Chapter 6

Work, Energy and Power

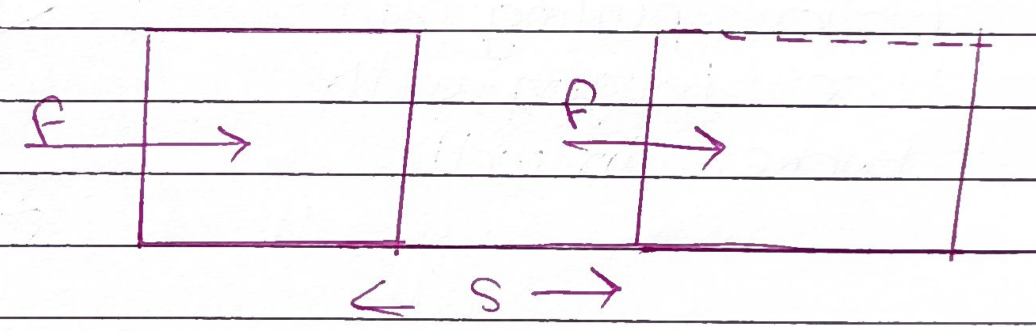
Work :-

Work is said to be done when a body t... some distance (s) by an applied force (f) i... direction of force.

- There are two types of necessary conditions
  1) There must be applied force.
  2) The body must travel some distance
  3)

1) (Imp) when the applied force on the body i... in the direction of distance

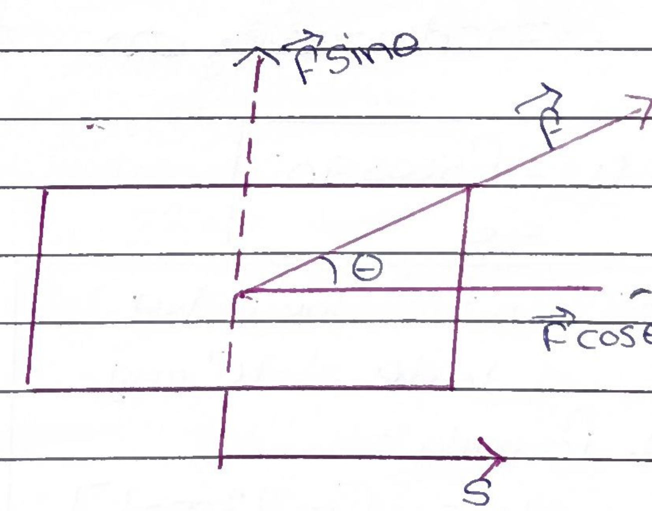
$w = f.s$ (Work = force × displacement)



2) When the force is applied on some angle (θ)
W = f component is the direction of dista... × distance

$w = f\cos\theta . s$

$$\boxed{w = \vec{f} \cdot \vec{s}}$$



Positive work done :-

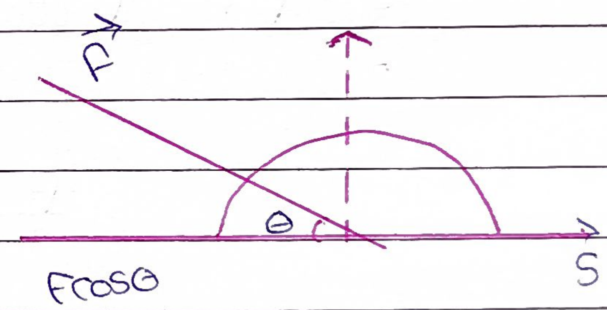
When the component of force acting on the body is in the direction of displacement, then the work done will be +ve

Eg : 1) By the engine of train

Negative work done :-

When the component of force acting on the ~~#~~body is in the opposite direction of displacement, than the work done will be -ve

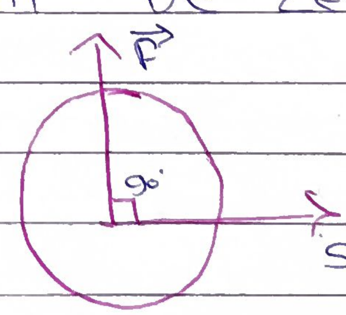
Eg : work done by the friction pulling of rope hanging with bucket in well



Zero work done : ~~when~~ force

When the force acting on the body and is perpendicular to the displacement of the body ~~an~~ and force or displacement is 0 then ~~work~~ work ~~donedone~~ done on the body will be zero.

