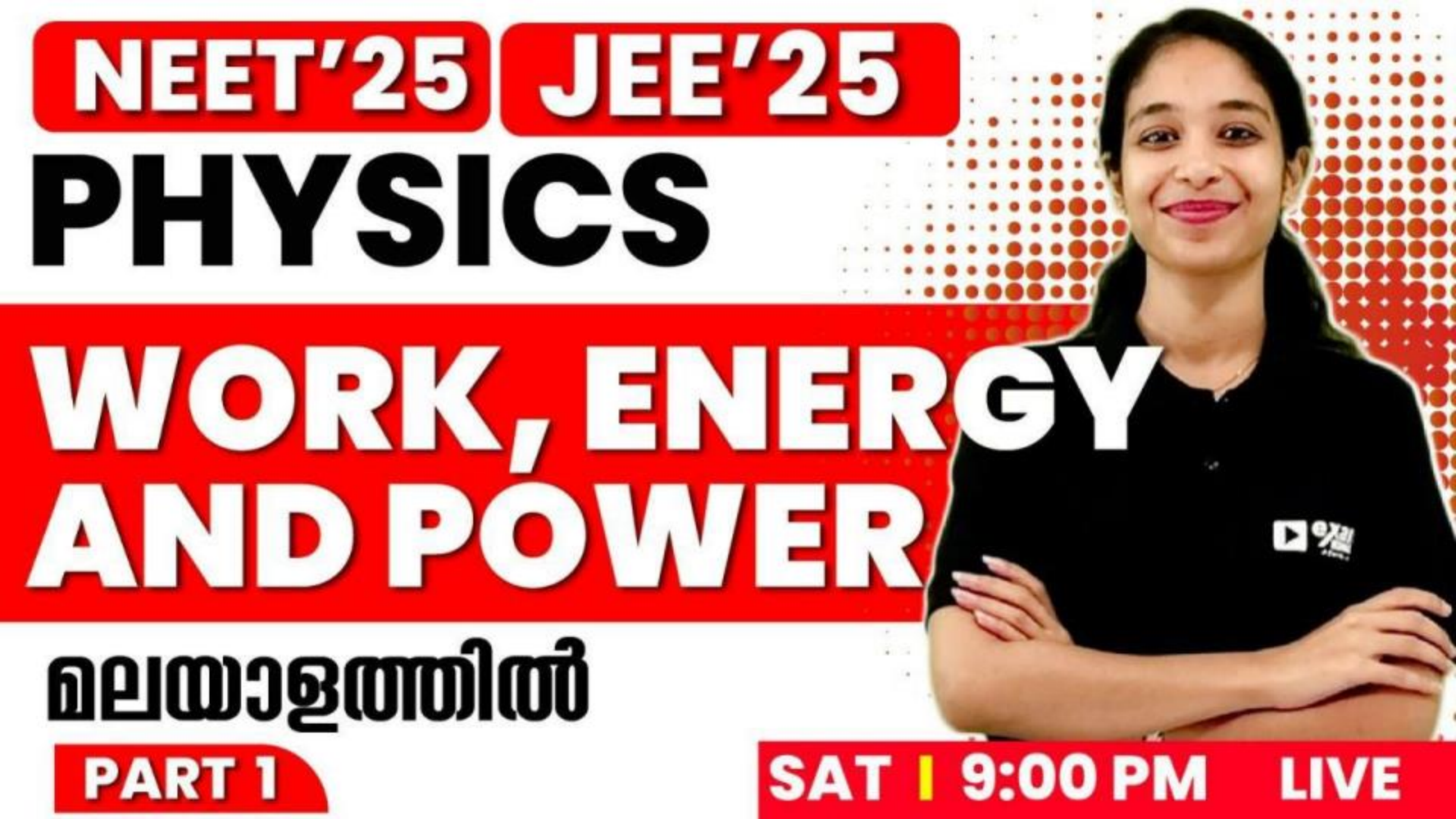
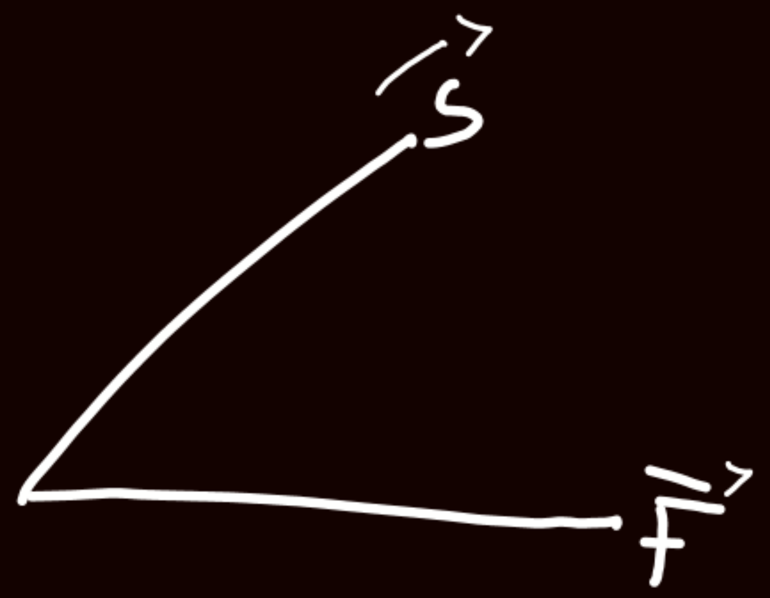

