



Mahendra Singh ✓

Expert in NEET UG

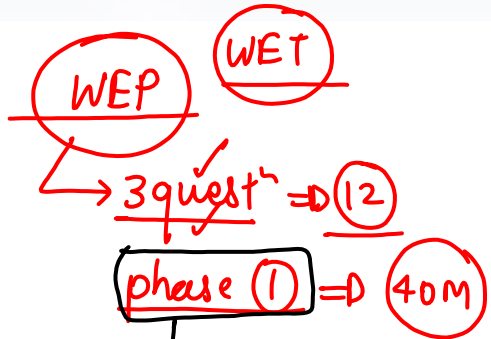
B.tech Gold Medalist, Awarded with Teaching Excellence by Unacademy. Produced AIR 49 in JEE Advanced, Got AIR 368 in GATE 2016 & AIR 192 in

23M Watch mins

892K Watch mins (last 30 days)

67K Followers

4K Dedications



"MSLIVE"

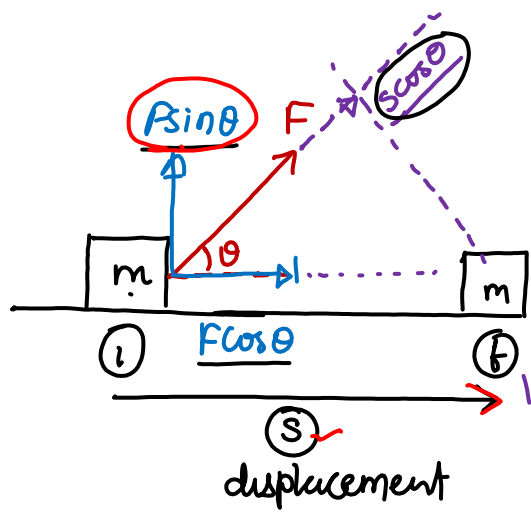
"9PM" WEP Practice Session

Sat. 6 30

→ Revision

Work, Energy and Power





$$W = (F \cos \theta) \times s$$

$$W = F (s \cos \theta)$$

constant Force $\downarrow$ displacement along $(\vec{F})$

θ angle b/w $\vec{F}$ and $\vec{s}$

Work

$$W = \vec{F} \cdot \vec{s}$$

$$\otimes W = F s \cos \theta$$

$$\rightarrow \theta = 0; \cos \theta = 1$$

$$W = F s (\text{max})$$

$$\rightarrow \theta = 90, \cos \theta = 0$$

$$W = 0$$

$$\rightarrow \theta = 180, \cos \theta = -1$$

$$W = -F s (\text{min})$$

$$\otimes W \begin{cases} +ve \\ 0 \\ -ve \end{cases}$$

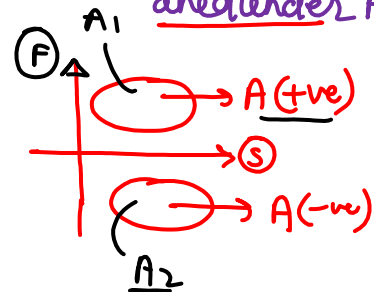
Work done by variable force -

$$\rightarrow dw = F ds$$

$$\int dw = \int F ds$$

$$W = \int F ds$$

area under F v/s s



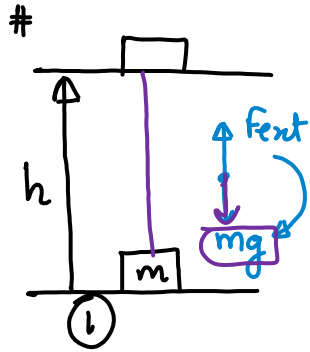
$$W = A_1 - A_2$$

Work



Work done by force of Gravity

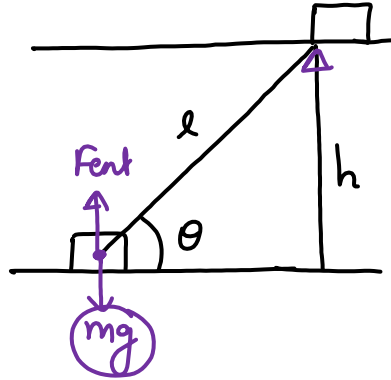
constant force
 $\text{mag} = mg = \text{const}$
 $\text{direct} = \downarrow = \text{const}$



$$\# W_{\text{ext}} = F_{\text{ext}} \cdot h$$

$$= \underline{mg(h)}$$

$$\underline{W_{mg} = -mgh.}$$



$$\# \underline{W_{\text{ext}} = mgh}$$

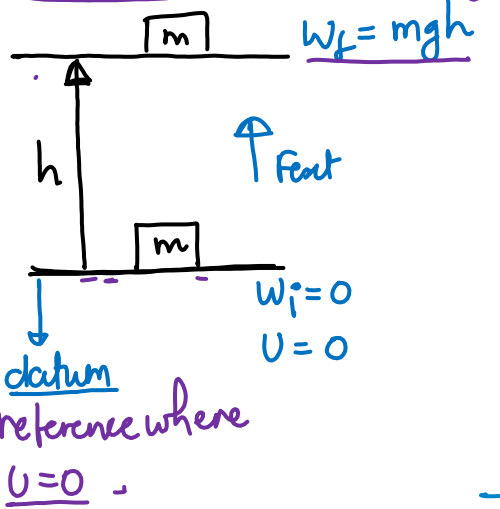
$$\underline{W_{mg} = -mgh}$$

W_{mg} (a) Work done against mg is path independent

Conservative Force

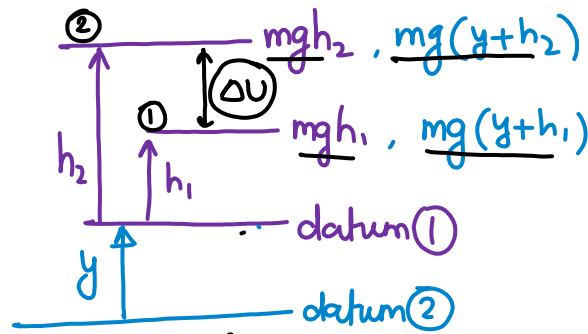


$$U = mgh$$



Potential Energy $\Rightarrow$ energy due change in configuratⁿ

PE is datum dependent



$$\Delta U = mg(h_2 - h_1)$$

$\Downarrow$
change in PE
 $\Downarrow$
datum independent

Relatⁿ b/w U and F_c

$$F_c = - \frac{dU}{dx}$$

$$W_{mg} = -mgh$$

$$dU = (dW) = -F_c dx$$

PE is defined only for conservative forces:

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

- (a) 8 J (b) 11 J (c) 5 J (d) 2 J

(NEET-II 2016)

$$\begin{aligned}\Delta \vec{r} &= \vec{r}_f - \vec{r}_i \\ &= (4\hat{j} + 3\hat{k}) - (-2\hat{i} + 5\hat{j}) \\ &= (2\hat{i} - \hat{j} + 3\hat{k})\end{aligned}$$

$$\begin{aligned}W &= \vec{F} \cdot \Delta \vec{r} \\ &= (4\hat{i} + 3\hat{j}) \cdot (2\hat{i} - \hat{j} + 3\hat{k}) \\ &= 8 - 3 \\ &= \underline{\underline{5}}\end{aligned}$$

$$\checkmark \vec{r}_i = -2\hat{i} + 5\hat{j}$$

$$\checkmark \vec{r}_f = 4\hat{j} + 3\hat{k}$$

$$\vec{F} = 4\hat{i} + 3\hat{j}$$

A particle moved from $(0, 1, 3) \rightarrow (2, 1, -1)$
 $\textcircled{1} \quad \quad \quad \textcircled{4}$

$$(2-0)\hat{i} + (1-1)\hat{j} + (-1-3)\hat{k}$$

$$\underline{\underline{\Delta \vec{r} = 2\hat{i} + 0\hat{j} - 4\hat{k} \checkmark}}$$

