

# Work, Energy And Power

## Work – energy theorem

- Work done by net force is equal to the change in kinetic energy of the body

- $W = \vec{F} \cdot \vec{d} = Fd \cos \theta$  (Dot product, hence it is a scalar quantity)

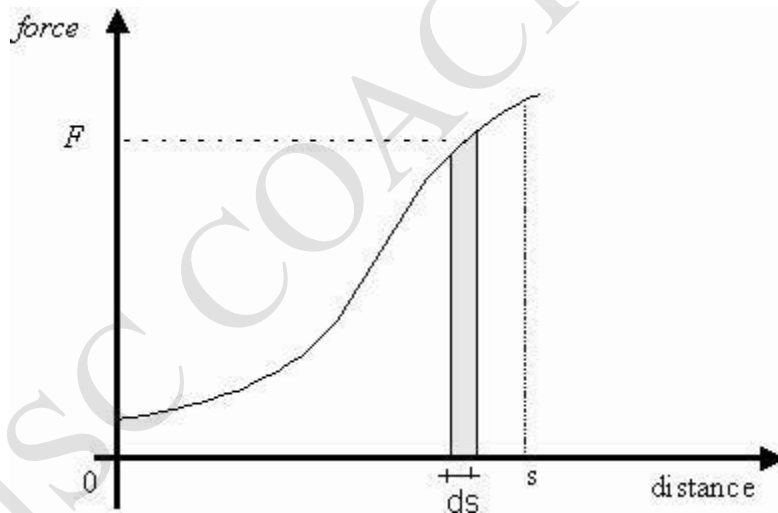
- No work is done if

- displacement is zero
- force is zero
- force and displacement are mutually perpendicular i.e.,

$$\theta = \frac{\pi}{2} = 90^\circ$$

- Kinetic energy,  $K = \frac{1}{2} m \vec{v} \cdot \vec{v} = \frac{1}{2} m v^2$

- Work done by variable force



- Work done is the area subtended by the curve on the distance axis.

$$W = \int_{x_i}^{x_f} F(x) dx$$

**Work – energy theorem for variable force**

$$dK = F dx$$

$$K_f - K_i = \int_{x_i}^{x_f} F dx$$

- **Potential energy**

- For constant force

$$V(h) = mgh$$

- For variable force,

$$\int_{x_i}^{x_f} F(x) dx = - \int_{V_i}^{V_f} dV = V_i - V_f$$

- Conservation of mechanical energy

$$\Delta K + \Delta V = 0$$

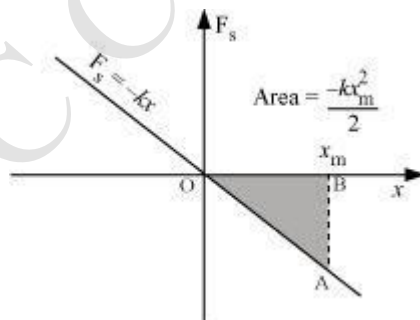
$$\text{For a body, } K_i + V(x_i) = K_f + V(x_f)$$

- For a conservative force, work done on a closed path is zero.

**Potential energy of a spring**

- **Hook's Law :**  $F_s = -kx$  ( $k$  = Spring constant; unit:  $\text{N m}^{-1}$ )

- For compression,  $F_s \rightarrow +ve$  and  $x \rightarrow -ve$
- For expansion,  $F_s \rightarrow -ve$  and  $x \rightarrow +ve$



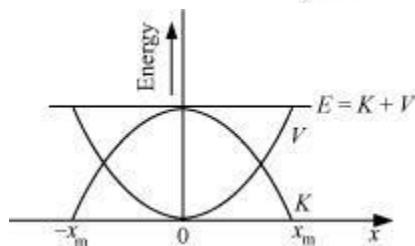
- Work done by a spring,

$$W_s = \int_0^{x_m} F_s \, dx = - \int_0^{x_m} kx \, dx = - \frac{kx_m^2}{2}$$

- Potential energy of the spring.

$$\text{P.E., } V(x) = \frac{kx^2}{2}$$

$$\text{Maximum speed, } v_m = \sqrt{\frac{k}{m}} x_m \text{ (at the equilibrium position)}$$



### Different Forms of Energy

- Internal energy – The sum of kinetic and potential energies of all the molecules constituting the body is called internal energy.
- Heat energy – A body possesses heat energy due to the disorderly motion of its molecules.
- Chemical energy – A body possesses chemical energy because of chemical bonding of its atoms.
  - Exothermic reaction: Heat is released.
  - Endothermic reaction: Heat is absorbed.
- Electrical energy – It is the work done in order to move an electric charge from one point to another in an electric field.
- Nuclear energy – It is the energy released when a heavy nucleus (such as U – 235) breaks up into lighter nuclei on being bombarded by a slow neutron.

### Power

- The rate of doing work is called power. The average power is given by,

$$P_{av} = \frac{W}{t}$$

- Instantaneous power – Limiting value of the average power of an agent in a small time interval, when the time interval approaches zero.

If  $\Delta W$  is work done in a small interval  $\Delta t$ , then instantaneous power is defined as

$$P = \lim_{\Delta t \rightarrow 0} \frac{\Delta W}{\Delta t} = \frac{dW}{dt}$$

### **Types of Collision**

- Elastic collision – Those collisions in which both momentum and kinetic energy of the system are conserved.
- Inelastic collision – Those collisions in which momentum of the system is conserved, but kinetic energy is not conserved.

### **Characteristics of elastic collision**

- total energy of the system is conserved
- linear momentum is conserved
- kinetic energy is conserved

### **Characteristics of elastic collision**

- total energy of the system is conserved
- linear momentum is conserved
- kinetic energy is not conserved