NEET'25
JEE'25
PHYSICS
WORK, ENERGY AND POWER
മലയാളത്തിൽ
PART 1
SAT | 9:00 PM LIVE

WORK

$$W = SF\cos\theta$$

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

H·W



$W = ?$

The work done by the force is defined to be the product of component of the force in the direction of the displacement and the magnitude of this displacement

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

$$W = FS\cos\theta$$

$$25 = 5 \times 10 \times \cos\theta$$

$$\cos\theta = \frac{25}{50} = \frac{1}{2}$$

$$\theta = \cos^{-1}\left(\frac{1}{2}\right) \Rightarrow \theta = 60^\circ$$

A block of mass m = 2 kg is pulled by a force F= 40 N upwards through a height h 2 m. Find the work done on the block by the applied force F and its weight mg.

$$W_{app} = 40 \times 2 = 80\,J$$

$$W_{mg} = -mgh = -2 \times 10 \times 2 = -40\,J$$

A constant force $F = (\hat{\imath} + 3\hat{\jmath} + 4\hat{k})$N acts on a particle and displaces it from (-1m, 2m, 1m) to (2m, -3m, 1m). Find the work done by the force.

Initial final

$\vec{S} =$ final - Initial

$F = (\hat{i} + 3\hat{j} + 4\hat{k})$

$\vec{S} = (2\hat{i} - 3\hat{j} + \hat{k}) - (-\hat{i} + 2\hat{j} + \hat{k})$

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

$(\hat{i} + 3\hat{j} + 4\hat{k}) \cdot (3\hat{i} - 5\hat{j} + 0\hat{k})$

$\vec{S} = 3\hat{i} - 5\hat{j} + 0\hat{k}$

$W = 3 - 15 = -12\,J$

A particle is shifted from point (0, 0, 1m) to (1m, 1m, 2m), under simultaneous action of several forces. Two of the forces are $F_1 = (2\hat{\imath} + 3\hat{\jmath} - \hat{k})$N and $F_2 = (\hat{\imath} - 2\hat{\jmath} + 2\hat{k})$. Find work done by resultant of these two forces.

$\vec{F_1} + \vec{F_2} = (2\hat{i} + 3\hat{j} - \hat{k}) + (\hat{i} - 2\hat{j} + 2\hat{k})$

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

$\vec{S} = (\hat{i} + \hat{j} + 2\hat{k}) - \hat{k}$

$\vec{S} = (\hat{i} + \hat{j} + \hat{k})$

$W = \vec{F} \cdot \vec{S} = (3\hat{i} + \hat{j} + \hat{k}) \cdot (\hat{i} + \hat{j} + \hat{k})$

$= 3 + 1 + 1$

$= 5J$

WORK DONE BY VARIABLE FORCE

Force : Is a function of position

$F(x)$

~~$F(x) \cdot x$~~

$$W = \int_{x_1}^{x_2} F(x)\, dx$$

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

$$W = \int_{x_1}^{x_2} F(x)\,dx$$

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

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

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

$$\int 7\,dx$$

$$7\int dx = x$$

$$\int 2x\,dx$$

$$2\int x\,dx = 2\,\frac{x^2}{2}$$

$$W = 7 \times 5 - 5^2 + 125$$
$$= 35 - 25 + 125$$
$$= 135\ J$$

$$\int x^n \, dx$$
$$= \frac{x^{n+1}}{n+1}$$

A force F = (2 + x) acts on a particle in x-direction, where F is in newton and x in metre. Find the work done by this force during a displacement from x = 1m to x = 2 m.

