Work → Whenever a force make a body move, then work is said to be done.

Force → Push, Pull

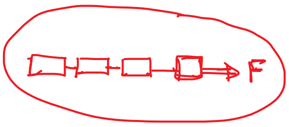
Note ⇒ For doing work **energy** is needed.

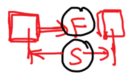
energy → Capability of doing work

→ Food → Human/animal

→ fuels → m/c

Power → Rate of doing work → 2 factors





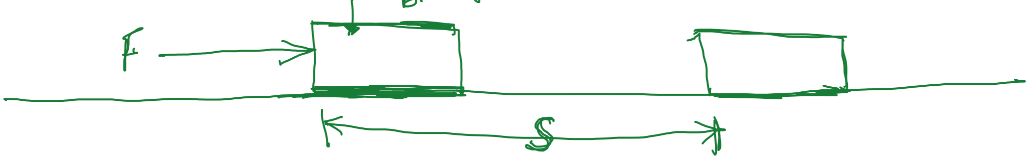
Eg. Moving Train

Eg. Horse Cart

→ Work is done when a force produces motion $W = FS$

→ Work is said to be '0' if force does not result into Displacement.

Mathematical Representation → Work done in moving a body is equal to the product of Force applied on it and distance/displacement covered along the direction of force.



$$W = F \times S$$

Unit Force → Newton (N)

Displacement → meter (m)

$W = Nm$

$1\ Nm = 1$ Joul

SI unit of work → Nm or Joul (J)

Quantity

- physical → Measurable
- Non-physical → Non-measurable

Physical
→ Measurable

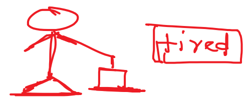
Non-physical
→ Non-measurable
→ Emotion

Measurable → Scalar, Vectors

Scalar
* Only Magnitude

Vectors
* Magnitude as well as direction

Note → Work is Scalar quantity



$$W = F \times S$$

W – Scalar quantity; F – Vector quantity; S – Vector quantity

Vector Quantity
- Scalar: Dot product or Scalar product
- Vector: or Cross

Work done against Gravity

Work done in lifting a body = Weight of body × Vertical distance

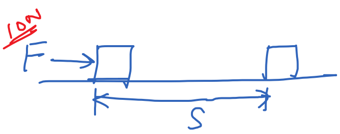
$g = 9.8\ m/s^2 \simeq 10\ m/s^2$

$$W = mgh$$

unit → Joule (J)

Work → Horizontal, Vertical

Horizontal



$$W = F \times S$$

Vertical

$$W = mgh$$

Q.① How much work is done by a force of 10N in moving an object a distance 1m in the direction of force?

Sol. $W = F \times S$

$W = 10N \times 1m$

$W = 10\ Nm = 10\ J$

Q.② Calculate the work done in lifting 200 kg of water through a vertical height of 6 m ($g = 10\ m/s^2$)

