Work and Energy

- Work is done when force produces motion.

Force → Particle

$W = F \times S$

Force ↑ displacement ↑

- Work done by a force on a body depends upon two factors
  - → Magnitude of force
  - → Displacement through which the body moves.

$W = F \times S$

⇒ Work done in moving a body is equal to the product of force exerted on the body and the distance moved by the body in the direction of force.

→ $W = F \times S$

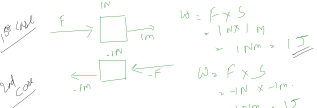
$= N \times M$

W = Joule

1 Joule = 1 N × 1 M

1 J is the amount of work done on an object when a force of 1 N displaces it by 1 m along the line of action of the force.

→ work is a scalar quantity.



$W = F \times S$

$= 1N \times 1M$

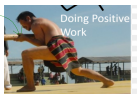
$= 1NM = 1J$

$W = F \times S$

$= -1N \times -1m$

$= 1NM = 1J$

Positive and Negative work



When displacement of an object is in the same direction as that of force applied it is called Positive work done.

→ work done by man → +ve

→ work done by gravitational force → -ve

Negative work - when displacement of an object is in the opposite direction of applied force then it is negative work done.

Zero work done

$W = F \times S$

$= 0$

$W = 0$

Force applied

displacement

Work done = 0

Example 11.1 A force of 5 N is acting on an object. The object is displaced through 2 m in the direction of the force (Fig.

2) Calculate the work done in lifting 200kg of water through a vertical height of 6 meters. (Assume $g = 10\ ms^{-2}$)

$W = F \times S$

$W = m \times a \times S$

$= m \times g \times h$

$= 200 \times 10 \times 6$

$W = 12,000\ J$

3) A car weighing 1000kg is travelling at $30\ ms^{-1}$ stops at a distance of 50m decelerating uniformly. What is the force exerted on it by the brakes? What is the work done by the brakes?

$W = F \times S$

$= 9000 \times 50$

$= 450,000\ J$

$F = ma$

$F = -9000\ N$

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

$0 = 900 + 2 \times a \times 50$

$a = -9\ ms^{-2}$

Work done = ΔKE

Energy

⇒ The ability to do work.

A ——— Fast ↑ Energy ↑ work done ↑

A' ——— B' Fast ↓ Energy ↓ work done ↓

The amount of energy possessed by a body is equal to the amount of work it can do when its energy is released

- Energy is a scalar qty.

$W_D = KE_i - KE_f$

Unit of Energy

→ Units of work and energy are the same i.e. joule.

1 kg = 1000 Joules

Different forms of Energy

Kinetic energy, chemical energy, Potential energy.

Kinetic Energy

Energy ↑ work done ↑ → constant force

Energy ↑ work done ↑

$(W_D) \propto (W_D)^2$

WD → velocity

KE → velocity

WD → mass

KE → mass

$W = F \times S$

Work = $F \times S$

Now finding S

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

$S = (v^2 - u^2)/2a$

Putting value of S in above equations

$W = F \times S$

$W = ma \times (v^2 - u^2)/2a$

$W = \frac{m(v^2 - u^2)}{2}$

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

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

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

→ If the mass of a body is doubled/halved its KE also gets doubled / halves

→ If the velocity of a body is doubled / halved its KE becomes four times / one-fourth respectively.

1) An object of mass 15 kg is moving with a uniform velocity of $4\ ms^{-1}$. What is the KE possessed by the object?

2) What is the work to be done to increase the velocity of a car from 30 Km h^{-1} to 60 Km h^{-1} if the mass of the car is 1500 kg?

30 × 5 / 18 ; 60 × 5 / 18

$W_D = KE_f - KE_i$

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

$= 156250$

3) How much work done on a bicycle of mass 20kg to increase its speed from 2 ms^{-1} to 5 ms^{-1}. Ignore friction & air resistance.

→ 210 J

4) Two bodies of equal masses move with uniform velocities v and 3v respectively. Find the ratio of K.E's.

1st body, 2nd body

$m_1 = 2m$, $m_2 = m$

$v_1 = v$, $v_2 = 3v$

$\frac{KE_1}{KE_2} = \frac{\frac{1}{2} \times 2m \times v^2}{\frac{1}{2} \times m \times 3v^2}$

$= \frac{2}{3}$

1st body mass is twice the mass of 2nd and 2nd body is velocity is thrice of 1st. Find the ratio of K.E.s.

Potential Energy

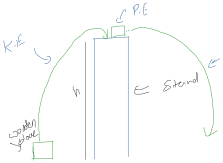
Mechanical Energy → K.E, P.E

→ stretch → K.E

→ regained → P.E.

back its original shape

→ The energy of a body due to its position or change in shape is known as Potential energy.



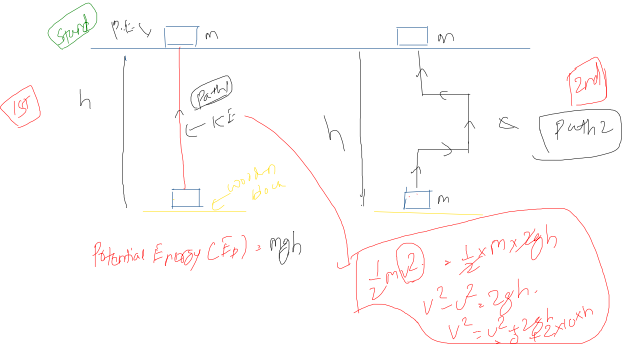
To lift the body above surface of the earth we have to do work against the gravity.

Work done = force × distance

= mg × h

P.E = mxgxh

= mgh.



Potential Energy (P.E) = mgh

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

$v^2 - u^2 = 2gh$.

$v^2 = u^2 + 2gh$ (u=0)

$v^2 = 2gh$

1) An object with 100N weight is raised to height of 1500 cm. Find the PE possessed by the object of that ht. Also find the new PE if the same object is raised to three times of the original ht. (given g = 10 ms⁻¹)

Sol: P.E = mgh = 100 × 15 = 1500 J

P.E = 3 × 1500 J = 4500 J

2) Find the energy possessed by an object of mass 10 kg when it is at a height of 6 m above the ground (given, $g = 9.8 ms^{-2}$)

P.E = mgh = 10 × 9.8 × 6 = 588 J

3) An object of mass 12 kg is at a certain height above the ground, if the potential energy of the object is 480 J, find the height at which the object is with respect to the ground. (given, $g = 10 ms^{-1}$)

Ans — 4m

4) A bag of wheat weighs 200 kg. To what height should it be raised so that its potential energy may be 9800 joules? (Take $g = 9.8 ms^{-2}$)

5) If accn due to gravity is $10 ms^{-2}$, what will be the potential energy of a body of mass 1 kg at a height of 5m?