$$W = \int_{x_1}^{x_2} F\,dx = \int_1^2 (2+x)\,dx$$

$$= \left[2x + \frac{x^2}{2}\right]_1^2$$

$$= \left[\left(2\times 2 + \frac{4}{2}\right) - \left(2 + \frac{1}{2}\right)\right]$$

$$= 4 + 2 - \frac{5}{2} = 6 - \frac{5}{2} = \frac{7}{2}$$

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

a. 5 J b. 25 J c. 20 J d. 30 J

NEET 2019

$F = 20 + 10y$ $0 \longrightarrow 1$

$$W = \int_0^1 (20 + 10y)\,dy = 20y + 10\frac{y^2}{2}\Big|_0^1$$

$$= 20 + 5 = 25\,J$$

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

a. 13 J b. 15 J c. 9 J d. 6 J

NEET 2013

$$W = \vec{F} \cdot \vec{S}$$
$$= (3\hat{i} + \hat{j}) \cdot (2\hat{i} + 3\hat{j} - 2\hat{k})$$
$$= 6 + 3 = 9J$$

$$\vec{S} = (4\hat{i} + 3\hat{j} - \hat{k}) - (2\hat{i} + \hat{k})$$
$$= 2\hat{i} + 3\hat{j} - 2\hat{k}$$