Sol. →

$m = 200\ kg$

$g = 10\ m/s^2$

$h = 6\ m$

$W = mgh = 200 \times 10 \times 6$

$W = mgh = 200 \times 10 \times 6$

$= 12000$ J

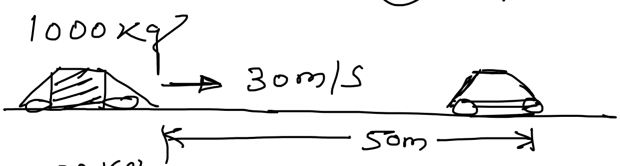
Equation of Motion

(I) $v = u + at$

(II) $s = ut + \frac{1}{2}at^2$

(III) $v^2 - u^2 = 2as$

Q.3



$m = 1000$ kg

$u = 30$ m/s

$v = 0$

(III) eqn of motion

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

$0 - 30^2 = 2a \times 50$

$-900 = 100a$

$a = -9 \text{ m/s}^2$

Work done by brake

$W = F \times S$

$S = 50$ m

$F = ma$

$F = 1000 \times -9$

$F = -9000$ N

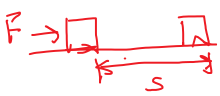
$W = -9000 \times 50$ m

$W = -450000$ J

$W = -4.5 \times 10^5$ J

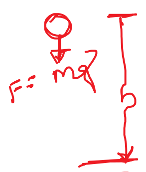
Work

Horizontal



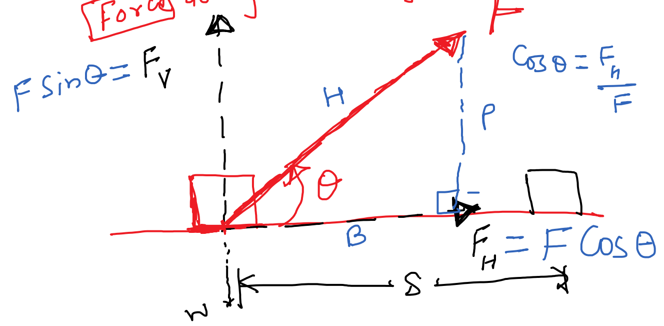
$W = F \times S$

Vertical



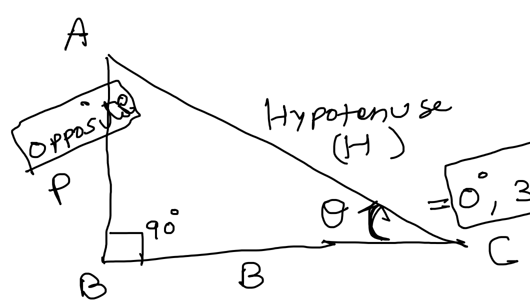
$W = mgh$

Force acting obliquely

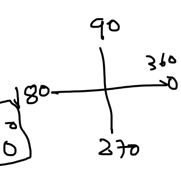


$W = F_h \times S = F S \cos\theta$

Right angle Triangle



$= 0^\circ, 30^\circ, 45^\circ, 60^\circ, 90^\circ$



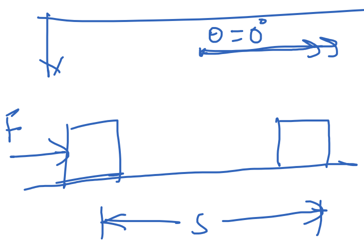
$\frac{H}{P} = \frac{1}{\ldots} = \text{Cosec}\,\theta$

1. $\frac{P}{H} = \sin\theta$
2. $\frac{B}{H} = \cos\theta$
3. $\frac{P}{B} = \tan\theta$
4. $\frac{H}{P} = \frac{1}{\sin\theta} = \text{cosec}\,\theta$
5. $\frac{H}{B} = \frac{1}{\cos\theta} = \sec\theta$
6. $\frac{B}{P} = \frac{1}{\tan\theta} = \cot\theta$

T.R \ θ	0° ($\sqrt{0/4}$)	30° ($\sqrt{1/4}$)	45° ($\sqrt{2/4}$)	60° ($\sqrt{3/4}$)	90° ($\sqrt{4/4}$)
$\sin\theta$	0	$\frac{1}{2}$	$\frac{1}{\sqrt{2}}$	$\frac{\sqrt{3}}{2}$	1
$\cos\theta$	1	$\sqrt{3}/2$	$1/\sqrt{2}$	$1/2$	0
$\tan\theta = \frac{\sin}{\cos}$	0	$1/\sqrt{3}$	1	$\sqrt{3}$	N.D
$\text{cosec}\,\theta$	N.D. (∞)	2	$\sqrt{2}$	$2/\sqrt{3}$	1
$\sec\theta$	1	$2/\sqrt{3}$	$\sqrt{2}$	2	N.D.
$\cot\theta$	N.D.	$\sqrt{3}$	1	$1/\sqrt{3}$	0

