CH # 08 WORK , POWER AND ENERGY

WORK:

“Work is said to be done when a force displaced a body.”

Formula:

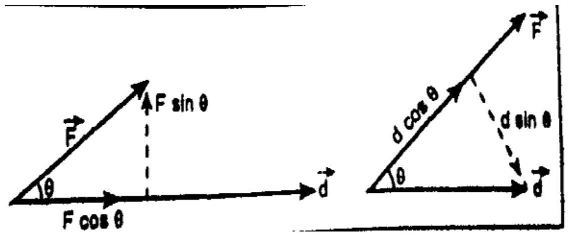
Work = Force x Distance

W = F.S

If Force “F” makes an angel θ with the direction of motion:

W = F S Cos θ

- Work is scalar quantity.



Units:

In S.I system unit of work is Joule (J).
In C.G.S system unit of work is Erg.

- 1 joule = 10^7erg.
- 1Kilo-Joule = 10^3erg.
- 1Mega-Joule = 10^6erg.

- **Work done when inclined force act:**

  Or

  Inclined work done (When θ = θ):

  If constant force *‘F’* is acting on the body at an angle θ with the direction of motion of the body then work is the product of magnitude of the displacement and of the component of the force in the direction of displacement.

  W = (FCosθ) S

  W = F S Cos θ

- **Work done when the force and displacement are in same direction:**

  Or

  Positive work done (When θ = 0^0) / Maximum work done:

  If the force is in the same direction as the displacement, the work is positive. Here θ = 0^0 the work will be positive and maximum.

  W = F S Cos θ

  Where θ = 0^0

  W = F S Cos (0)

  W = F S (1)

  W = F S

- **Work done when the force and displacement are in opposite direction:**

  Or

  Negative work done (When θ = 180^0):

  If the force is in the opposite direction as the displacement, the work is negative. Here θ = 180^0 the work will be negative.

  W = F S Cos θ

  Where θ = 180^0

  W = F S Cos (180)

  W = F S (-1)

  W = - F S

- **Work done when the force is at right angle to the displacement:**

Or

Minimum work done (When $\theta = 90^0$)/Zero work done:

If the force is at right angle to the displacement, the work is minimum. Here $\theta = 90^0$ the work will be zero minimum.

$$W = F\,S\cos\theta$$
$$\text{Where } \theta = 90^0$$
$$W = F\,S\cos(90)$$
$$W = F\,S\,(0)$$
$$W = 0$$

ENERGY:

"The capability of doing work is known as energy."

Unit:

In S.I system unit of energy is Joule (J).

i) KINETIC ENERGY:

"The energy possess by a body due to its motion is called kinetic energy."

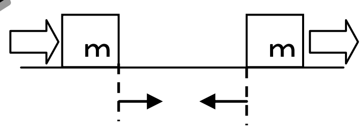
Formula:

$$K.E = \frac{1}{2} mV^2$$

- K.E represents the Kinetic Energy.
- Unit of Kinetic Energy is Joule (J).

DERIVATION OF K.E = ½ mV²:

Consider a body of mass "m". If a force "F" is applied through distance "S" in the horizontal direction so that it's final velocity becomes "V" then work is done given by:



$$W = F \,.\, S \quad \text{\_\_\_\_\_\_\_\_\_\_\_\_ (i}$$

According to Newton's 2nd law of motion:

$$F = ma \quad \text{\_\_\_\_\_\_\_\_\_\_\_\_ (ii}$$

Here

$$Vi = 0 \text{ m/s}$$
$$Vf = V$$
$$S = S$$

Substituting the above values in 3rd equation of motion:

$$2aS = Vf^2 - Vi^2$$
$$2aS = V^2 - 0$$

$$S = \frac{V^2}{2a} \quad \text{\_\_\_\_\_\_\_\_\_\_ (iii}$$

Substituting the value of "F" from eq (ii and the value of "S" form eq (iii in eq (i we get:

$$W = ma \,.\frac{V^2}{2a}$$

$$W = \frac{1}{2} mV^2$$

The work is done appear as kinetic energy. (Therefore W = K.E)

$$\boxed{K.E = \frac{1}{2}mV^2}$$

- Kinetic energy is directly proportional to mass (K.E α m).
- Kinetic energy is directly proportional to square of Velocity (K.E α V^2).

ii) POTENTIAL ENERGY:

"Energy possess by a body due to its position is known as potential energy."

