

2. Work and Energy

- **Condition for scientifically work to be done**
 - There must be a displacement
 - Displacement of an object must be in the direction of applied force
- **Work done** by a constant force is defined as

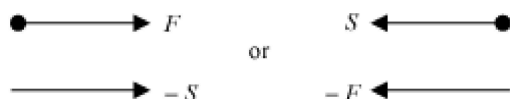
Work = Force \times Displacement [along the direction of force]

$$W = F \times s \text{ [Unit – Joule, } 1 \text{ J} = 1 \text{ N-m]}$$

- Work done against gravity = Weight \times Height = mgh

- **Condition for the Negative Work done**

Force and displacement must be in opposite direction



- **Conditions for no work done**
 - No displacement (e.g. a boy pushes the wall)
 - Displacement occurs perpendicularly to the applied force (e.g. in case of circular motion, there is no work done by the centripetal force)

Energy: Unit – Joule

- **Kinetic energy** (because of motion): It depends on the mass and the speed of the body. Kinetic energy = $\frac{1}{2}mv^2$
- **Potential energy** (Because of position and shape of the body). Potential energy = mgh [gravitational potential energy; h = height, g = acceleration due to gravity]
- **Mechanical energy**: A body is said to have mechanical energy if it possesses either kinetic energy or potential energy or both.
- **Various forms of energy are** Chemical energy, Sound energy, Light energy, heat energy, magnetic energy, and muscular energy.
- Grease and other lubricating substances are used to minimize the energy loss due to the friction.
- **Energy Chain**: The sun's energy reaches us through a series of conversions which is called energy chain i.e the interconversion of energy from one form to various other forms.
- **Conservation of energy**: It states that energy cannot be created or destroyed. It can only be transformed from one form to another.

- **Energy** : Capacity to do work is called energy.
- There are various form of energy e.g. heat energy, mechanical energy, nuclear energy, light energy etc.
- **Mechanical Energy**: It is caused by the motion or the position and configuration of the object.
- **Kinetic energy**: A body possesses kinetic energy by virtue of its motion.

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

- **Proof**

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

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

$$\begin{aligned} W &= ma \times \frac{v^2 - u^2}{2a} \\ &= \frac{1}{2} m(v^2 - u^2) \\ &= \frac{1}{2} mv^2 \text{ [when } u = 0] \end{aligned}$$

The kinetic energy of the wind is used in windmills to generate electricity.

Relationship between kinetic energy and momentum

$$\text{K.E.} = \frac{1}{2} mv^2 = \frac{1}{2} m \left(\frac{p}{m} \right)^2 = \frac{p^2}{2m} \quad (\text{where } K = \text{Kinetic energy})$$

- **Potential energy**: A body possesses potential energy by virtue of its configuration or position.
- **Gravitational potential energy**

$$PE = mgh \quad [h = \text{height of object from the earth surface}]$$

- **Elastic potential energy**

$$U = \frac{1}{2} kx^2 \quad [\text{Where } x = \text{compression or elongation in the spring}]$$

- **Law of conservation of energy**
 - The total amount of energy in a system always remains constant.

$$mgh + \frac{1}{2} mv^2 = \text{constant}$$

Power: It is defined as rate of doing work.

$$P = \frac{W}{t} \quad (\text{Unit - Watt, } 1W = \frac{1J}{1s})$$

$$1 \text{ Horse Power} = 746 \text{ Watts}$$

For electric appliances,

$$\text{power} = \text{voltage} \times \text{current}$$

Energy consumed in time $t = \text{Power} \times \text{time}$.

Power is also defined as the product of force and average speed.

$$P = F \times v$$

- The commercial unit of energy is kilowatt-hour (kWh).

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

- The amount of electrical energy consumed in our house is expressed in terms of ‘units’, where

$1 \text{ unit} = 1 \text{ kWh}$
