WORK AND ENERGY

Non zero work:→ displacement in the force's (F's) direction

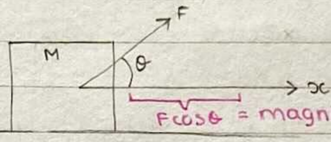
WORK

work = Force x displacement in the direction of force. or disp x Force in the direction of disp

work done by a force is defined as the product of the force and the displacement in the direction of the applied force. +ve and -ve.

No sense of direction

Values of work.



Fcosθ = magnitude of F in x's direction

(i) work = 0 when F ≠ 0 and displacement ≠ 0.

- displacement is ⊥ to the applied force. θ = 90

(• Displacement = 0)

(• Force = 0)

[cos90 = 0. $x \times F \times 0 = 0$]

$W = x \times F$ = x × Force in the direction of x

$= x \times F\cos\theta = Fx\cos\theta$

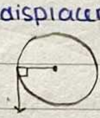
↳ same direction as x.

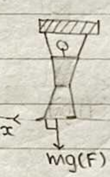
examples:→ carrying a load on your head and walking along a straight road.

→ uniform circular motion (centripetal acc ⊥ velocity and displacement)

(centrifugal and centripetal motions can't do work)

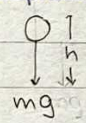
→ Magnetic fields can't do work on moving charges.





(ii) work = POSITIVE

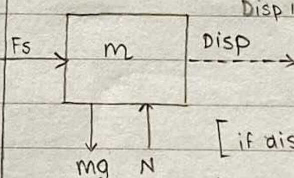
- displacement and force are in the same direction



- Same direction so θ = 0

$F \times x\cos\theta = mg \times h \times \cos 0$

$= mgh \times 1 = mgh$

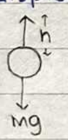


Disp in '→' direction, F '→' direction, so force F_s has done the work

[if disp was ↓ mg(↓) would be the force doing the work and if disp was ↑ N(↑) would be the force doing the work]

(iii) work = NEGATIVE

- displacement in the opposite direction of the force, -ve work by F



- opp. directions so θ = 180°

$F \times x\cos\theta = mg \times h \times \cos 180$

$= mgh \times -1 = -mgh$

OR F = mg disp = -h as it's in the opp. direction

$W = F \times disp = mg \times -h = -mgh$

+ve & -ve work done, force should be external

example.

1) A woman pulls her horse in ← direction, and the horse moves in ← direction (of the F applied).

By woman: positive work on horse

2) A woman pulls her horse in ← direction, but the horse resists and applies a force in the opposite direction. However, he moves in ← direction despite his force.

By woman: positive work on horse.

By Horse: negative work.

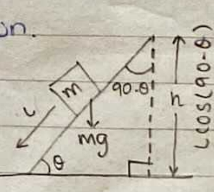
3) " horse resists and applies a force in → direction. The horse moves in → direction.

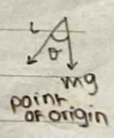
By woman: negative work

By horse: positive work.

F = mg x = h

$W = mg \times L\cos(90-\theta)$





Energy

Mechanical Energy

- if an object can move it contains ME, total M.E = sum of P.E + K.E

Potential energy

- energy possessed by a body by the virtue of its position / configuration. is of three types:

a) gravitational, b) elastic c) electrostatic

a) if a stone falls on glass from a height the glass will break.

b) compressed / stretched spring

c) if 2 alike charges are forcefully brought together they store P.E

- P.E depends on the position of the object.

- P.E of a mass in a gravitational field depends on

(i) P.E ∝ mass (m)

(ii) P.E ∝ height of the object (m) *

(iii) P.E ∝ gravitational acceleration

- P.E = mgh.

(∝ ⊗ as constant → 1)

→ P.E and K.E are: scalar quantities.

S.I unit : Joules (J) C.G.S unit : erg.

$1\ J = 10^7\ erg$

Kinetic energy

- possessed by a moving body. is of three types:

a) rotational b) translational c) vibrational.

a) due to a body's rotatory movement about a fixed point

b) linear motion (in a straight line)

c) vibrations / to and fro motion.

(by virtue of its motion).