Inclined / Oblique force

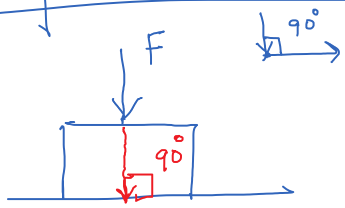
$W = F\,S\cos\theta$



$\theta = 0^\circ$

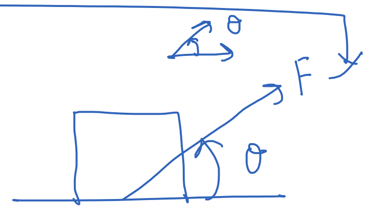
$W = F\,S\cos 0^\circ$

$W = F\,S$



$W = F\,S\cos 90^\circ$

$W = 0$



$W = F\,S\cos\theta$

$\cos 0^\circ = 1$

$\cos 30^\circ = \sqrt{3}/2$

$\cos 45^\circ = 1/\sqrt{2}$

$\cos 60^\circ = 1/2$

$\cos 90^\circ = 0$

$\cos 45^\circ = 1/\sqrt{2}$
$\cos 60^\circ = 1/2$
$\cos 90^\circ = 0$

$\theta = 30^\circ$

$W = FS\cos 30^\circ$

$W = FS \times \frac{\sqrt{3}}{2}$

$$W = \frac{\sqrt{3}}{2} FS$$

$\theta = 45^\circ$

$W = FS\cos 45^\circ$

$$W = \frac{1}{\sqrt{2}} FS$$

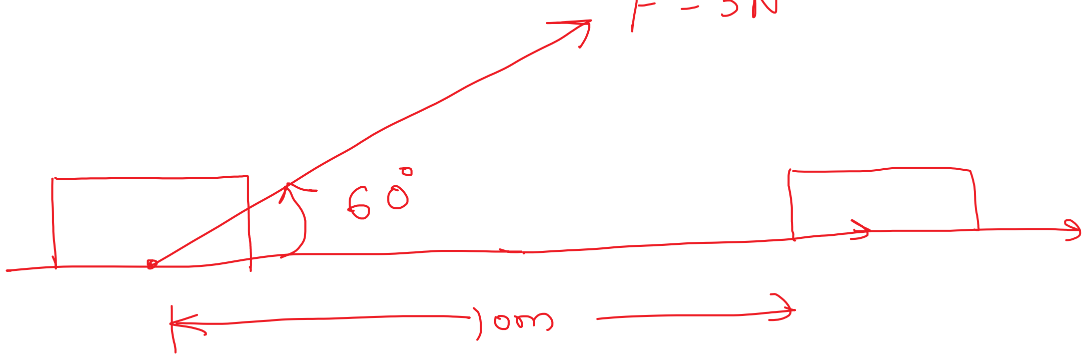
$\theta = 60^\circ$

$W = FS\cos 60^\circ$

$W = FS \times \frac{1}{2}$

$$W = \frac{1}{2} FS$$

Q



Sol $W = FS\cos 60^\circ$

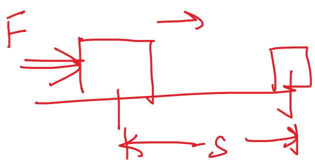
$W = \frac{1}{2} FS = \frac{1}{2} \times 5 \times 10 \text{ J} = 25 \text{ J}$

* When the displacement of the body is perpendicular to the direction of force, no work is done

* The work done on a body moving in a circular path is '0'

Work

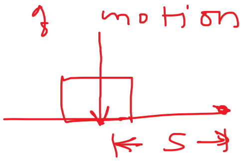
Positive



$$W = FS$$

0

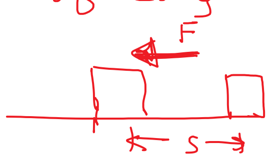
Force acts at 90° to the direction of motion

