

## CBSE Class 9 Work Energy and Power Quick Study Chapter Note

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### Work:

In our daily life anything that makes us tired is known as **work**. For example, reading, writing, painting, walking, etc.

In physics work (W) is said to be done, when a force (F) acts on the body and point of application of the force is displaced (s) in the direction of force.

Work done = force x displacement or,  $W = F \times s$

- (i) If the body is displaced in the same direction of force, Work done is positive
- (ii) If the displacement is against a force, the work is done against the force. Work done is negative
- (iii) If the displacement is perpendicular to the direction of the force, work done is zero.

### Unit of work

Unit of work is joule (J). One joule of work is said to be done when a force of 1 Newton acting on a body displacing it by a distance of 1 m.

### Larger units of work are

- (i) kilo joules (1000 joule) (ii) mega joule (10 lakh joule)

**ENERGY** - The energy of the body is defined as its capacity to do work

**Unit of energy - Energy** is measured in terms of work. Unit of energy is also joule. One joule of energy is required to do one joule of work

### Different forms of energy

#### 1. Mechanical Energy

The energy used to displace a body or to change the position of the body or to deform the body is known as mechanical energy.

Mechanical energy is of two types (i) Potential energy (ii) Kinetic energy.

## POTENTIAL ENERGY

The energy possessed by a body by virtue of its position or due to state of strain, is called potential energy.

### Example :

The work done to lift a body above the ground level gives the potential energy of the body. Eg. Weight lifting.

Water stored in reservoir has large amount of potential energy due to which it can drive a water turbine when allowed to fall down. This is the principle of production of hydro electric energy.

### Expression for potential energy of a body above the ground level

Consider an object of mass  $m$ . It is raised through a height “ $h$ ” meter from the ground.

By applying force  $F$ , The object gains energy to do the work done ( $w$ ) on it.

Work done = force  $\times$  displacement

$$w = F \times h \text{ (Since } F = m a, a = g, F = mg)$$

$$w = m g h$$

**KINETIC ENERGY-** Energy possessed by an object due to its motion is called kinetic energy.

Kinetic energy of an object increases with its speed. Kinetic energy of an object moving with a velocity is equal to the work done on it to make it acquire that velocity

### Example -

Kinetic energy of a hammer is used to drive a nail into the wall. Bullet fired from a gun can penetrate into a target due to its kinetic energy.

### Expression for kinetic energy:

Let a body (ball) of mass  $m$  is moving with an initial velocity  $v$ . If it is brought to rest by applying a retarding (opposing) force  $F$ , then it comes to rest by a displacement  $S$ .

Let,  $K_E$  = work done against the force used to stop it.

$$K_E = F \times S \text{ ----> (1)}$$

But retarding force  $F = ma$  ----> (2)

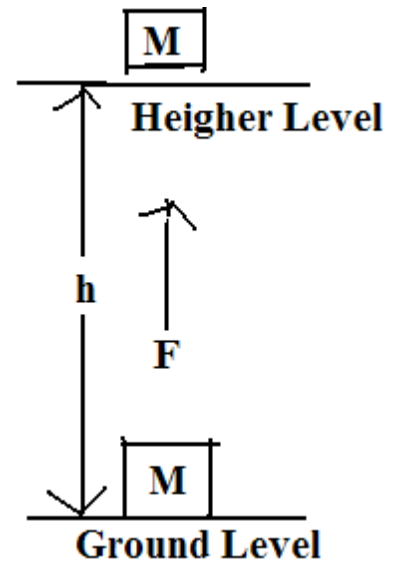
Let initial velocity  $u = v$ , final velocity  $v = 0$

From III equation of motion,  $v^2 = u^2 + 2aS$

Applying,  $0 = v^2 - 2aS$  ( "a" is retardation)  $\Rightarrow 2aS = v^2$

$$\text{Displacement, } S = \frac{v^2}{2a} \text{ ----> (3)}$$

Substituting (2) and (3) in (1)  $K_E = ma \times \frac{v^2}{2a} \Rightarrow K_E = \frac{1}{2} mv^2$



**LAW OF CONSERVATION OF ENERGY**

Energy can neither be created nor destroyed, but it is transformed from one form to another.