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

a. $\frac{15}{9}$ J b. $\frac{5}{19}$ J c. $\frac{3}{8}$ J d. $\frac{8}{3}$ J

2006

$F = ma$

$F = 3 \cdot \frac{2}{3} = 2N$

$\vec{S} = \frac{1}{3}t^2$

$\vec{V} = \frac{1}{3}2t = \frac{2}{3}t$

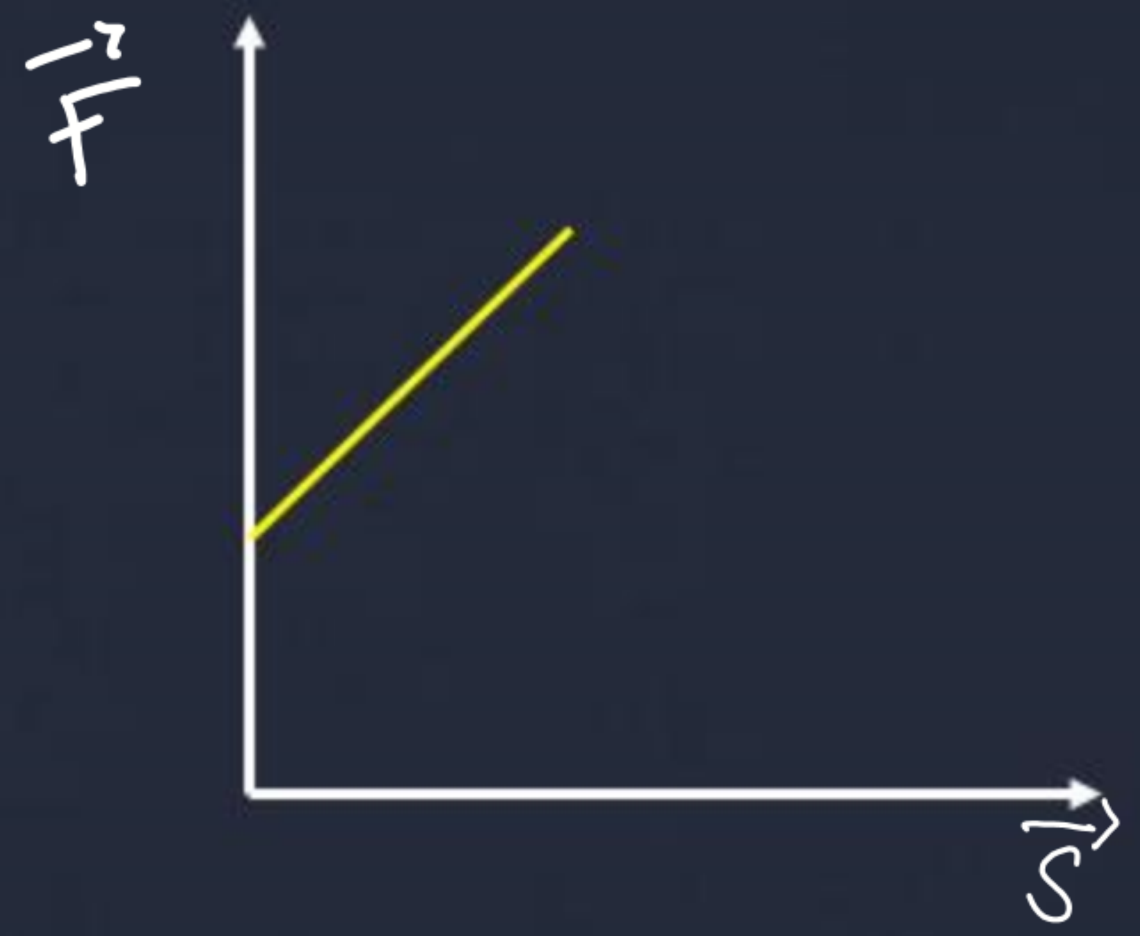
$\vec{a} = \frac{2}{3}$

$W = 2 \times \frac{1}{3}t^2$

$W\big|_{t=2} = \frac{2}{3} \times 4 = \frac{8}{3} J$

FORCE – DISPLACEMENT GRAPH

W = Area under the graph



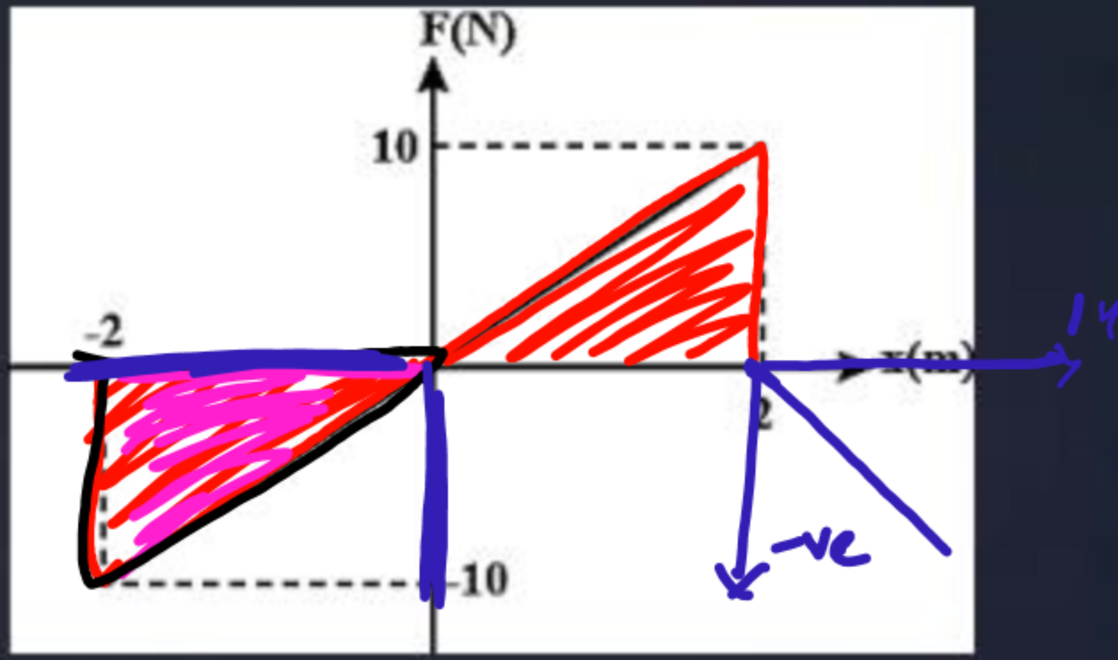
A force F acting on a particle varies with the position x as shown in figure. Find the work done by this force in displacing the particle from -2 to 2