Example

MCQ type Question [+4 , -1]

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

(a) 13 J

HW

(b) 15 J

(c) 9 J

(d) 6 J

(NEET 2013)

Example

MCQ type Question [+4 , -1]

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

- (a) 60° (b) 75° (c) 30° (d) 45° (1997)

$$W = FS \cos \theta$$

$$25 = 5(10) \cos \theta$$

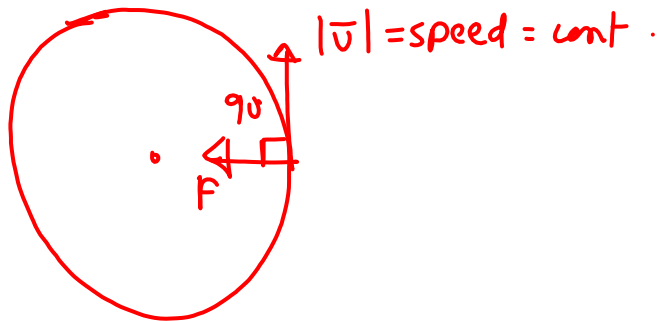
$$\frac{25}{50} = \cos \theta$$

$$\cos \theta = \frac{1}{2} = \cos 60^\circ$$

When a body moves with a constant speed along a circle

- (a) ~~no work~~ is done on it
- (b) no acceleration is produced in it $\times$
- (c) its velocity remains constant $\times$
- (d) no force acts on it. $\times$

(1994)



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 $y = 1$ m is
 (a) 20 J (b) 30 J (c) 5 J (d) 25 J

(NEET 2019)

$$F = 20 + 10y$$

$F = f(y)$

Variable.

$$\begin{aligned}
 W &= \int F \, dy \\
 &= \int_0^1 (20 + 10y) \, dy \\
 &= 20y \Big|_0^1 + 10 \frac{y^2}{2} \Big|_0^1 \\
 &= 20(1-0) + 5(1^2 - 0^2) \\
 &= 20 + 5 \\
 &= 25 \text{ J}
 \end{aligned}$$

hellophysics

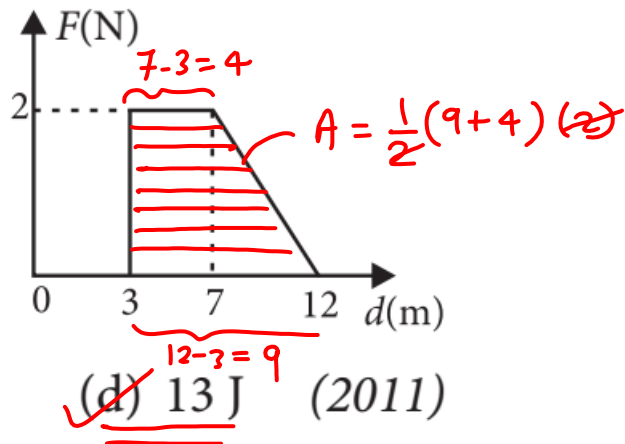
✓ t.me/unacademyhellophysics

Example

MCQ type Question [+4 , -1]

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

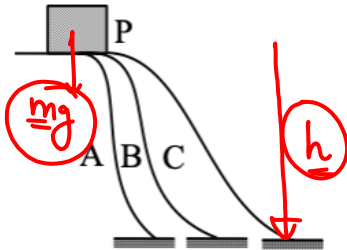
- (a) 18 J (b) 21 J (c) 26 J





Example

A greased block P may slide along any of the three frictionless slopes A, B, or C, to reach the ground. The work done on the block by the block's weight Mg, are W_A , W_B , and W_C for the three slopes respectively. Then-



(A) $W_A < W_B < W_C$

(B) $W_A > W_B > W_C$

☒ (C) $W_A = W_B = W_C$

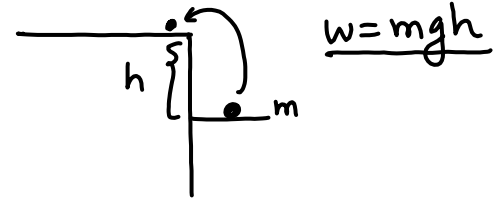
(D) None of the above



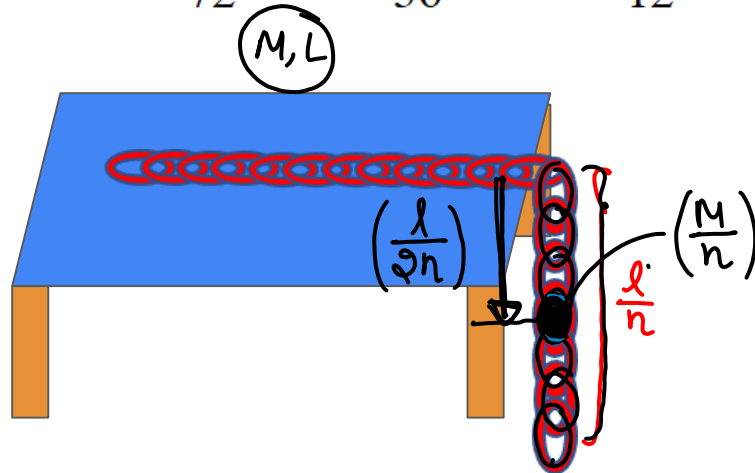
Example

$$\frac{l}{6} = \frac{l}{n} \Rightarrow n = 6$$

A uniform chain has a mass m and length l . It is held on a frictionless table with one sixth of its length hanging over the edge. The work done is just pulling the hanging part back on the table is -



- (A) $mg \frac{l}{72}$ (B) $\frac{mg l}{36}$ (C) $\frac{mg l}{12}$ (D) $\frac{mg l}{6}$



$$W = \left(\frac{M}{n} \right) g \left(\frac{l}{2n} \right)$$
$$= \frac{Mg l}{2n^2}$$
$$\underline{n = 6}$$



Example

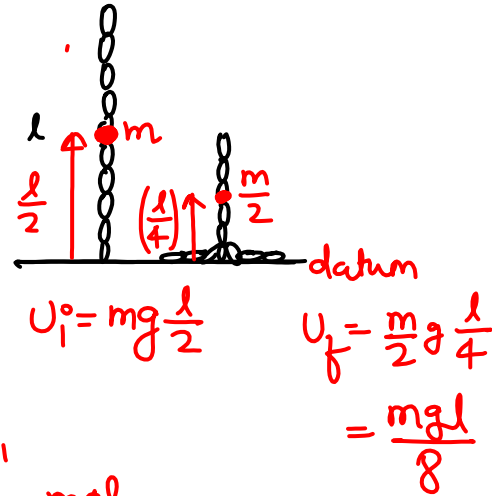
A man places a chain (of mass ' m ' and length ' ℓ ') on a table slowly. Initially the lower end of the chain just touches the table. The man drops the chain when half of the chain is in vertical position. Then work done by the man in this process is :