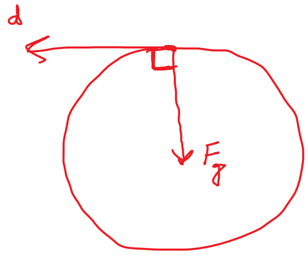


$$W = 0$$

Negative

→ Force acts opposite to direction of motion of body

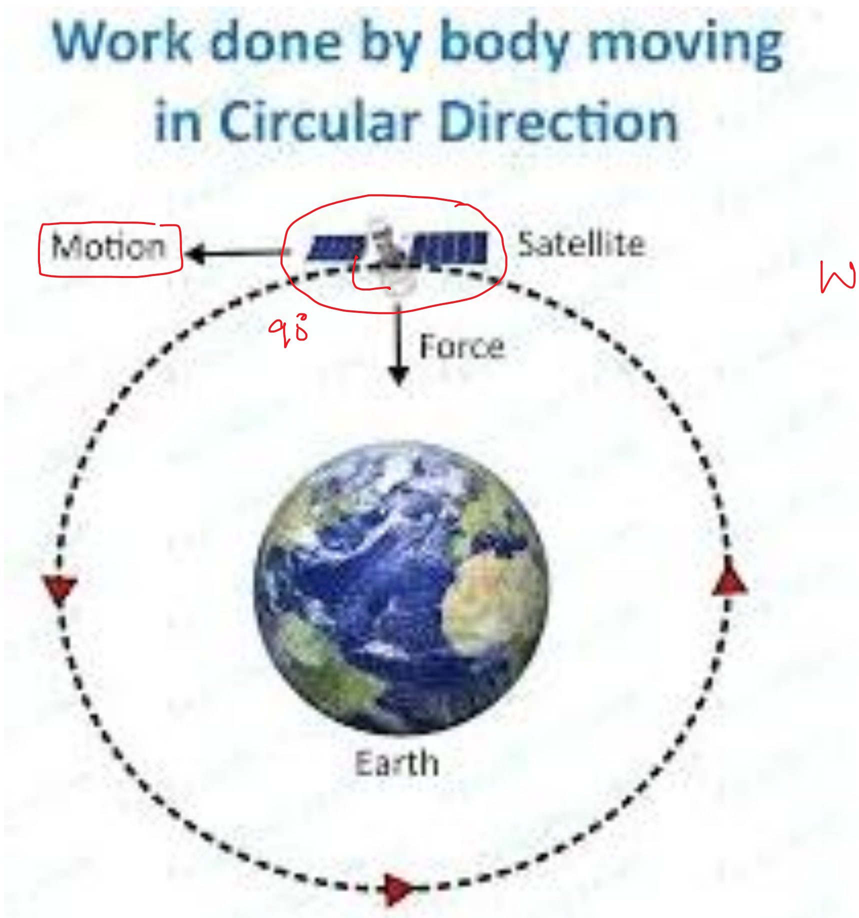




$W = 0$

$W = \vec{F} \cdot \vec{S} = FS\cos 180^\circ$

$W = -FS$

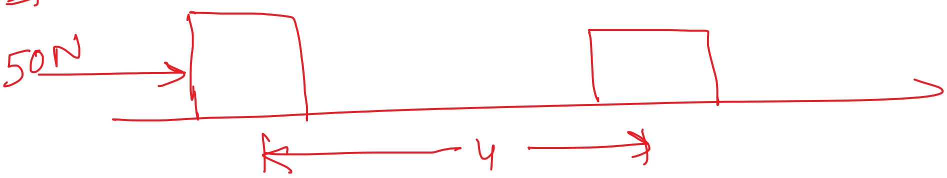


$W = FS\cos 90^\circ$

$W = FS \times 0$

$W = 0\,J$

Q. (a)

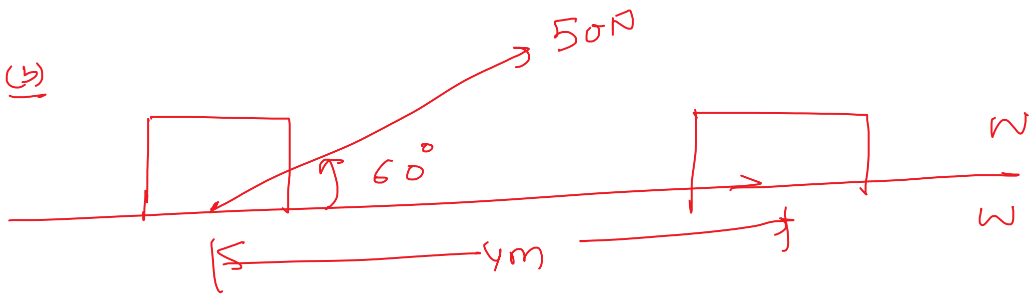


$W = F \times S = 50 \times 4$

$= 200\,Nm$

$= 200\,J$

(b)



$W = FS\cos 60^\circ$

$W = 50 \times 4 \times \frac{1}{2}$

$W = 100\,J$

Q.