Formula:

$$P.E = mgh$$

- P.E represents the Potential Energy.
- Unit of Potential Energy is Joule (J)

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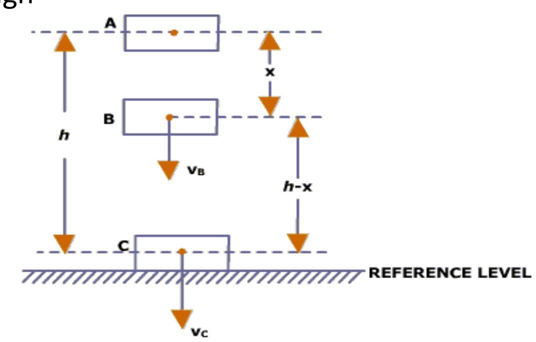

Freely falling body

iii) GRAVITATIONAL POTENTIAL ENERGY:

"The potential energy possessed by body in the gravitational fields called the gravitational potential."

Explanation:

Consider a body of mass 'm' on the ground. If it is lifted up with constant speed through a vertical height 'h' , the force required to raise the body is just equal and opposite to its weight W = mg. Thus work done on it against gravitational field is store in it as gravitational work = mgh.

$$P.E = w.h = mgh$$

iv) ELASTIC POTENTIAL ENERGY:

If a spring is wound, work is done in winding it against the elastic force of spring. This work is stored in the spring is potential energy. This type of potential is due to constrained position of the spring and is called elastic potential energy."

EXPLANATION:

To find the energy stored in a compressed spring, we calculate the work required to compress it. A force 'F' pushes a spring to compress it from its equilibrium position 'O' to some other position 'X', this force is directly proportional to the amount of compression.

$$F \propto x \text{ or } F = K x$$

Where 'K' is force constant (spring constant) its value depends upon how stiff the spring is. Since the compression force is zero at 'O' and 'Kx' at 'x', the average force needed to compress the spring from position 'O' to 'x' is:

$$F_{av} = \frac{O + Kx}{2} = \frac{Kx}{2} = \frac{1}{2}Kx$$

Therefore work done in compressing the spring is $W = F_{av}X$.

$$W = \frac{1}{2}Kx \times x = \frac{1}{2}Kx^2$$

This work causes the elastic potential energy, therefore,

$$\boxed{Elastic potential energy = \frac{1}{2}Kx^2}$$

LAW OF CONSERVATION OF ENERGY:
STATEMENT:

"Energy can neither be created nor be destroyed but it can convert form one form to another form."

EXPLANATION ORINTER CONVERSION OF ENERGY (KINETIC AND POTENTIAL):
One form of energy can be converted into other kinds; hence K.E can be converted into P.E and Vice versa.

EXPLANATION:
Consider an object of mass lying at the height 'h' from earth surface at point 'p'. It possesses potential energy equal to mgh and kinetic energy equal to zero. Let the body be allowed to fall down under the action of gravity. During its downward motion, its height above the ground decreases continuously so its potential energy also decreases. As the body has been accelerating under the action of gravity, hence the work done by it is equal to its kinetic energy. Thus when the body falls freely under gravity and when there is no opposing force there is a continuously decrease in its P.E and this decrease is equal to increase in K.E. When it reaches the surface of the earth its P.E is zero and whole of the energy is kinetic.

Lost in P.E at 'O' = Gain in K.E at 'O'

$$mgh = \frac{1}{2}mV^2$$

POWER:

"Rate of doing work is known as power."

FORMULA:

$$Power = \frac{Work\ done}{Time\ taken}$$

$$\boxed{P = \frac{W}{t}}$$

POWER IN THE FORM OF FORCE AND VELOCITY:
Suppose a constant force 'F' acts on a body and displaces it through distance 'd' in the direction of force in time 't' the work done is,

W = (F) (d)

And average power developed is,

$$P = \frac{W}{t}$$

$$P = \frac{Fd}{t} = F\frac{d}{t}$$

$$\therefore \frac{d}{t} = Average\ velocity$$

$$\boxed{P = F.V}$$

Hence power is the product of force and velocity.

- Power is scalar quantity.
- Power is represented by P.

UNIT:

In S.I system unit of power is Watt (Watt).

1Watt = 1J/S.
1Kw = 10^3 Watt
1Mw = 10^6 Watt

*Old unit of power is “horse power” (hp).
1hp = 746Watt
1hp = 0.746Kilowatt

JOULE:

“Work done is said to be one joule if a force of one Newton displace a body through one meter.”

1 Joule = 1Newton x 1Meter