(A) $-mg \frac{\ell}{2}$

(B) $-\frac{mg\ell}{4}$

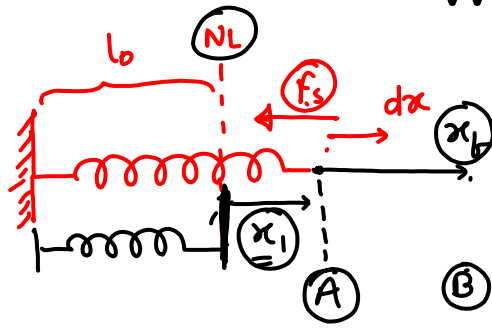
(C) $-3 \frac{mg\ell}{8}$

(D) $-\frac{mg\ell}{8}$



$$\begin{aligned} W &= U_f - U_i \\ &= \frac{mg\ell}{8} - \frac{mg\ell}{2} \\ &= \frac{mg\ell - 4mg\ell}{8} \\ &= \underline{\underline{-3 \frac{mg\ell}{8}}} \end{aligned}$$

Work done by Spring Force



$$\underline{F_s = -kx}$$

W against $F_s = \frac{1}{2}kx^2$
 $\Downarrow$
 store in spring as
 elastic potential energy

$$W_s = \int F_s dx = -\frac{1}{2}k[x_f^2 - x_i^2]$$

$$\begin{aligned} &= \int -kx dx \\ &= -k \cdot \frac{x^2}{2} \Big|_{x_i}^{x_f} \\ &= -\frac{1}{2}kx^2 \Big|_{x_i}^{x_f} \end{aligned}$$

(or) ✓

$$\boxed{W_s = \frac{1}{2}k(x_i^2 - x_f^2)}$$

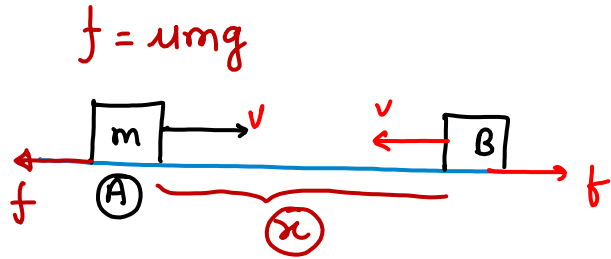
$$\underline{x_i = 0, x_f = x}$$

$$\underline{W_s = -\frac{1}{2}kx^2}$$

$\boxed{U = \frac{1}{2}kx^2}$ *

depends on x_i and x_f
 not on the path
 $F_s \rightarrow$ conservative

Work done by Friction



$$W_{AB} = -\mu mg x$$

$$W_{BA} = -\mu mg x$$

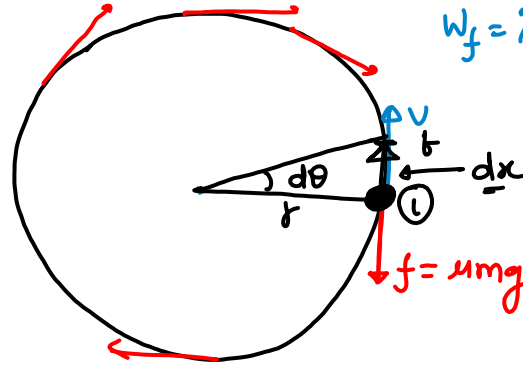
round trip
(A $\rightarrow$ B $\rightarrow$ A)

$$W = -\mu mg x - \mu mg x = -2\mu mg x \neq 0$$

$\neq$ non conservative force

conservative force, w during round trip $= 0$

(eg)

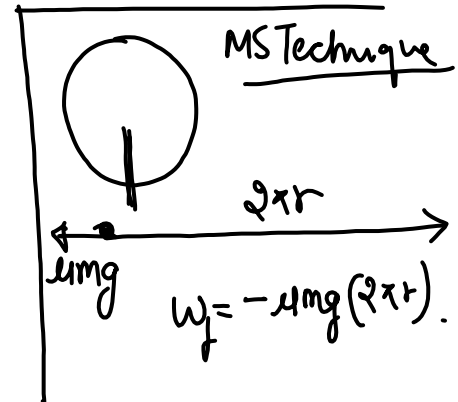


$w_f = ?$ in making circle

$f = \mu mg$ (always)
(tangential)

magn_i = const
directⁿ $\neq$ const

$$\begin{aligned} W_f &= \int -f \, dx \\ &= \int -\mu mg \, dx \\ &= -\mu mg \int_0^{2\pi r} dx \\ &= -\mu mg (2\pi r) \end{aligned}$$



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

- (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) $W_P = W_Q$; $W_P = W_Q$

(2015 Cancelled)

$$W_s = \frac{1}{2} K x^2 \quad \frac{K}{K} = \frac{F^2}{2K}$$

Case a

$$x = \text{const}$$

$$W_s \propto K$$

$$K_P > K_Q$$

$$\underline{W_P > W_Q}$$

Case b

$$F = \text{const}$$

$$W_s \propto \frac{1}{K}$$

$$K_P > K_Q$$

$$\underline{W_P < W_Q}$$

Example

MCQ type Question [+4 , -1]

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 unstretched. The maximum extension produced in the length of the spring will be

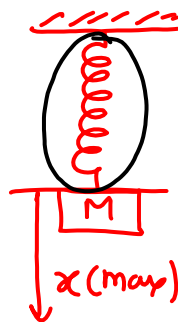
☒ (a) $2Mg/k$

(b) $4Mg/k$

(c) $Mg/2k$

☒ (d) Mg/k

(2009)



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

$$x = \frac{2Mg}{k}$$

Example

MCQ type Question [+4 , -1]

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

- (a) $U/4$ (b) $4U$
(c) $8U$ (d) $16U$

(2006)

$$\frac{U}{U'} = \left(\frac{2}{8}\right)^2 = \frac{1}{16}$$

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

$$U \propto x^2$$

Kinetic Energy $\Rightarrow$ energy possessed by body due to its motion



$$p = mv$$



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

scalar quantity -

$$\underline{\vec{v} \cdot \vec{v} = v^2}$$

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

$$KE = \frac{1}{2} \frac{p^2}{m}$$

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

②

$$p = \sqrt{2mKE}$$

Example

MCQ type Question [+4 , -1]

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

$p = \text{same}$

(a) $E_1 < E_2$ (b) $\frac{E_1}{E_2} = \frac{m_1}{m_2}$

(c) $E_1 > E_2$ (d) $E_1 = E_2$ (2004)

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

$$E \propto \frac{1}{m}$$

$$\underline{E_1 < E_2}$$

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

- (a) $4 : 1$ (b) $1 : 1$ (c) $1 : 2$ (d) $1 : 4$. (1999)

Two bodies of masses m and $4m$ are moving with equal kinetic energies. The ratio of their linear momenta is $E_1 = E_2$, $p^2 \propto m$

- (a) $1 : 2$ (b) $1 : 4$ (c) $4 : 1$ (d) $1 : 1$.

$p \propto \sqrt{m}$. (1998, 1997, 1989)

$$p = \text{const.}$$

$$\frac{E_1}{E_2} = \left(\frac{4}{1} \right)$$

$$E \propto \frac{1}{m}$$

Example

MCQ type Question [+4 , -1]

A ball of mass 2 kg and another of mass 4 kg 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

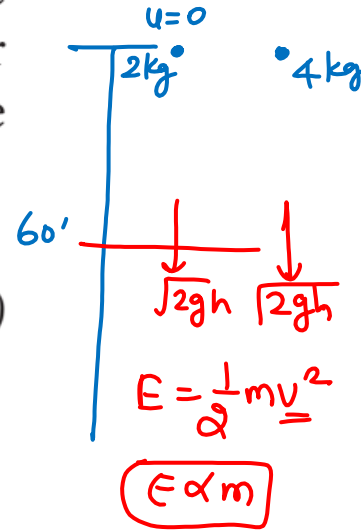
(a) $\sqrt{2} : 1$

(b) $1 : 4$

(c) $1 : 2$

(d) $1 : \sqrt{2}$

(2004)



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

- (a) 100%
(c) 265%

- (b) 150%
(d) 73.2%.