$$W = Fs\cos 90^\circ$$
$$= 0$$



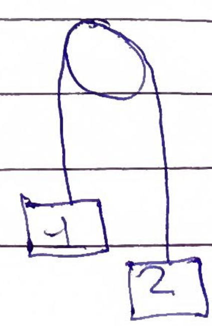
SI unit - Joule kg

1 Joule = 10^7 erg

D. formula =

$W = [M L^2 T^{-2}]$

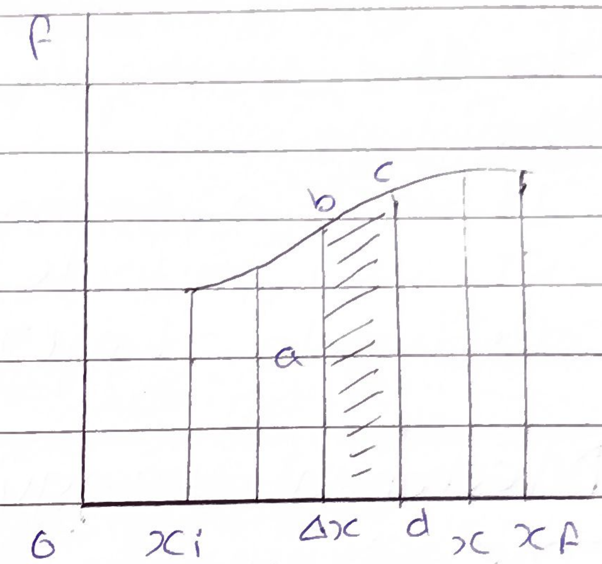
e.g weight lifting pulley system



Work done by a variable force :-

area = a × Δx
work = f . Δx

Suppose a variable force 'F' is acting on a body in same direction let, we have calculate the total work done when the body displaced from initial position (x_i) to the final position (x_f)



when the body displaced by a small displacement Δx then the work done will be

$$w = f . \Delta x = \text{area of rectangle}$$

To calculate the total work done we add all the similar rectangle given by

$$W = \Sigma$$

$$w = \sum_{x_i}^{x_f} f \Delta x$$

When $\Delta x \to 0$ the we can represent work done as:

$$w = \int_{x_i}^{x_f} f dx$$

Energy :

Energy is defined as the capacity or ability of doing work by an object. It is equal to the work done by the force acting on the body
It is a Scalar quantity
SI unit = Joule , erg, ev, Kwh
D. formula = [ML²T⁻²]

Mechanical energy :-

The energy of an object do to all the mechanical means is called mechanical energy.
1) kinetic energy 2) potential energy

1) Kinetic energy :-

The energy possesed by the motion of the object is called K.E.
It is equal to half of product of mass and square of velocity of particle

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

By the constant force F → let a particle of mass 'm' moving with velocity v starting from 'resty by a constant force F

we know,

$v^2 - u^2 = 2as$ also $F = ma$

$v^2 - 0 = \frac{2Fs}{m}$ $a = \frac{F}{m}$

$\frac{mv^2}{2} = fs =$ work done = energy

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

When force is variable -

Small work done by the variable force is given by

$$\boxed{dw = fds}$$

Let the particle initial velocity u, final velocity V

$\vec{F} =$ [illegible] $\quad dw =$ [illegible] $\frac{\;}{dt}$ [illegible] $\quad \left[\frac{ds}{dt} = v\right]$

$= m\frac{dv}{dt}$

$$dw = mv\,dv$$

Integration on both sides :-

prove that workdone on particle by a force is equal to change in K.E

$$\int dw = m\int_u^v v\,dv \qquad \boxed{w = K_f - K_i}$$

$$w = m\left(\frac{v^2}{2}\right)_u^v$$

$$w = m\left(\frac{v^2}{2} - \frac{u^2}{2}\right) = \boxed{w = \frac{1}{2}mv^2 - \frac{1}{2}mu^2}$$

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Potential energy :

Potential energy stored in a body or a system is that energy which is possesed by its position. It is also known as energy of configuration

↳ eg: A body lying on the roof of a building has some potential energy

There are three types of potential energy :

1) Gravitational P.E
2) Elastic P.E
3) Electrostatic P.E

1) Gravitational P.E :

The energy possesed by it's position above the surface of earth is called gravitational P.E

Note : we consider P.E on the surface of earth is 0

Let us consider a body of mass 'm' initially placed on the surface of earth where $h = 0$

Force on the body is $\vec{F} = mg$

When this body is displaced to a height 'h' then work done will be

$w = f \times$ displac..