$W = Area$

$= \frac{1}{2}bh + \frac{1}{2}bh$

$= \frac{1}{2} \times -2 \times -10 + \frac{1}{2} \times 2 \times 10$

$= 10 + 10 = 20J$



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

a. 21 J b. 26 J c. 13 J d. 18 J

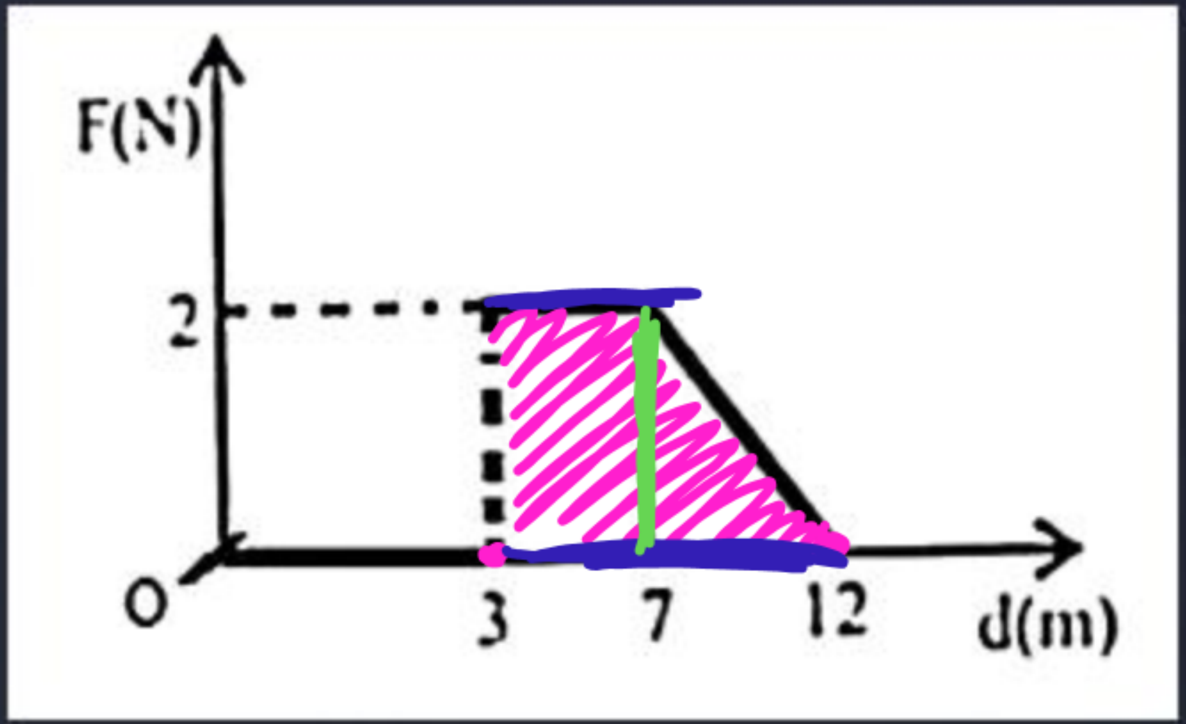
PRELIMS 2011

$W = \text{Area under graph}$

$= \left(\frac{a+b}{2}\right)h$

$= \left(\frac{4+9}{2}\right)2$

$= 13 J$



Area of trapezium

A force $F = -k(y\hat{i} + x\hat{j})$, where k is a positive constant, acts on a particle moving in the XY-plane. Starting from the origin, the particle is taken along the positive X-axis to the point (a, 0) and then parallel to the Y-axis to the point (a,a). The total work done by the force on the particle is