(2002)

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

$$4E = \frac{p'^2}{2m}$$

$$E_f = \underline{300\% \uparrow} E_i + E_i$$

$$E_f = \underline{4E}$$

$$\begin{aligned} p' &= \sqrt{2mE} \quad (2) \\ p &= \sqrt{2mE} \quad (1) \end{aligned}$$

$$\begin{aligned} &= (2-1) \times 100 \\ &= 100\% \end{aligned}$$

$$\begin{aligned} P_i &= P, \quad E_i = E = \frac{p^2}{2m} \\ P_f &\rightarrow \uparrow 50\%, \quad P_f = P + \left(\frac{P}{2}\right) \\ &= \left(\frac{3P}{2}\right) \end{aligned}$$

$$\% E = ?$$

$$E_f = \frac{(3/2P)^2}{2m} = \left(\frac{p^2}{2m}\right) \left(\frac{9}{4}\right)$$

$$\begin{aligned} \% E &= \left(\frac{9}{4} - 1\right) \times 100 \\ &= \frac{5}{4} \times 100 \\ &= 125\% \end{aligned}$$

Example

MCQ type Question [+4 , -1]

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

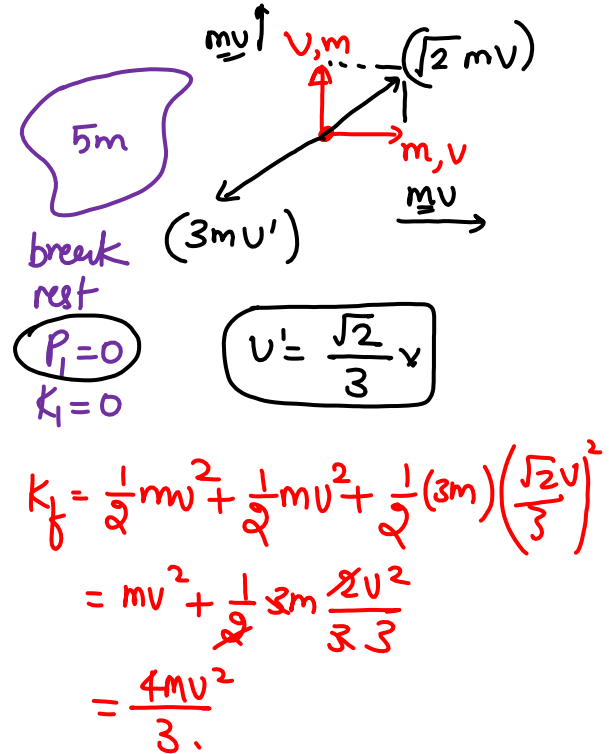
(a) $\frac{3}{5}mv^2$

(b) $\frac{5}{3}mv^2$

(c) $\frac{3}{2}mv^2$

✓ (d) $\frac{4}{3}mv^2$

= (Odisha NEET 2019)



Example

MCQ type Question [+4 , -1]

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?

- (a) mv^3 (b) $\frac{1}{2}mv^2$ $m = \left(\frac{M}{l}\right)$
 (c) $\frac{1}{2}m^2v^2$ (d) $\frac{1}{2}mv^3$

(2009) $\left(\frac{m}{l}\right)$

$$\frac{dm}{dt} = \text{rate of mass flowing/sec} - \left(\frac{1}{2}mv^2\right)$$

$$m = \frac{M}{l}$$

$$\frac{M}{\text{sec}} = \frac{m \cdot l}{\text{sec}} = mv$$

$$= \frac{1}{2}mv \cdot v^2$$

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

$$\left(\frac{m}{l}\right) = \left(\frac{m}{l}\right) \times \left(\frac{l}{t}\right)$$

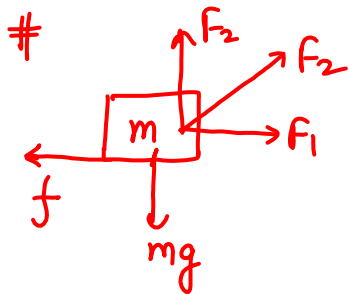
need

$$\left(\frac{dm}{dt}\right) = \dot{m} = \rho A v$$

velocity

$$(\dot{m} \propto v)$$

Work Energy Theorem



$$W_{\text{all}} = \Delta KE = K_f - K_i$$



$$W_{\text{ext}} + W_c + W_{nc} + \underbrace{W_{\text{other}}}_0 = K_f - K_i$$

$$W_c = -\Delta U$$

##

$$W_{\text{ext}} + W_{nc} = \Delta KE + \Delta U$$

#

$$W_{nc} = 0$$

no non conservative

$$W_{\text{ext}} = \Delta KE + \Delta U$$

$$F_{\text{ext}} = 0$$

$$W_{\text{ext}} = 0$$

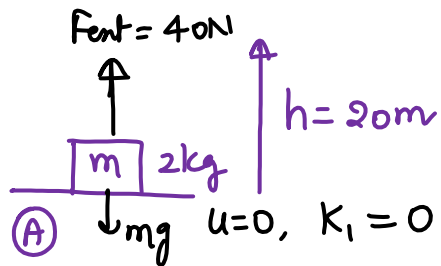
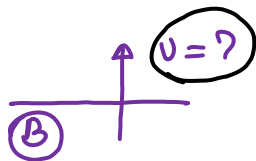
$$0 = \Delta KE + \Delta U$$