$w = mg(h-0)$

$\boxed{w = mgh}$

$w = mg(h_1 - h)$

$= mgh_1 - mgh$

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Conservative force :-

The force is conservative if the work done by the force in displacing the particle from one point to another point is independen of path.

Non-conservative force :-

The force is non conservative if the work done by the force in displacing the particle from one point to anther point is dependent of path

P.E is equal to = -ve to the work done

$$\Delta u = -w$$

$$w = \int_{x_i}^{x_f} f dx \qquad \Delta u = -\int_{x_i}^{x_f} f dx$$

$$\boxed{\frac{du}{dx} = -f}$$

-ve force is equal to the potential gradient

$$\boxed{f = -\frac{du}{dx}}$$

It is defined as the, If only conservative force is doing work on a particle then its total mechanical energy remains constant.

conservative force → Mechanical energy cons.

$$K.E + P.E = constant$$

we know that,

change in K.E = work done

$$\Delta K = W$$

$$\Delta K = fdx \quad \text{---} (1)$$

change in P.E = -work done

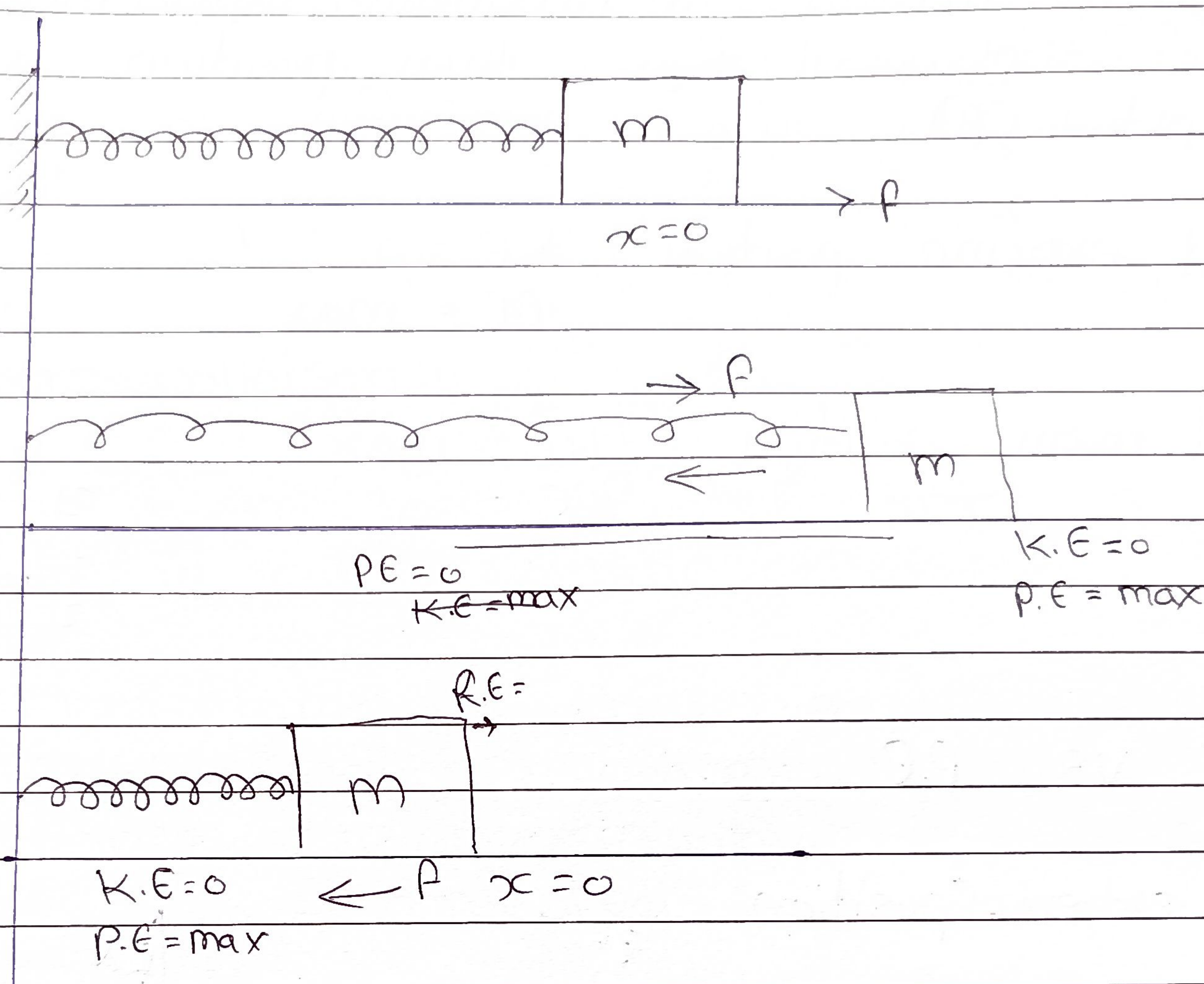
$$\Delta u = -fdx \quad \text{---} (2)$$