a. $-2ka^2$ b. $2ka^2$ c. $-ka^2$ d ka^2

AIIMS 2017

$W_1 = F_x x$

$= -ky x = -ky a$

$= -k \times 0 \times a = 0$

$W_2 = F_y y = -kx a$

$= -k a a = -ka^2$

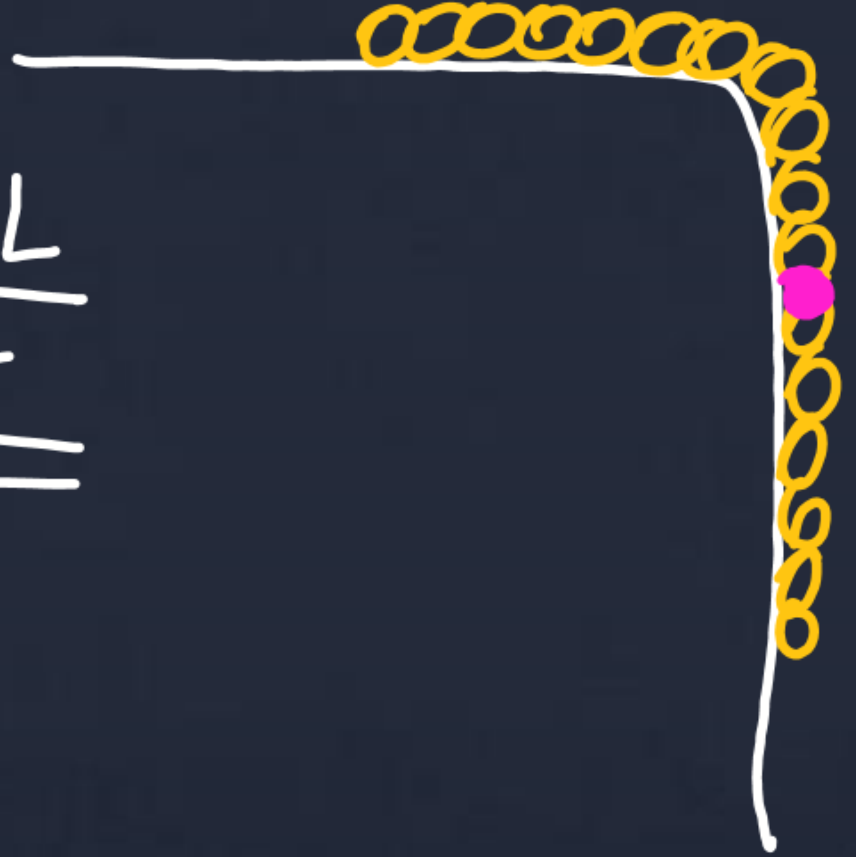
$W = W_1 + W_2 = 0 + (-ka^2) = -ka^2$

A uniform chain of length Land mass M is lying on a smooth table and one-third of its length is hanging vertically down over the edge of the table. If g is acceleration due to gravity, the work required to pull the hanging part on to the table is

a. MgL b. MgL/3 c. MgL/9 d. MgL/18

JEE 1985

$$W = FS$$
$$= mas$$
$$= \frac{M}{3} g \frac{L}{6} = \frac{MgL}{18}$$



$$m = \frac{M}{3}$$
$$a = g$$
$$S = \frac{L}{3} \times \frac{1}{2}$$

KINETIC ENERGY

The energy possessed by a body by virtue of its motion is called kinetic energy.

$$K = \frac{1}{2}mv^2$$ → Speed / Velocity

Velocity ⟹ vector

$$K = \frac{1}{2}m(\vec{v}\cdot\vec{v}) = \frac{1}{2}mv^2$$

A body of mass 0.8 kg has initial velocity $(3\hat{i} - 4\hat{j})$ m/s and final velocity $(-6\hat{j} + 2\hat{k})$ ms[1]. Find change in kinetic energy of the body

$$\Delta K = K_f - K_i$$

$$= \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2$$

$$= \frac{1}{2} m (v_f^2 - v_i^2)$$

$$= \frac{1}{2} \times 0.8 (40 - 25)$$

$$= \frac{1}{2} \times 0.8 (15) = 6$$

$$V_f = \sqrt{36 + 4} = \sqrt{40} =$$

$$V_i = \sqrt{9 + 16} = \sqrt{25} = 5$$

When a man increases his speed by 2 m/s, he finds that his kinetic energy is doubled. Find the original speed of the man.

$$K = \frac{1}{2} m v^2 \qquad V \qquad K$$

$$K' = 2K = \frac{1}{2} m (v+2)^2 \qquad V+2 \qquad K' = 2K$$

$$\frac{2K}{K} = \frac{\frac{1}{2} m (v+2)^2}{\frac{1}{2} m v^2}$$

$$2 = \frac{v^2 + 4v + 4}{v^2}$$

$$2v^2 = v^2 + 4v + 4$$

$$2v^2 - v^2 - 4v - 4 = 0$$

$$v^2 - 4v - 4 = 0$$

$$\frac{4 \pm \sqrt{16+16}}{2} = \frac{4 \pm \sqrt{2 \times 16}}{2} = \frac{4 \pm 4\sqrt{2}}{2}$$

$$\frac{4 \pm 4\sqrt{2}}{2}$$

$$\frac{4 + 4\sqrt{2}}{2} \qquad \frac{4 - 4\sqrt{2}}{2}$$

$$\frac{\overset{2}{\cancel{4}}(1+\sqrt{2})}{\cancel{2}} \qquad \frac{\overset{2}{\cancel{4}}(1-\sqrt{2})}{\cancel{2}}$$

$$2 + 2\sqrt{2} \qquad 2 - 2\sqrt{2}$$

$$\underline{\underline{\left(2 \pm 2\sqrt{2}\right)}}\, m/s$$

A block of mass 10kg is moving in x-direction with a constant speed of 10m/s. It is subjected to a retarding force $F = 0.1x\,J/m$ during its travel from $x = 20m$ to $x = 30m$. Its final kinetic energy will be :