Alternatively, whenever energy gets transformed, the total energy remains unchanged.

**Proof – Freely falling body :** Consider a body of mass  $m$  falls from a point A, which is at a height  $h$  from the ground as shown in fig.

At A,

Kinetic energy  $K_E = 0$

Potential energy  $P_E = mgh$

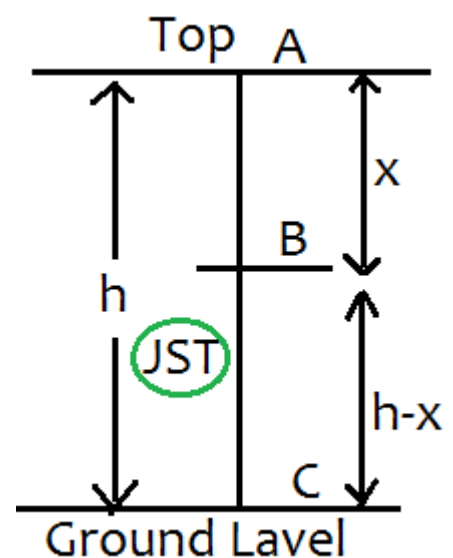
Total energy  $E = K_E + P_E = 0 + mgh$

$E_A = mgh$

Case: 1: During the free fall, let the body is at a position B on moving a distance  $x$  from A.

At B, Velocity  $v^2 = u^2 + 2as$

Applying,  $v^2 = 0 + 2ax = 2ax$



$$K_E = \frac{1}{2} mv^2 = \frac{1}{2} m \times 2gx = mgx$$

Potential energy ,  $P_E = mg (h - x)$

Total energy  $E = P_E + K_E = mg (h-x) + mgx = mgh - mgx + mgx$

$$E_B = mgh$$

Case - 2: During free fall let the body reaches the position C when fall to A.

At C, Potential energy  $P_E = 0$

Velocity of the body C is  $v^2 = u^2 + 2as$

$$u = 0, a = g, s = h$$

Applying  $v^2 = 0 + 2gh = 2gh$

Kinetic energy  $K_E = \frac{1}{2} mv^2 = \frac{1}{2} \times m \times 2gh \Rightarrow K_E = mgh$

Total energy at C =  $P_E + K_E = 0 + mgh = m g h$

Thus, Sum of potential and kinetic energy of freely falling body at all points remains same.

**Power:** Power is defined as the rate of doing work or work done per unit time

$$\text{Power} = \frac{\text{work done}}{\text{time taken}} = P = \frac{W}{t}$$

## UNIT OF POWER

The unit of power is J/S known as watt, its symbol is W.

$$1 \text{ watt} = \frac{1 \text{ joule}}{1 \text{ second}}$$

$$1 \text{ W} = 1 \text{ J/S}$$

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

$$1 \text{ kW} = 1000 \text{ W} \Rightarrow 1 \text{ kW} = 1000 \text{ J /s.}$$

Commercial unit of energy is kilo watt hour

Example : How much energy will be used when a hundred watt bulb is used for 10 hour?

$$\text{Energy} = 100 \text{ watt} \times 10 \text{ hour} = 1000 \text{ w h} = 1 \text{kw h}$$

1 k w h is known as 1 unit.

One kilowatt hour means thousand watt of power is consumed in one hour.

$$1 \text{ kWh} = 1 \text{ kW} \times 1 \text{ h} = 1000 \text{ W} \times 60 \times 60 \text{ s} = 1000 \text{ Js}^{-1} \times 3600 \text{ s} = 3.6 \times 10^6 \text{ J}$$

$$1 \text{ unit} = 1 \text{ kilowatt hour} = 3.6 \times 10^6 \text{ J}$$

Example: An electric bulb of 60 W is used for 6 h per day. Calculate the „units” of energy consumed in one day by the bulb.