$$\Delta K + \Delta u = fdu - fdx$$

$$\Delta K + \Delta u = 0$$

$$K_i + P_i = K_f + P_f$$

Potential energy of a ~~psrin~~ Spring -



$\vec{F} \propto x$

$\vec{F} = -kx$

$dw = fdx$

$\int dw = fdx \int_{x_f}^{x_i} -Kx\,dx$

$w = -k\left(\frac{x^2}{2}\right)_{x_i}^{x_f}$

Extreme -
When the mass is at maximum displacement the displacement from the mean position is called amplitude (A)

At extreme position - KE = 0
PE = max

At mean position = KE = max
PE = 0

$\frac{1}{m} mv^2 = 0$

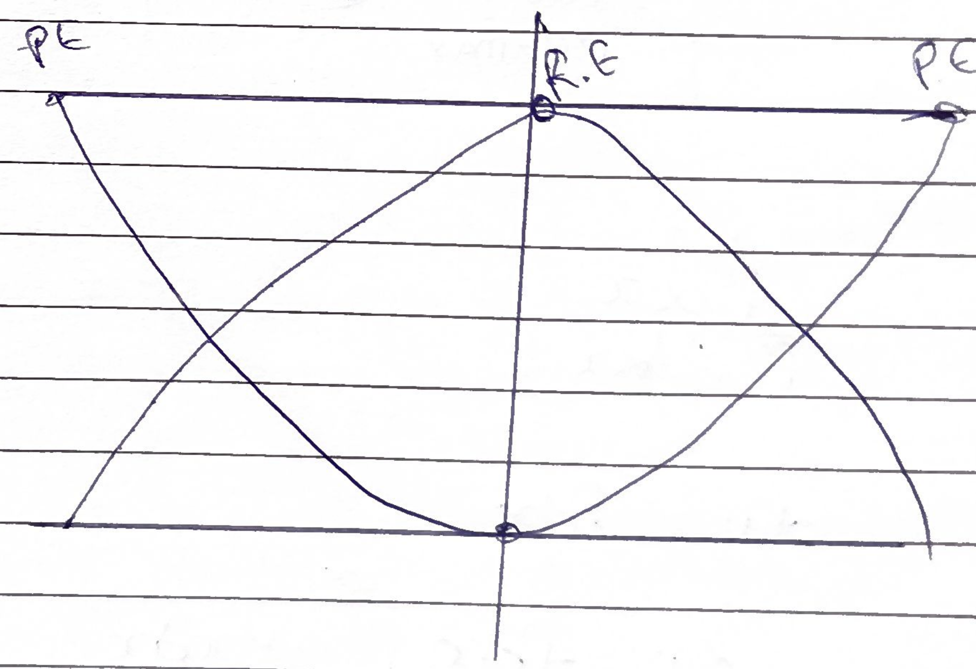
$\frac{1}{2} mv^2 = max$

K.E vs P.E

At extreme position

K.E = 0 PE = max

At mean position
KE = max P.E = 0



Colloison : a colloison is said to occur between two bodies if they physically colloid if the path of one body is affected by the force of other one.

Types of colloison :-

☆ Elastic colloison :

If thaer is no loss of K.E during a colloison is called elastic colloison

- Momentum is conserved
- Total energy is conserved
- forces are conservative
- K.E is conserved

Inelastic colloison :

If there is loss of K.E during colloison is called inelastic colloison.