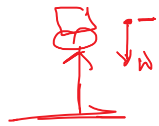
(1) 5kg

Q:

$W = mgh$

$W = +5 \times 10 \times 9$

$= +450\ J$



Energy (ऊर्जा)

1. Definition → The Capability (क्षमता) of doing work (कार्य)

2. Nature of Quantity → Scalar Quantity
   - Scalar ↑ only magnitude
   - Vector ↑ magnitude & direction →

3. SI unit → Joul (J)

   Bigger unit → Kilo Joul (KJ)

   $1\ KJ = 1000\ J$

4. The energy required to do 1 Joul of work is Called 1 Joul of Energy.

5. SI unit: Joul (J) → James prescott Joule

6. Different form of energy

   1. Potential Energy → The energy of a body due to its position above the ground is known as potential energy.
      - ↓ Gravitational Potential energy → Dam
      - ↳ Elastic potential ↓ Rubber → Rubber string

energy

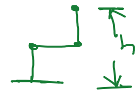
→ Dam

→ Rubber string

Note → Energy, a body possess when it is not in motion.

P.E. = Work done on body, against gravity, in moving the body to that position

Note
↑
Irrespective of path



$$P.E. = W = mgh$$

② Kinetic Energy

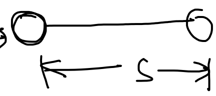
(i) Definition → The energy of a body due to its motion is called kinetic energy.

(ii) Eg: * moving cricket ball
* Runner
* Running motor cycle.

(iii) Derivation

A body of mass (m) with initial velocity (u) attain (V) final velocity and acceleration 'a' and travel distance (S)

III eqn of motion



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

$$s = \frac{v^2 - u^2}{2a} \quad \text{—— (1)}$$

$$W = F\,S$$

Now

$$W = F\,S$$

$$W = ma \times \frac{v^2 - u^2}{2a}$$

$$W = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$ → work energy theorem

↑
change in K.E

if $u = 0$

$$W = \frac{1}{2} m v^2$$

is equal to work done

K.E possessed by an object of mass 'm' and moving with a uniform velocity 'v' is

$$\boxed{E_K = W = \frac{1}{2} m v^2}$$

③ Mechanical energy

$$\boxed{M.E. = P.E. + K.E}$$

Eg: moving ceiling fan

Sustainable Development

↓

Fossil fuel

Other forms

④ Heat energy

⑤ Electric energy

⑥ Magnetic energy

⑦ Light energy → Renewable energy

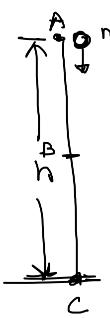
⑧ Chemical energy

⑨ Nuclear energy

- Nuclear fission — $^{235}_{92}U$
- Nuclear fusion — Sun

⑩ Sound energy

Conservation of Energy → Energy can neither be created nor be destroyed but it can be transferred from one form to another form.



$$\rightarrow mgh + \underset{K.E}{0} = T \quad (P.E)$$

$$\rightarrow mg\frac{h}{2} + \frac{1}{2} m v_1^2 = T = mgh$$

$$\rightarrow 0 + \frac{1}{2} m v^2 = T$$

$$\boxed{mgh + \frac{1}{2} m v^2 = \text{Constant}}$$

Q. An object of mass 15 kg is moving with $v = 4\,m/s$ $K.E = ?$

Sol. $K.E. = \frac{1}{2} m v^2$

$1\,kg = 1000\,g$

$v = 4\,m/s$

$= \frac{1}{2} \times 15 \times 4 \times 4$

$= 120\,J$

Q. Find the energy possessed by an object of mass 10 kg when it is at height of 60 cm above the ground and $g = 10\,m/s^2$

$1\,m = 100\,cm$

Sol. $m = 10\,kg$

$h = 60\,cm$

$h = \frac{60}{100}\,m = 0.6\,m$

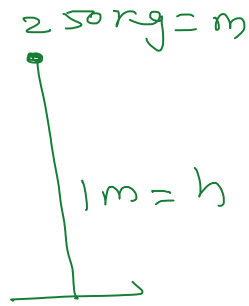
$P.E. = mgh = 10 \times 10 \times 0.6 = 60$ Joul

9. Is it possible that an object is in the state of accelerated motion due to external force acting on it, but no work is being done by the force. Explain it with an example.
10. A ball is dropped from a height of 10 m. If the energy of the ball reduces by 40% after striking the ground, how much high can the ball bounce back? ($g = 10\ m\ s^{-2}$)
11. If an electric iron of 1200 W is used for 30 minutes everyday, find electric energy consumed in the month of April.