**Solution:** Power of electric bulb = 60 W = 0.06 kW. Time used,  $t = 6 \text{ h}$

$$\text{Energy} = \text{power} \times \text{time taken} = 0.06 \text{ kW} \times 6 \text{ h} = 0.36 \text{ kW h} = 0.36 \text{ „units”}.$$

The energy consumed by the bulb is 0.36 “Units”.

Practice Board Questions:

Q.1. A man whose mass is 50 kg climbs up 30 steps of a stair in 30 s. If each step is 20 cm high, calculate the power used in climbing stairs

Ans: Mass of man=50 Kg ;  $g = 10 \text{m/s}^2$

$$1 \text{ step} = 20 \text{cm} \Rightarrow 30 \text{ steps} = 600 \text{ cm} = 6 \text{m} \text{ } \therefore h = 6 \text{m}$$

$$w = mgh \Rightarrow w = 50 \times 10 \times 6$$

$$\text{But } , t = 30 \text{sec} \Rightarrow p = w/t \Rightarrow p = 50 \times 10 \times 6 / 30 \text{ } \therefore p = 100 \text{ W}$$

Q. A ball is dropped from a height of 10m. If the energy of the ball after striking the ground, how much high can the ball bounce ( $g = 10 \text{ms}^{-2}$ ) [Oswaal 2015]

Ans: On reaching the ground the energy of the object = the energy at the top [law of conservation of energy]

$$\text{Energy at the top} = \text{potential energy} = mgh = m \times 10 \times 10 = 100m \text{ joule [let mass be m]}$$

$$\text{Loss of energy} = 40\% \text{ of } 100m \text{ Joule}$$

$$\text{Energy left} = 60\% \text{ of } 100m = 60/100 \times 100m = 60m$$

Now the energy of the object on reaching the top again will be equal to that at the surface = 60m but height will differ

$$P_E = mgh = m \times 10 \times h \quad \text{So, } 60x = 10xh \Rightarrow 60x / 10x = h \Rightarrow h = 6 \text{ meter}$$

∴ The ball bounces back to 6m.

Q. A man drops a stone of mass 2 kg from the top of a building of height 15m when it reaches the ground, find its kinetic energy. How?

Solution:

$$u = 0$$

$$v^2 = u^2 + 2as \Rightarrow v^2 = 2 \times 10 \times 15 = 300$$

$$K_E = \frac{1}{2}mv^2 = 0.5 \times 2 \times 300 = 300\text{j}$$

Q. Two balls have different masses but same kinetic energy. which has more momentum? Justify your answer

Solution: The relation between momentum (p), mass (m) and kinetic energy (E) for a body is given as  $2mE^{\frac{1}{2}}$

$$\text{Thus, we have } p \propto E^{\frac{1}{2}}$$

$$\text{and also } p \propto m^{\frac{1}{2}}$$

so, momentum is directly proportional to the square root of mass.

Now, for body 1

$$p_1 = (2m_1E_1)^{\frac{1}{2}}$$

And for body 2

$$p_2 = (2m_2E_2)^{\frac{1}{2}}$$

Thus, if two body have same kinetic energies ( $E_1 = E_2$ ) the one with greater mass will have more momentum

Q. Give two examples where a body possesses both, kinetic energy as well as potential energy.

Ans: (i) flying areoplane has both K.E and P.E. (ii) A flying bird has both the energies

Q. Calculate the amount of work done in drawing a bucket of water weighing 15 kg from a well of depth 30m.

Answer: Given, mass  $m = 15 \text{ kg}$  ; Acceleration due to gravity,  $g = 9.8 \text{ m/s}^2$  ; Height  $h = 20 \text{ m}$   
Here, work is done against gravity,  $\Rightarrow W = mgh = 15 \times 9.8 \times 30 = 4410 \text{ joules} = 4.41\text{KJ}$