H.W

$$W = (KE)_f - (KE)_i$$

$$\Rightarrow \int_{20}^{30} F.dx = (KE)_f - \frac{1}{2}mv^2$$

$$\Rightarrow (KE)_f = \frac{1}{2}mv^2 + \int_{20}^{30} 0.1x dx$$

$$= \frac{1}{2}mv^2 + 0.1\left[\frac{x^2}{2}\right]_{20}^{30}$$

Step 2: Calculations

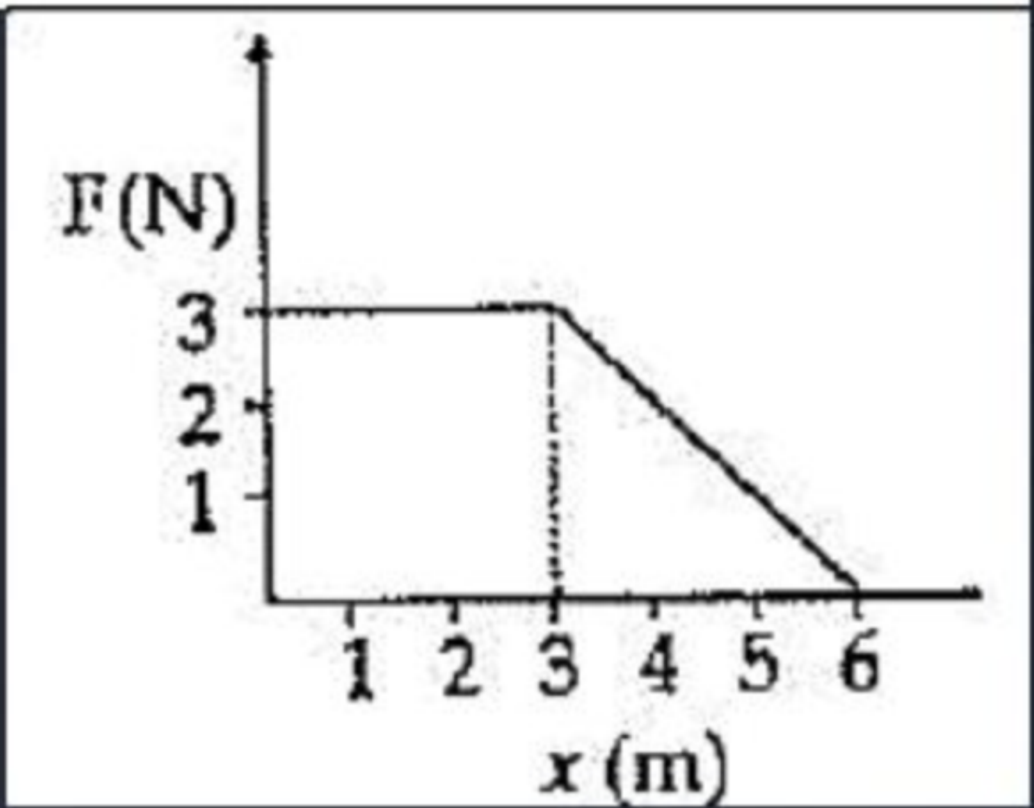
Putting given values

$$(KE)_f = \frac{1}{2} \times 10 \times (10)^2 + 0.1 \times \left[\frac{(30)^2 - (20)^2}{2}\right]$$

$$(KE)_f = 475 \text{ Joule}$$

A force F acting on an object varies with distance x as shown in the figure. The force is in N and x in m. The work done by the force in moving the object from $x = 0$ to $x = 6$ m is:

H.W



Work done in moving the object by distance $x = \int_0^x F.dx$

$= \text{Area under the given curve [from } x = 0\text{m to } x = 6\text{m]}$

$= (3 \times 3) + (\frac{1}{2} \times 3 \times 3)$

$= 13.5\text{J}$

A ball of mass 2kg 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?