Long Answer Type Questions

1. A light and a heavy object have the same momentum. Find out the ratio of their kinetic energies. Which one has a larger kinetic energy?
2. An automobile engine propels a 1000 kg car (A) along a levelled road at a speed of 36 km h^{-1}. Find the power if the opposing frictional force is 100 N. Now, suppose after travelling a distance of 200 m, this car collides with another stationary car (B) of same mass and comes to rest. Let its engine also stop at the same time. Now car (B) starts moving on the same level road without getting its engine started. Find the speed of the car (B) just after the collision.
3. A girl having mass of 35 kg sits on a trolley of mass 5 kg. The trolley is given an initial velocity of 4 $m\ s^{-1}$ by applying a force. The trolley comes to rest after traversing a distance of 16 m.
    - (a) How much work is done on the trolley?
    - (b) How much work is done by the girl?

4. Four men lift a 250 kg box to a height of 1 m and hold it without raising or lowering it.
    - (a) How much work is done by the men in lifting the box?
    - (b) How much work do they do in just holding it?
    - (c) Why do they get tired while holding it? ($g = 10\ m\ s^{-2}$)



(a) $W = U = mgh = 250 \times 10 \times 1 = 2500\ J$

(b) $W = 0$

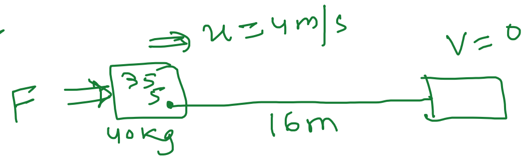
(c) P.E work against gravity

Sol. (3)

a) $\Rightarrow u = 4\ m/s$ $v = 0$ $W = Fs$ $W = mgs$

$\sqrt{35}$

a)



$w = mgs$

$w = 40 \times a \times 16m$

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

$0 - 4^2 = 2 \times a \times 16$

$a = -\frac{1}{2}$

$w = 40 \times -\frac{1}{2} \times 16$

$w = -320J$

b) 0

Power

① Definition → The rate of doing work is called power.

② $P = \frac{W}{t}$

③ unit → J/s

1 J/s = 1 watt } SI unit

④ Commercial unit

(i) 1 kW = 1000 W

(ii) 1 h.p. = 746 W

(iii) 1 MW = 10^6 W

⑤ Commercial unit of energy

1 unit = 1 kWh

1 kWh = 1000 W × 3600 sec

$1\ kWh = 3.6 \times 10^6\ J$

$P = \frac{W}{t}$

$Pt = W$

Watt sec = W

J

$$1\ kWh = 3.6 \times 10^6\ J$$

Q. An electric bulb consume 7.2 KJ of electrical energy in 2 min. What is the power

Sol. → $P = \frac{W}{t} = \frac{7.2 \times 1000\ J}{2 \times 60\ s}$

1 KJ = 1000 J

1 min = 60 sec

$= \frac{3.6 \times 100}{6}$

$= \frac{360}{6}$

$P = 60\ J/s$

$P = 60\ W$

Q. What is the power of a pump which takes 10s to lift 100 kg of water to a water tank situated at a height of 20m. $g = 10\ m/s^2$

Sol. $P = \frac{W}{t} = \frac{P.E}{t} = \frac{mgh}{t}$

$P = \frac{100 \times 10 \times 20}{10\ s} = 2000\ W$

Q. A family uses 250 unit of electrical energy in a month. Calculate it in energy.

250 unit

$E = 250 \times 1\ kWh$

$\text{unit} = \frac{E}{3.6 \times 10^6}$

$E = 250 \times 1\ kWh$

$= 250 \times 3.6 \times 10^{6}\ J$

$= 9 \times 10^{8}\ J$

unit = $\frac{\quad}{3.6 \times 10^{6}}$

$E = unit \times 3.6 \times 10^{6}$