$$0 = K_f - K_i + U_f - U_i$$

$$K_i + U_i = K_f + U_f$$

Energy conservation

Work Energy Theorem



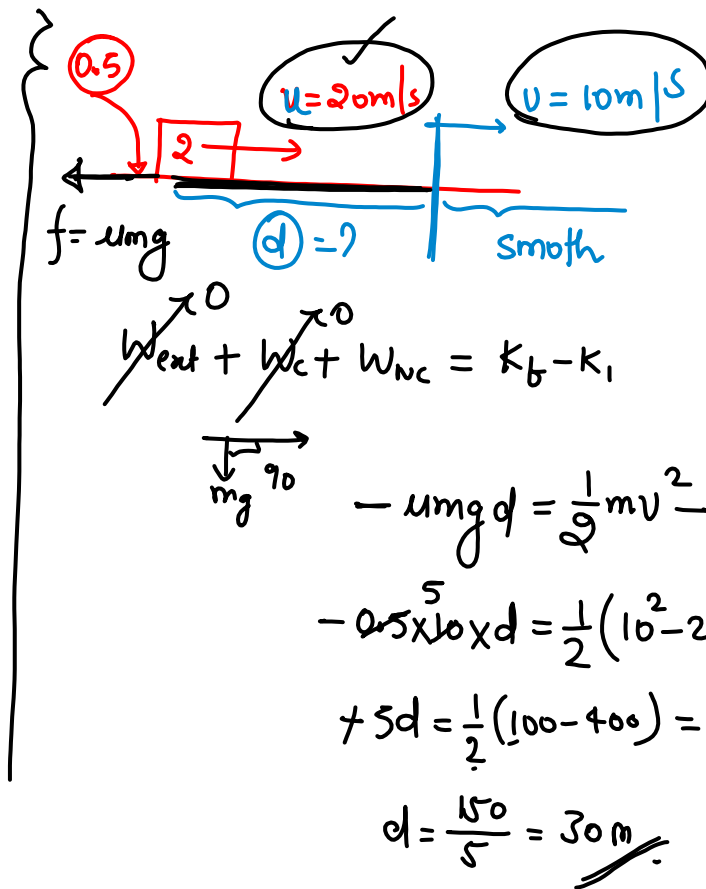
$$W_{ext} + W_c = K_f - K_i$$

$$40 \times (20) - (2 \times 10)(20) = \frac{1}{2}mv^2 - 0$$

$$800 - 400 = \frac{1}{2}(2)v^2$$

$$400 = v^2$$

$$v = 20 \text{ m/s}$$



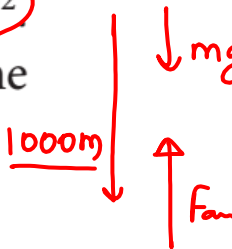
Example

MCQ type Question [+4 , -1]

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 50 m s^{-1} . Take g constant with a value 10 m s^{-2} . The work done by the (i) gravitational force and the (ii) resistive force of air is

- | | |
|-----------------------------------|--------------------------------|
| (a) ~~X~~ (i) 1.25 J | (ii) -8.25 J |
| (b) ~~X~~ (i) 100 J | (ii) 8.75 J |
| ~~(c)~~ (i) <u>10 J</u> | ~~(ii)~~ <u>-8.75 J</u> |
| (d) ~~X~~ (i) <u>-10 J</u> | (ii) -8.25 J |

(NEET 2017)

$m = 1 \text{ g} = \frac{1}{1000} \text{ kg} = 10^{-3} \text{ kg}$
 $w_{mg} = 10^{-3} \times 10 \times 10 = \underline{10 \text{ J}}$


$$\begin{aligned}
 w_{mg} + w_f &= KE_f - KE_i \\
 10 + w_f &= \frac{1}{2} (10^{-3}) 50^2 - 0 \\
 10 + w_f &= \frac{1}{2} \times 10^{-3} \times 2500 \\
 &= \frac{25}{2} = 12.5 \\
 w_f &= \underline{12.5 - 10}
 \end{aligned}$$

A body of mass 3 kg 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

$$W = \Delta KE = \frac{8}{3} - 0$$

- (a) $\frac{19}{5}$ J (b) $\frac{5}{19}$ J (c) $\frac{3}{8}$ J ☒ (d) $\frac{8}{3}$ J (2006)

$$s = \frac{1}{3}t^2$$

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

$$t = 0$$

$$v = 0$$

$$K_i = 0$$

$$t = 2$$

$$v = \frac{4}{3} \text{ m/s}$$

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

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

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

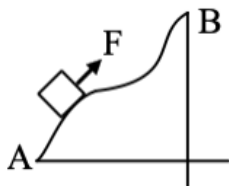


Example

HW

A body of mass m was slowly pulled by a force which at each point was directed along a tangent to the path. The work done by the applied force

9pm



- (A) does not depend upon path
- (B) depends upon path
- (C) does not depend upon positions of A and B
- (D) both (A) and (C) are correct.



HW

9pm

Example

A boy is sliding down a long icy hill on his sled. In order to decrease his mass and increase his velocity, he drops his heavy winter coat and heavy boots from the sled while he is moving. Will his strategy work ?

- (A) No because he loses the potential energy of the objects that he leaves behind
- (B) No because although his kinetic energy increases, his momentum decreases
- (C) Yes because although his kinetic energy decreases, his momentum increases
- (D) Yes because although momentum decreases, his kinetic energy decreases

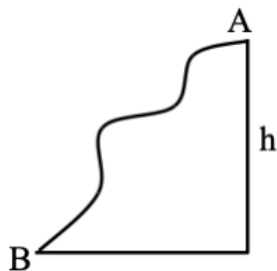




Example

HW

When an object is allowed to slide down a hill it stops at the point B because of friction. If friction force depends only on the normal component of the reaction force with coefficient of friction variable along the path, the work done in taking the object slowly from B to A along the hill will be



(A) mgh

(B) $2 mgh$

(C) $> 2 mgh$

(D) $< mgh$

Example

MCQ type Question [+4 , -1]

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? ($g = 10 \text{ m/s}^2$)

- (a) 30 J (b) 40 J (c) 10 J (d) 20 J

HW

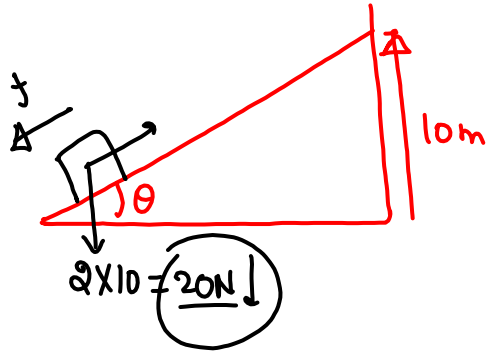
(2009)

Example

MCQ type Question [+4 , -1]

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

- (a) 1000 J (b) 200 J
 (c) 100 J (d) zero. (2006)



$$W_g = 2 \times 10 = \underline{\underline{200 \text{ J}}}$$

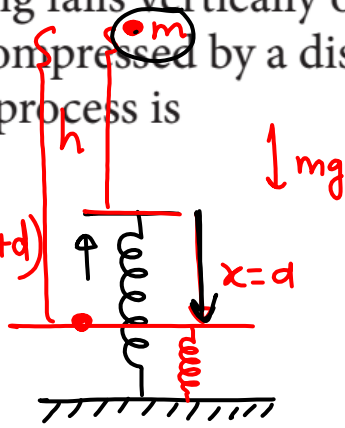
A vertical spring with force constant k is fixed on a table. A ball of mass m at a height h above the free upper end of the spring falls vertically on the spring so that the spring is compressed by a distance d . The net work done in the process is

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



$$W_{mg} = mg(d+h)$$

$$W_s = -\frac{1}{2}kd^2$$

(2007)

Example

MCQ type Question [+4 , -1]

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

- (a) $U(x) < E$ (b) $U(x) = 0$
(c) $U(x) \leq E$ (d) $U(x) > E$

(Karnataka NEET 2013)

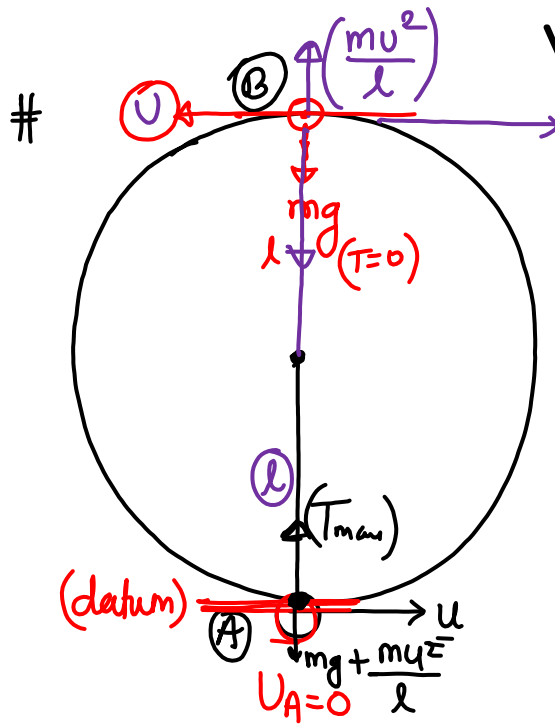
HW

$$E = U + K$$

$\downarrow$
 $U > 0$



Vertical Circular Motion



FBD

$$\frac{mv^2}{l} = mg + T \rightarrow 0$$

$u \rightarrow u_{min}$

$$u_{min} = \sqrt{gl}$$

$$T_{max} = \frac{mv^2}{l} + mg = \underline{\underline{6mg}}$$

$u = ?$ for looping the loop.
(min)

