9th Standard Science

Work, Power and Energy

Work: When a force acts on an object and the object shows displacement, the force has done work on the object.

Two conditions need to be satisfied for work to be done:

(i) A force should act on object

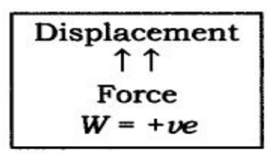
(a) The object must be displaced

Work = Force x Displacement Unit of workdone = Joule = Newton x metre 1 Joule work is said to be done when 1 Newton force is applied on an object and it shows the displacement by 1 meter.

(Case I)

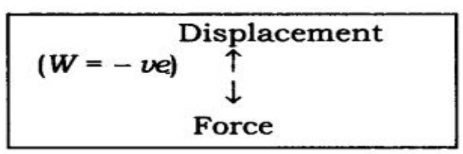
If displacement is in the direction of the force

$$W = F \times s$$



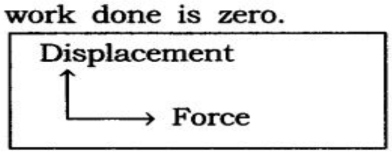
If displacement is in the direction opposite to the force

$$W = -F \times s$$



(Case II)

If displacement is perpendicular to the force work done is zero.



Energy

The capacity of a body to do work is called the energy of the body.

Unit of energy = Joules 1KJ = 1000 J

Forms of Energy: The various forms of energy are potential energy, kinetic energy, heat energy, chemical energy, electrical energy and light energy.

Kinetic Energy: Energy possessed by a body due to its motion. Kinetic energy of an object increases with its speed.

Kinetic energy of body moving with a certain velocity = work done on it to make it acquire that velocity

Derivation

Let an object of mass m, move with uniform velocity u, let us displace it by s, due to constant force F, acting on it

$\therefore$ Work done → $W = F \times s$ ... (i)

due to force the velocity changes to v, and the acceleration produced is a

$\therefore$ relationship between v, u, a and s = $v^2 - u^2 = 2as$

$$\therefore \quad s = \frac{v^2 - u^2}{2a} \quad \text{... (ii)}$$

$$F = ma \quad \text{... (iii)}$$

Substitute (ii) and (iii) in (i) we get

$$W = F \times s$$

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

$$W = \frac{1}{2} m (v^2 - u^2)$$

if $u = 0$, (object starts at rest)

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

Work done = Change in kinetic energy

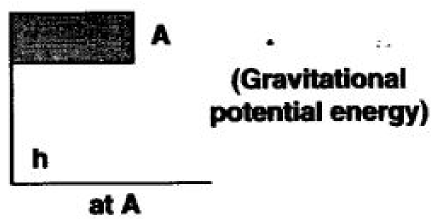
$$\therefore \quad E_k = \frac{1}{2} mv^2$$

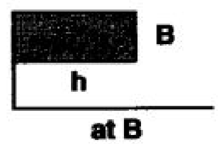
Potential Energy

The energy possessed by a body due to its position or shape is called its potential energy.

Shape

Position





Greater energy due to compression in spring and due to greater height of the object.

Less energy due to less compression in spring and due to less height of the object.

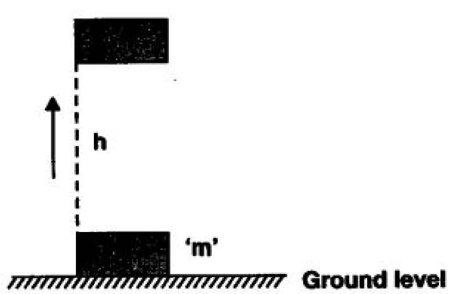
Gravitational Potential Energy: (GP)

When an object is raised through a height, work is said to be done on it against gravity.

The energy possessed by such an object is called the gravitational potential energy.

GPE = work is done in raising a body from the ground to a point against gravity.

Derivation



Consider a body with mass m, raised through a height h, from the ground,

Force required to raise the object = weight of object mg.

The object gains energy to the work done on it.

$\therefore$ Work done on the object against gravity is W.

$$\therefore \quad W = \text{force} \times \text{displacement}$$
$$= mg \times h$$
$$W = mgh$$
$$\therefore \quad P_E = mgh$$

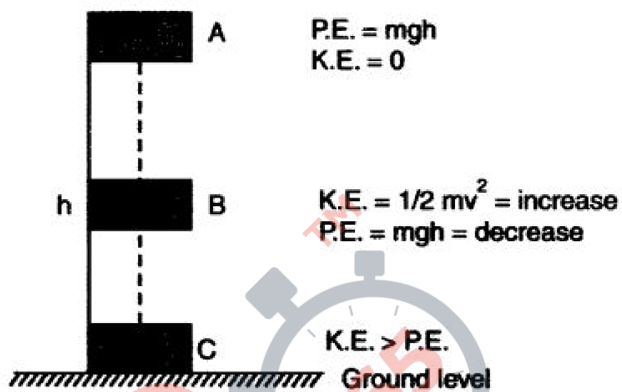
Work done in both the cases (i) and (ii) is same as a body is raised from position A to B, even if the path taken is different but the height attained is the same.

Mechanical Energy: The sum of kinetic energy and potential energy is called mechanical energy.

Law of Conservation of Energy:

Energy can neither be created nor destroyed, it can only be transformed from one form to another. The total energy before and after transformation remains the same.

Case (i)



Potential energy + Kinetic energy = Constant (Mechanical energy)

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A body of mass ‘m’ is raised to height ‘h’ at A its potential energy is maximum and kinetic energy is 0 as it is stationary.

When body falls at B, h is decreasing hence potential energy decreases and V is increasing hence kinetic energy is increasing.

When the body is about to reach the ground level, h = 0, v will be maximum hence kinetic energy –> potential energy

Decrease in potential energy = Increase in kinetic energy

This shows the continual transformation of gravitational potential energy into kinetic energy.

Power

$$\text{Power} = \frac{\text{Work}}{\text{Time}} \qquad \therefore\ P = \frac{W}{t}$$

$$\text{Watt} = \frac{\text{Joules}}{\text{Second}}$$

$$1 \text{ kilowatt} = 1000 \text{ watts}$$

$$1 \text{ kilowatt} = 1000 \text{ J/s}$$

Commercial Unit of Energy

Commercial unit of energy = 1 kilowatt hour (kwh)

$$\therefore \quad 1 \text{ kWh} = 1 \text{ kilowatt} \times 1 \text{ hour}$$

$$= 1000 \text{ watt} \times 3600 \text{ seconds}$$

$$= 3600000 \text{ Joule} \quad (\text{watt} \times \text{second})$$

$$1 \text{ kWh} = 3.6 \times 10^6 \text{ J.}$$

$$\therefore \quad \boxed{1 \text{ kWh} = 1 \text{ unit}}$$

The energy used in one hour at the rate of 1 kW is called 1 kWh.