- M.K.E = sum of Translational K.E and Rotational K.E (R.K.E = 0)

- K.E depends on

(i) K.E ∝ mass (m)

(ii) K.E ∝ v^2

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

(∝ ⊗ as constant → ½)

* from a reference plain located within the frame of reference. Reference plain ⊥ to g. g ↓ Ref.p →
Ref. frame is usually ground.

Types of P.E

(i) Chemical energy → Petrol has c. energy as it can drive a car

(ii) Electrical energy → electrical charges have e. energy as they can move fans, etc.

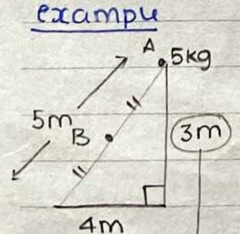
(iii) Nuclear energy → possessed by nucleons inside the nucleus, work: movement of alpha / beta particles.

(iv) Light energy → sunlight falls on solar panels.

(v) Radiated energy → sound energy

Energy of a body is its ability to do work when it applies a force and creates a displacement.
You can't measure energy

example

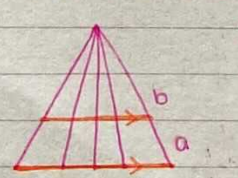


$5^2 = 4^2 + x^2$

$x = 3$

A → 5 × 10 × 3 = 150 J mgh

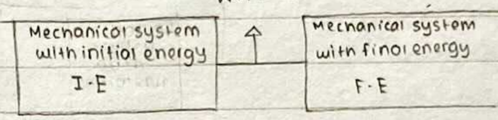
B → 5 × 10 × 1.5 = 75 J mgh



All lines are divided in the ratio a:b

ENERGY TRANSFORMATION

- If there is any change in the total energy of a particle m. work is said to be done by an external agency of force.



[Assumptions : no dissipation of energy,
Internal energies are neglected]

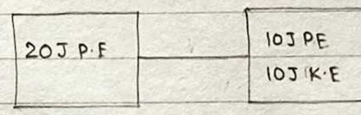
Work done = ΔE = F·E − I·E

- If there is a change in energy from one form to another work is said to be done.

- Change in K·E / P·E in a given system is always = the work done by the external source.

  $W = K{\cdot}E_{(F)} - K{\cdot}E_{(i)}$

  $W = P{\cdot}E_{(F)} - P{\cdot}E_{(i)}$



10 J of work is done

Dissipation of energy – wastage / loss of energy (into other forms) in a way that it cannot be utilized to do useful work.

Law of conservation of energy

Energy can neither be created nor destroyed, but can be transformed from one form to another.

examples:

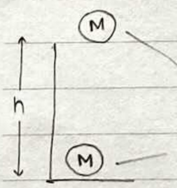
(i) Electrical energy – Kinetic energy   A FAN
(ii) Sound energy – electrical energy   MIKE
(iii) electrical energy – sound energy   LOUDSPEAKERS

Energy can be wasted, but not lost
Sum total of energy in a closed system is always constant
Sum total of KE & PE during a free fall is always constant.

- work done on object in the direction of motion → object gains energy
- work done on object against direction of motion → energy is lost

example

When a ball is thrown up : mg (force) → negative work.
our hands → positive work
Total work done = $\Delta K{\cdot}E$



PE = mgh = 10mh
KE = 0

PE = 0
KE = $\frac{1}{2}mv^2$

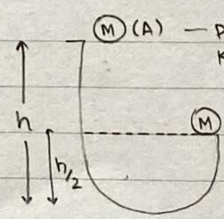
Near the ground

$\frac{1}{2}mv^2 = 10mh$

$v^2 = 20h = 2\times10\times h$

$= 2gh \quad v = \sqrt{2gh}$

Velocity at bottom



M (A) — PE = mgh
KE = 0

M (B) — PE = mgh/2
KE = $\frac{1}{2}mx^2$

(A) (B)

$mgh = \frac{mgh}{2} + \frac{mx^2}{2}$

↓

$x = \sqrt{gh}$

Velocity ½ way down

WORK DONE [Fuel (chemicals) → carb (mix fuel+air) → Ignition (heat, light, sound = dissipated energy)