Energy conservation b/w (A) and (B)

$$U_A + K_A = U_B + K_B$$

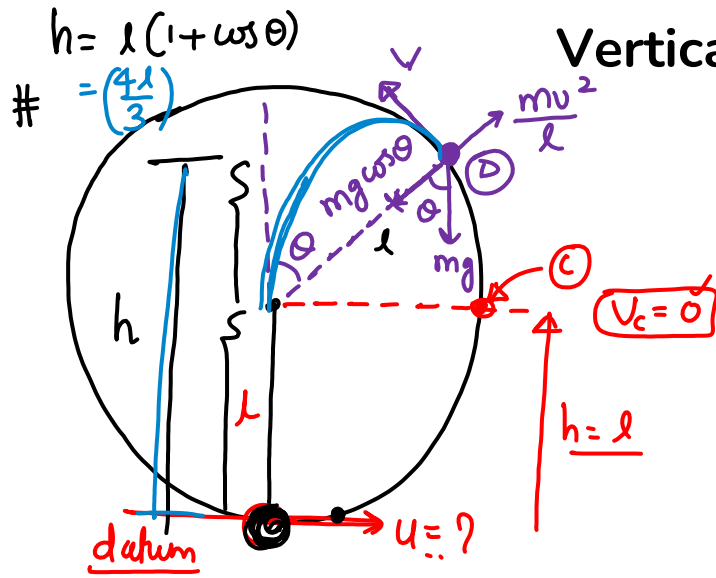
$$0 + \frac{1}{2}mv^2 = 2mgl + \frac{1}{2}m(\sqrt{u})^2$$

$$\times \frac{2}{m} \quad u^2 = 4gl + gl$$

$$u_{min} = \sqrt{5gl}$$



Vertical Circular Motion



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

$$u = \sqrt{2gl}$$

$u \leq \sqrt{2gl}$
pendulum, oscillate

what if $u > \sqrt{2gl}$ but $u < \sqrt{3gl}$

say $u = \sqrt{3gl}$

at point D

$$\frac{mv^2}{l} = mg \cos\theta + \text{?}$$

$$v^2 = gl \cos\theta$$

b'z string become slack

(A) and (D)

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

$$\frac{1}{2}m(\sqrt{3gl})^2 = mgl(1 + \cos\theta) + \frac{1}{2}mgl \cos\theta$$

$\times \frac{2}{m}$

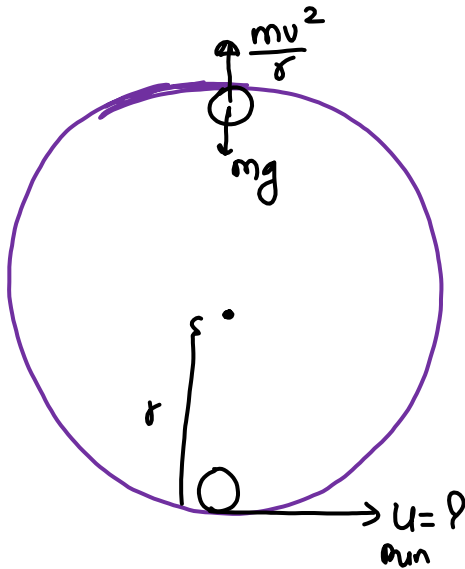
$$3gl - 2gl = 3gl \cos\theta$$

$$\cos\theta = \frac{1}{3} \checkmark$$



Vertical Circular Motion

#



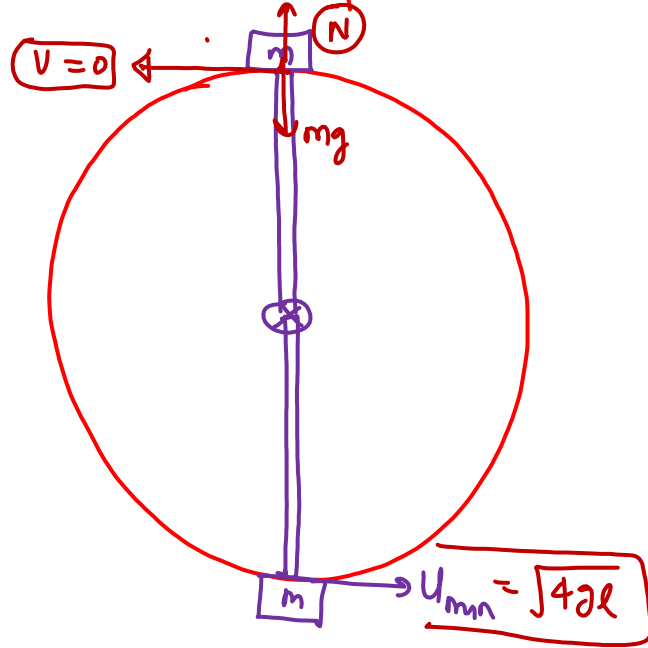
$$v_{\text{min}} = \sqrt{gR}$$

$$u_{\text{min}} = \sqrt{5gR}$$

Vertical Circular Motion



Rod + Block system.



Vertical Circular Motion



Example

MCQ type Question [+4 , -1]

What is the minimum velocity with which a body of mass m must enter a vertical loop of radius R so that it can complete the loop?

(a) $\sqrt{3gR}$

(b) $\sqrt{5gR}$

(c) $\sqrt{gR}$

(d) $\sqrt{2gR}$ (NEET-I 2016)

Example

MCQ type Question [+4 , -1]

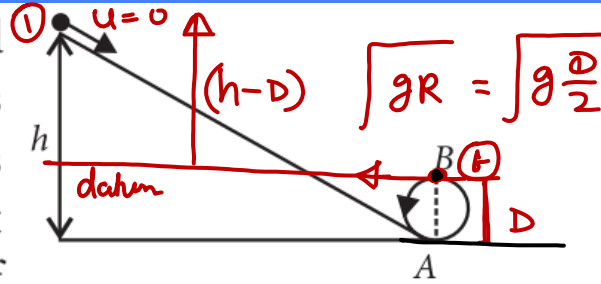
A mass m is attached to a thin wire and whirled in a vertical circle. The wire is most likely to break when

- (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~~ (NEET 2019)

Example

MCQ type Question [+4 , -1]

