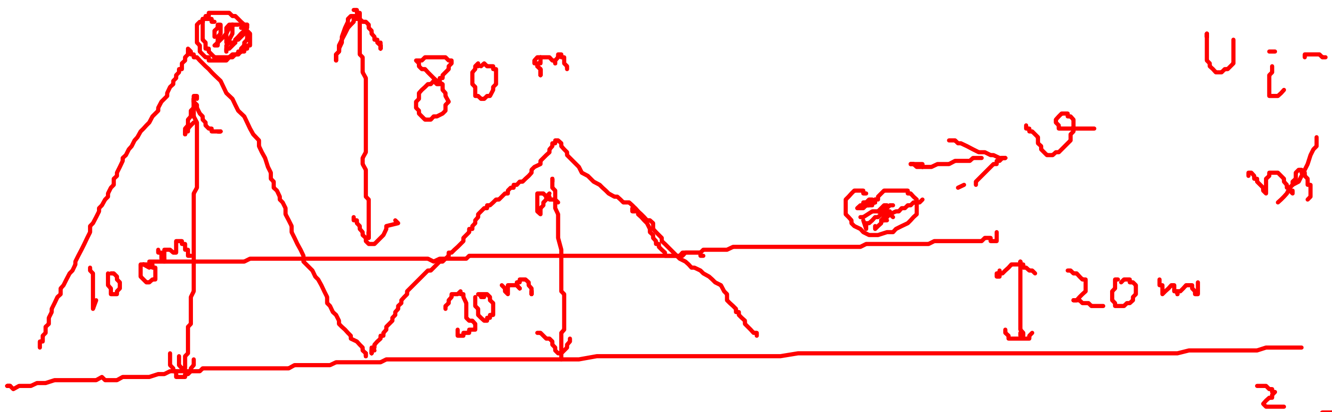
(A) 10 m/s (B) 34 m/s

(C) 40 m/s (D) 20 m/s



$U_i + K_i = U_f + K_f$

$U_i - U_f = K_f - K_i$

$mg \times 80 = \frac{1}{2} m v^2$

$v^2 = 1600$

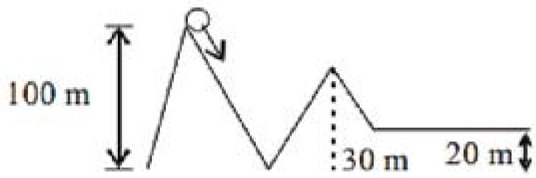
$v = 40$ m/s

PQ4S277

Ans [B]

- For the potential energy, only the difference between the initial and final points count.
So this difference is $100-20=80\ m$

$$mgh = \frac{1}{2} mv^2 \left(1 + \frac{k^2}{R^2}\right) = \frac{1}{2} mv^2 . \frac{7}{5}$$



$$\therefore \frac{1}{2} mv^2 \left(\frac{7}{5}\right) = mg \times 80$$

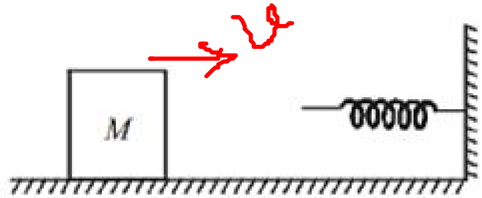
$$\text{or } v^2 = 2 \times 10 \times 80 \times \frac{5}{7} = 1600 \times \frac{5}{7}$$

- Conservation of energy:
$Mgh = \frac{1}{2}\ mv^2$

$$\text{or } v = 34 \text{ m/s}$$

PQ4Q278

The block of mass M moving on the frictionless Horizontal surface collides with the spring of spring Constant K and compresses it by length L. The maximum momentum of the block after collision is



AIEEE - 2005

(A) Zero

(B) $\frac{ML^2}{K}$

(C) $\sqrt{MK}\,L$

(D) $\frac{KL^2}{2M}$

PQ4S278

Ans [C]

Elastic energy stored in spring $= \frac{1}{2}\ KL^2$

$\therefore$ kinetic energy of block $E = \frac{1}{2}\ KL^2$

Since $p^2 = 2ME$

$$\therefore\ p = \sqrt{2ME} = \sqrt{\frac{2M \times KL^2}{2}}$$

$$= \sqrt{MK}\ .L$$

●when conservative forces act on system only,
Machenical energy is conserved,i.e
K.E+P.E=constant
$\Delta u + \Delta k = 0$

●$p = \sqrt{2M(K.E)}$.

P-Q506

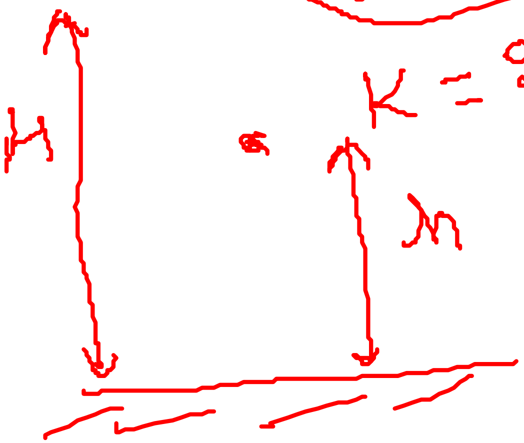
A particle is released from a height **H**. At certain height its kinetic energy is two times its potential energy. Height and speed of particle at that instant are

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



P-Q506-Solution

Ans [B]

Conservation of energy

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

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

Point at KE is 2PE

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

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