H.W

Given that Mass $m_1 = 2, m_2 = 4$

As both balls are falling through the same height therefore they possess the same velocity

$KE = 0.5mv^2$

$KE \alpha m$......(v is constant)

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

A particle is projected making angle 45° with horizontal having kinetic energy K. the kinetic energy at highest point will be

H.W

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

At heightst point velocity will become $\frac{u}{\sqrt{2}}$

$$K' = \frac{1}{2}m \times (\frac{u}{\sqrt{2}})^2$$

$$K' = \frac{K}{2}$$

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

H.W

$$\Rightarrow \frac{KE_1}{KE_2} = \frac{p_1^2/2m_1}{p_2^2/2m_2}$$

Given $\Rightarrow p_1 = p_2 = p(\text{say})$

$$\Rightarrow \frac{4}{1} = \frac{p^2/2m_1}{p^2/2m_2}$$

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

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

H.W

$$v = \frac{dx}{dt} = 3 - 8t + 3t^2 \Rightarrow dx = (3 - 8t + 3t^2)dt$$

$$\Rightarrow a = \frac{dv}{dt} = 0 - 8 + 6t$$

Now,

$$dw = F\,dx$$

$$\Rightarrow dw = (ma)dx$$

$$\Rightarrow dw = (0.003)(-8 + 6t)(3 - 8t + 3t^2)dt$$

$$\Rightarrow dw = (0.003)(18t^3 - 72t^2 + 82t - 24)dt$$

$$\Rightarrow w = (0.003)\int_0^4 (18t^3 - 72t^2 + 82t - 24)dt$$

$$\Rightarrow w = 0.003 \times 176 = 0.528\ J$$

Two bodies of masses m and 4m are moving with equal kinetic energy. Then the ratio of their linear momentum will be

H.W

relation between Linear momentum and KE is $p = \sqrt{2mKE}$

therefore for m and 4m masses we have

$p_1 : p_2 = \sqrt{m_1} : \sqrt{m_2} = \sqrt{m} : \sqrt{4m} = 1 : 2$

A body moves a distance of 10 m along a straight line under the action of a force of 5 N. If the work done is 25 joule, the angle which the force makes with the direction of motion of the body is

H.W

$$W = Fs\cos\theta$$

$$\Rightarrow \cos\theta = \frac{W}{Fs} = \frac{25}{50} = \frac{1}{2}$$

$$\Rightarrow \theta = \cos^{-1}\left(\frac{1}{2}\right)$$

$$\Rightarrow \theta = 60^\circ$$

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

H.W

Force, $\vec{F} = (-2\hat{i} + 15\hat{j} + 6\hat{k})N$

Displacement, $\vec{s} = 10\hat{j}$ m

We know that,

$W = \vec{F} . \vec{d}$

$W = (-2\hat{i} + 15\hat{j} + 6\hat{k}).(10\hat{j}) = 0 + 150 + 0$

$W = 150$ J

Two masses of 1 gm and 4 gm are moving with equal kinetic energies. The ratio of the magnitudes of their linear momenta is:

H.W

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

Two masses are given as- $m_1 = 1$ gm and $m_2 = 4$ gm

But $K_1 = K_2$

$$\therefore \frac{p_1^2}{2m_1} = \frac{P_2^2}{2m_2}$$

Or $\frac{P_1^2}{2(1)} = \frac{P_2^2}{2(4)}$

$$\Rightarrow P_1 : P_2 = 1 : 2$$

When the kinetic energy of a body is increased to three times, then the momentum increases

H.W

P = momentum, K = kinetic energy, then

$P_1^2 = 2mK_1,\ P_2^2 = 2mK_2.$

$\therefore \left[\frac{P_2}{P_1}\right]^2$

$= \frac{K_2}{K_1} = \frac{3K_1}{K_1} = 3$

$\therefore \frac{P_2}{P_1}$

$= \sqrt{\frac{3}{1}} = 1.732$

If the momentum of a body increases by 50% its kinetic energy increases by ?

H.W

If p increases by 50%, the new momentum

$p' = p + \frac{p}{2} = \frac{3p}{2}$

Relation between kinetic energy and momentum is given by;

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

$K = \frac{1}{2}\frac{m^2v^2}{m} = \frac{1}{2}\frac{p^2}{m}$

The new kinetic energy

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

So,

$$\frac{K'}{K} = \frac{\frac{p'^2}{2m}}{\frac{p^2}{2m}} = \frac{p'^2}{p^2} = \frac{\frac{(3p)^2}{2}}{p^2} = \frac{9}{4}$$

$K' = \frac{9}{4}K$

$$\frac{K'-K}{K} \times 100 \Rightarrow \frac{\frac{9}{4}K-K}{K} \times 100 \Rightarrow 125\%$$

Hence, its kinetic energy increases by: 125%