A body initially at rest and sliding 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



$$mgh = \frac{mgD}{4} + mgD$$

$$mgh = \frac{5mgD}{4}$$

$$h = \frac{5D}{4}$$

- (a) $\frac{3}{2}D$ (b) D (c) $\frac{7}{5}D$ (d) $\frac{5}{4}D$

(NEET 2018)

loss in GPE = gain in KE

$$mg(h-D) = \frac{1}{2}m\left(\sqrt{\frac{gD}{2}}\right)^2$$

$$mgh - mgD = \frac{1}{2}m\frac{gD}{2}$$

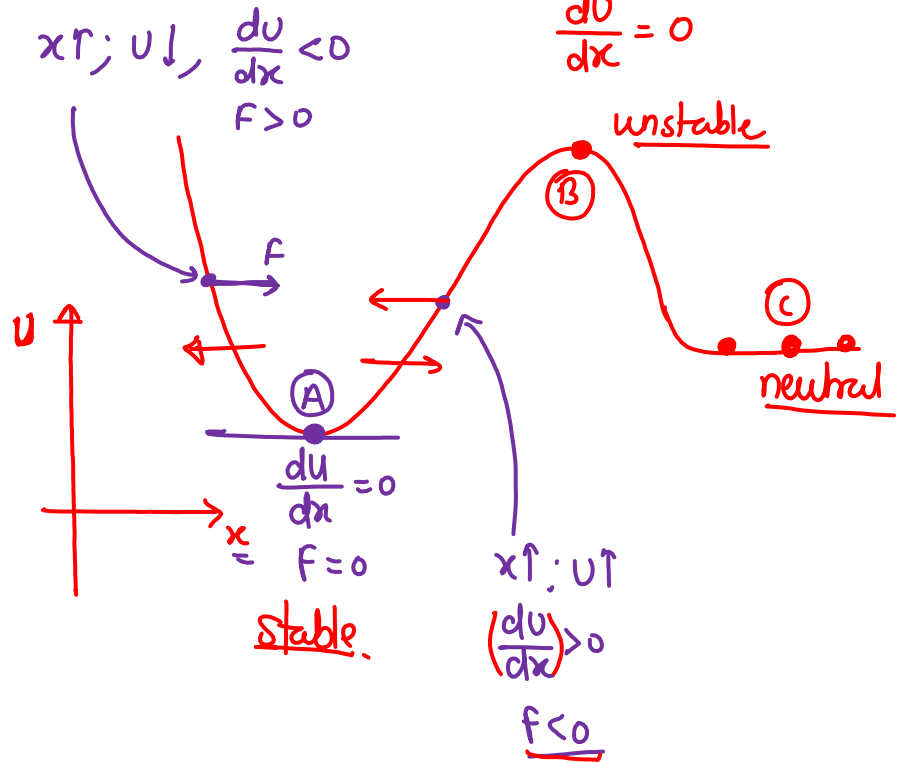


$$F = -\left(\frac{dU}{dx}\right)$$

Equilibrium of Particle

$$F_c = 0$$

$$\frac{dU}{dx} = 0$$



Equilibrium of Particle



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 the particle from the centre of the field. For stable equilibrium, the distance of the particle is

- (a) $\frac{B}{2A}$ (b) $\frac{2A}{B}$ (c) $\frac{A}{B}$ (d) $\frac{B}{A}$ (2012)

$$\begin{aligned}\frac{dU}{dr} &= 0 = \frac{d}{dr} \left(\frac{A}{r^2} - \frac{B}{r} \right) \\ &= A(-2)r^{-3} - B(-1)r^{-2} \\ 0 &= -\frac{2A}{r^3} + \frac{B}{r^2}\end{aligned}$$

$$\begin{aligned}\frac{2A}{r^3} &= \frac{B}{r^2} \\ r &= \frac{2A}{B}\end{aligned}$$



The potential energy of a system increases if work is done

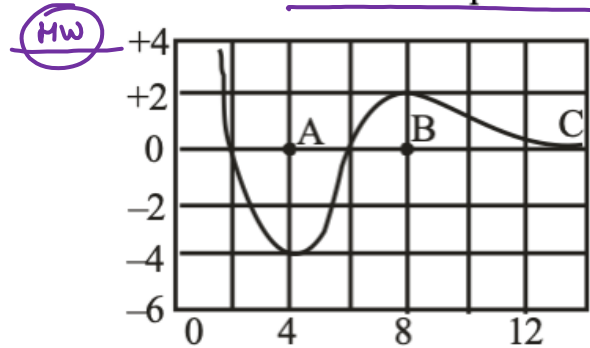
- (a) upon the system by a nonconservative force
- (b) by the system against a conservative force
- (c) by the system against a nonconservative force
- (d) upon the system by a conservative force. (2011)

HW 9PM



Example

For the potential energy function shown in fig.
there will be an unstable equilibrium at position



- (A) A
- (B) B
- (C) C
- (D) none of the above



Example

$F = 2x^2 - 3x - 2$. Choose correct option-

- (A) $x = -1/2$ is position of stable equilibrium
- (B) $x = 2$ is position of stable equilibrium
- (C) $x = -1/2$ is position of unstable equilibrium
- (D) $x = 2$ is position of neutral equilibrium

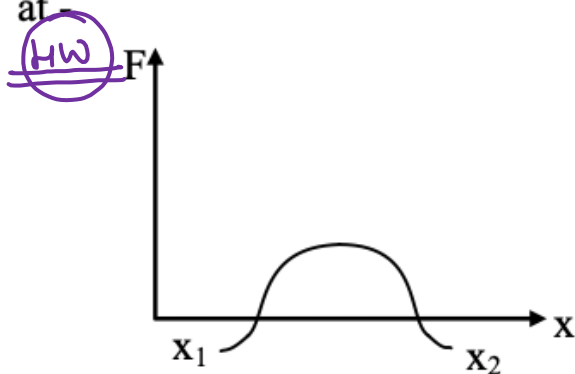

$$F = -\frac{dw}{dx}$$

$$\frac{dw}{dx}$$

Example

MCQ type Question [+4 , -1]

The force acting on a body moving along x-axis varies with the position of the particle as shown in the figure. The body is in stable equilibrium at



- (A) $x = x_1$ (B) $x = x_2$
(C) Both x_1 and x_2 (D) Neither x_1 nor x_2



Power



rate of doing work

$$P = \frac{dE}{dt}$$

$$P = \frac{dw}{dt} = \frac{F dx}{dt}$$

$$P = F v$$

or

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

Example

MCQ type Question [+4 , -1]

One coolie takes 1 minute to raise a suitcase through a height of 2 m but the second coolie takes 30 s to raise the same suitcase to the same height. The powers of two coolies are in the ratio

- (a) 1 : 3 (b) 2 : 1 (c) 3 : 1 ✓ (d) 1 : 2

$$\frac{p_1}{p_2} = \frac{t_2}{t_1} = \frac{30}{60} \quad (\text{Karnataka NEET 2013})$$

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

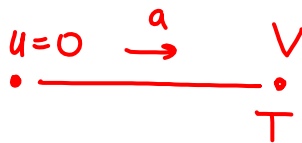
$$P_{avg} = \frac{0 + P_{ir}}{2} = \frac{1}{2} \frac{MV^2}{T}$$

(a) $\frac{MV^2}{T} = \underline{\underline{P_{ins}}}$

(b) $\frac{1}{2} \frac{MV^2}{T^2}$

(c) $\frac{MV^2}{T^2}$

(d) $\frac{1}{2} \frac{MV^2}{T} = P_{avg}$
(Mains 2010)



$$a = \frac{V}{T}$$

$$F = ma = M \cdot \frac{V}{T}$$

$$P = FV = \frac{MV}{T} V$$



Example

Power supplied to a particle of mass 2 kg varies

with time as $P = \frac{3t^2}{2}$ watt. Here t is in second and velocity of particle at $t = 0$ is $v = 0$. The velocity of particle at time $t = 2$ s will be-

