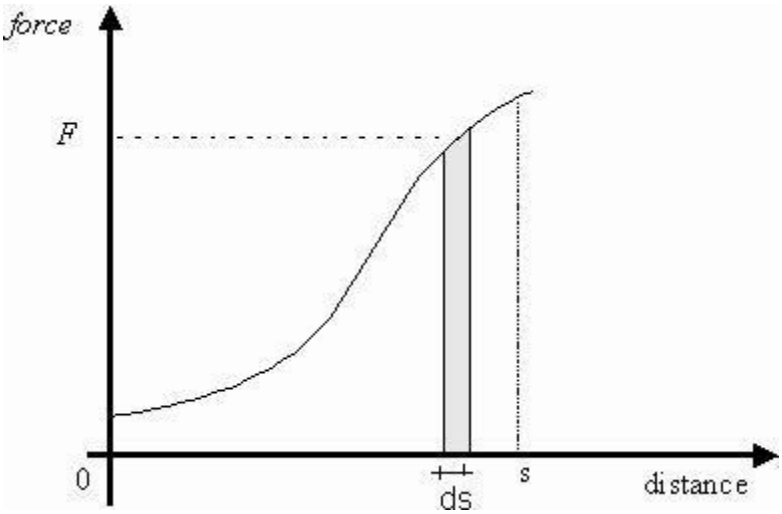
Work, Energy And Power

Work – energy theorem

- Work done by net force is equal to the change in kinetic energy of the body
- $W = \bar{F}.\bar{d} = Fd\ \cos\theta$ (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., $\theta = \frac{\pi}{2} = 90°$
- Kinetic energy, $K = \frac{1}{2}m\bar{v}.\bar{v} = \frac{1}{2}mv^2$
- **Work done by variable force**



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

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

Work – energy theorem for variable force

$$\mathrm{d}K = F\mathrm{d}x$$

$$K_f - K_i = \int_{x_i}^{x_f} F\mathrm{d}x$$

- **Potential energy**

  - For constant force

    $V(h) = mgh$

- For variable force,

  $$\int_{x_i}^{x_f} F(x)\mathrm{d}x = -\int_{V_i}^{V_f} \mathrm{d}V = V_i - V_f$$

- Conservation of mechanical energy

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

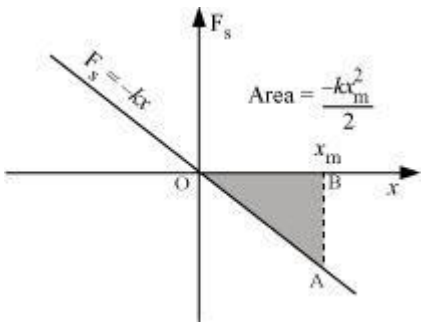
  For a body, $K_i + V(x_i) = K_f + V(x_f)$

- 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: N m^{-1})

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



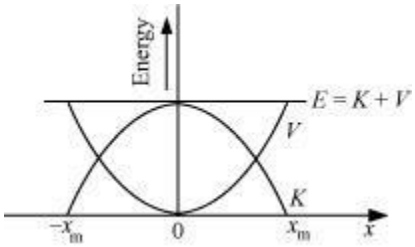
- Work done by a spring,

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

- Potential energy of the spring.

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

Maximum speed, $v_m = \sqrt{\frac{k}{m}} x_m$ (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 ΔW is work done in a small interval Δt, then instantaneous power is defined as

$$P = \underset{\Delta t \to 0}{\text{Lt}} \frac{\Delta W}{\Delta t} = \frac{dW}{dt}$$

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 syatem is conserved
- linear momentum is conserved
- kinetic energy is conserved

Characteristics of elastic collision

- total energy of the syatem is conserved
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