(A) 1 m/s

(B) 4 m/s

(C) 2 m/s

(D) $2\sqrt{2}$ m/s

$$\checkmark P = \frac{dw}{dt} = \frac{3t^2}{2}$$

$$\int dw = \int \frac{3t^2}{2} dt$$

$$\checkmark W = K_f - K_i = \left. \frac{3}{2} \frac{t^3}{3} \right|_0^2$$

$$\cancel{\frac{1}{2}} m v^2 - 0 = \cancel{\frac{1}{2}} 2^3$$

$$\cancel{v}^2 = \cancel{2}^2$$

$$v = \underline{2 \text{ m/s}}$$



Example

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

HW

(A) $\frac{mv_1 t}{t_1}$

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

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

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



Example

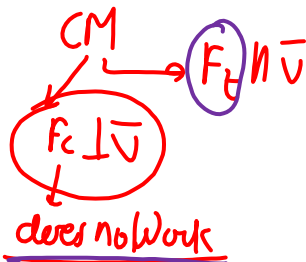
A particle of mass m is moving in a circular path of constant radius r such that its centripetal acceleration a_c is varying with time t as $a_c = k^2 r t^2$, where k is a constant. The power delivered to the particle by the force acting on it is –

A $2\pi m k^2 r^2$

✓ B $\underline{m k^2 r^2 t}$

C $\frac{(m K^4 r^2 t^5)}{3}$

D Zero



$$a_c = k^2 r t^2 = \frac{v^2}{r}$$

$$v^2 = k^2 r^2 t^2$$

(or)

$$\underline{v = k r t}$$

$$\frac{dv}{dt} = a_t = k r$$

$$F_t = m a_t = m k r$$

$$P = F v$$

$$= m k r \cdot (k r t)$$

$$\underline{= m k^2 r^2 t}$$

Example

MCQ type Question [+4 , -1]

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

- (a) $(2t^3 + 3t^4)$ W (b) $(2t^3 + 3t^5)$ W
(c) $(2t^2 + 3t^3)$ W (d) $(2t^2 + 4t^4)$ W

4W

(NEET-I 2016)

Example

MCQ type Question [+4 , -1]

The heart of a man pumps 5 litres of blood through the arteries per minute at a pressure of 150 mm of mercury. If the density of mercury be $13.6 \times 10^3 \text{ kg/m}^3$ and $g = 10 \text{ m/s}^2$ then the power (in watt) is

- (a) 3.0 (b) 1.50 (c) 1.70 (d) 2.35 (2015)

HW

A car of mass m starts from rest ^{$u=0$} and accelerates so that the instantaneous power delivered to the car has a constant magnitude P_0 . The instantaneous velocity of this car is proportional to

- (a) $t^2 P_0$ ~~(b) $t^{1/2}$~~ (c) $t^{-1/2}$ (d) $\frac{t}{\sqrt{m}}$
(Mains 2012)

$$P_0 = \frac{dw}{dt} = \text{const}$$

$$\int dw = \int P_0 dt$$

$$W = \frac{1}{2}mv^2 - 0 = P_0 t$$

$$v = \left(\frac{2P_0}{m} \right)^{1/2} t^{1/2}$$

$$v \propto t^{1/2} \rightarrow a \propto t^{-1/2}$$

$$x \propto t^{1/2+1}$$

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

Example

MCQ type Question [+4 , -1]

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?

- (a) 400 W (b) 200 W
(c) 100 W (d) 800 W (2010)

100 W .



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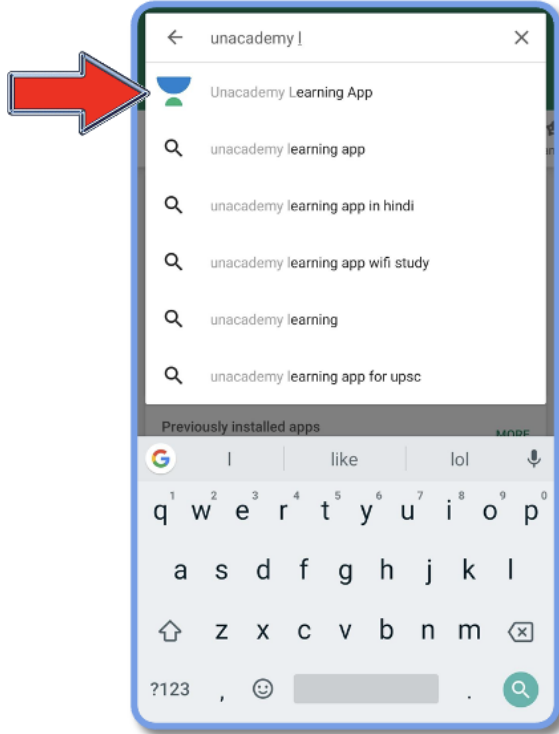
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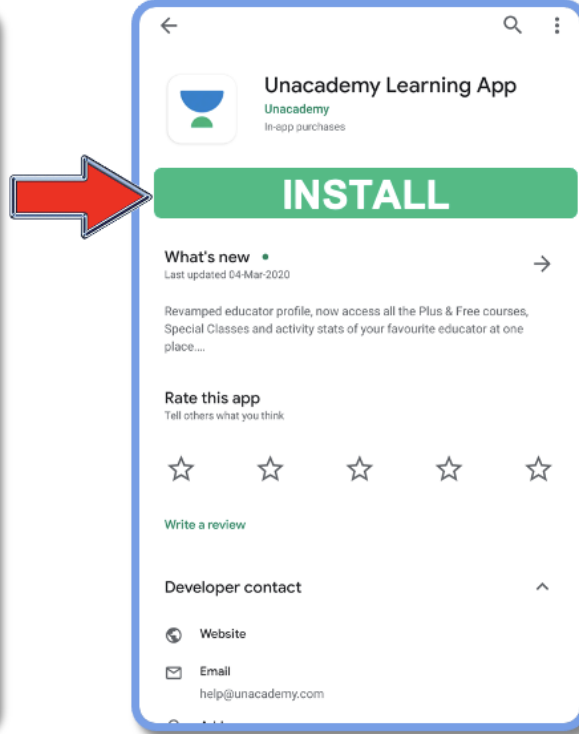
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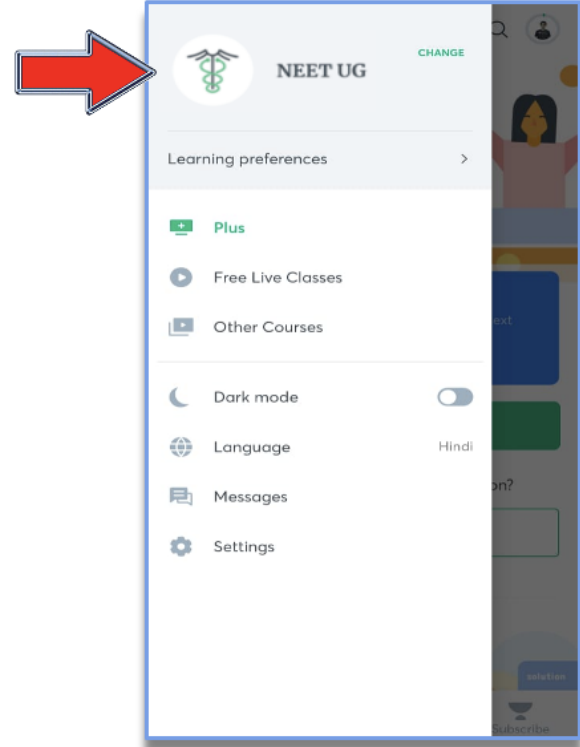
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