SLO Based Quick Revision Notes

batch: 2022-23 @sochbadlobyMAK

WORK & ENERGY

student: Aimen Jamil

	Work	Energy
definition	→ Work is the ability to supply force and a change in displacement	→ Energy is the ability to supply or create work.
equation	→ $W = F \cdot d$	→ There are various equations depending upon the types of energy.
relation	→ The components of the force are parallel to displacement.	→ Energy is the result of the work performed.
example	→ Driving a car upto hill	→ Light energy, heat energy

→ WORK DONE:

→ **definition:**

- When constant force is applied on a body and it covers the displacement in the direction of force then work is done.

→ **formula:** $W = (f \cos\theta) d$

→ **quantity:** scalar

→ **dimensions:** $[ML^2T^{-2}]$

→ **units:** Joules, Nm, kgm^2s^{-2}

→ Cases:

1. **Maximum work done (+ve)**, if $\theta = 0°$
   $W = Fd\cos\theta = Fd\cos(0°) = +Fd$
2. **Maximum work done (-ve)**, if $\theta = 180°$
   $W = Fd\cos\theta = Fd\cos(180°) = Fd(-1) = -Fd$
3. **Zero work**, if $\theta = 90°$
   $W = Fd\cos\theta = Fd\cos(90°) = 0$

Work done by Constant force

→ Work done may be +ve, zero, or -ve, depending on angle between force and displacement.

Work done by Variable force

→ In many cases the force does not remain contant for e.g. when rocket moves away.

→ Work done in this case is

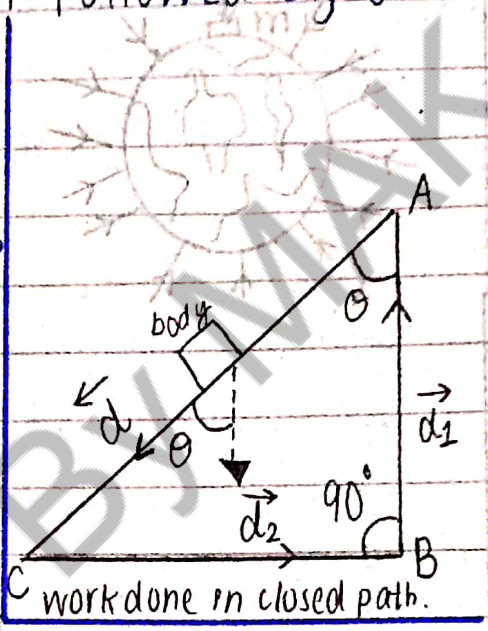
$$W = \sum_{i=1}^{i=n} (F_{xi} \cos\theta_i)\, \Delta d_i$$

Work done in gravitational field

→ **definition:**

In gravitational field, the work done is independent of path followed by a body in a closed path.

→ Consider this figure:



(i) Work done b/w C & B:

$\Delta W_{C\to B} = w \cdot d_2 = wd_2 \cos 90°$

$\boxed{\Delta W_{C\to B} = 0}$

(ii) Work done b/w B & A:

$\Delta W_{B\to A} = wd_1 \cos 180° = wd_1(-1)$

or $\boxed{\Delta W_{B\to A} = -wd_1}$

(iii) Work done b/w A & C:

$\boxed{\Delta W_{A\to C} = wd\cos\theta = w(d\cos\theta)} \to (1)$

Since, $d_1 = d\cos\theta$, Then eq (1) becomes,

$\Delta W_{A\to C} = w(d\cos\theta) = wd_1$

$\boxed{\Delta W_{A\to C} = wd_1}$

Total work done in closed path 'ACBA' will be; $W_T = \Delta W_{C\to B} + \Delta W_{B\to A} + \Delta W_{A\to C}$

Putting values, then

$W_T = 0 + (-wd_1) + wd_1 = 0$

Thus, $\boxed{W_T = 0}$

ENERGY	POWER
definition	
Energy is the capacity to do work.	Power is the rate at which work is done, or energy is transmitted.
units	
Joules (J)	Watt ∴ 1 watt = Js^{-1} ∴ 1 hp = 746 watts
formula	
There are various equations depending upon types of energy.	$P = \frac{W}{t} = \frac{\vec{F}\cdot\vec{d}}{t} = \vec{F}\cdot\vec{V}$
common symbol (s)	
W	P
example	
I left a 60W light bulb on for 30 days, which raised my electricity bill by 43.2 kWh.	My car's battery can provide 500 amps at 12 volts, which equals 6kW of power.

Conservative forces	Non-conservative forces
definition	
work done is independent of the path	work done depends on the path.
energy dissipation	
Total energy remains constant.	energy dissipated as heat energy.
example	
i) elastic spring force ii) electrostatic force iii) Gravitation force	i) The force due to air resistance ii) Tension in a string

Average Power	Instantaneous Power
definition	
• The total work 'ΔW' done by a body in total time 'Δt'	• The rate of doing work in any instant of time
formula	
• $P_{av} = \left[\frac{\text{total work done}}{\text{total time}}\right]$	• $P_{inst} = \lim_{\Delta t \to 0} \left[\frac{\Delta W}{\Delta t}\right]$

Kinetic energy	Potential energy
definition	
• Energy in the body due to it's motion	• Energy in a body due to it's position
formula	
• $K.E = \frac{1}{2} mv^2$	• $P.E = mgh$
transferability	
• K.E can be transformed from one moving object to another	• Potential energy can not be tranferred.
SI Unit	
• Joule (J)	• Joule (J).
determining factors	
• speed/velocity and mass	• Height or distance and mass
example	
• waterfall (flowing water)	• water at the top of waterfall before precipice.

Efficiency:

- **definition:**
- Mechanical efficiency is the ratio of work output to work input.
- **fact:** (Scalar quantity) (No unit)
- The efficiency of an ideal machine = 100%.
  The efficiency of an actual machine = < 100%.

→ **OUTPUT**

- If a machine moves a Load W through a distance h, then the useful work done by machine is called output.
- Output = Load x distance h

$$Output = F_{out} \times D_{out}$$

INPUT

- If an effort F_{in} acts through a distance D_{in} then the work done on the machine is called input.
- Input = Effort force x Effort distance

$$Input = F_{in} \times D_{in}$$

→ **Formula:** Efficiency = output work / input work

$$Efficiency = \frac{F_{out} \times D_{out}}{F_{in} \times D_{in}}$$

∴ **% efficiency** = output work / input work x 100%

→ **Example:**

Diesel engine = (34-40)% efficiency
steam turbine = (34-46)% efficiency

Absolute Potential Energy

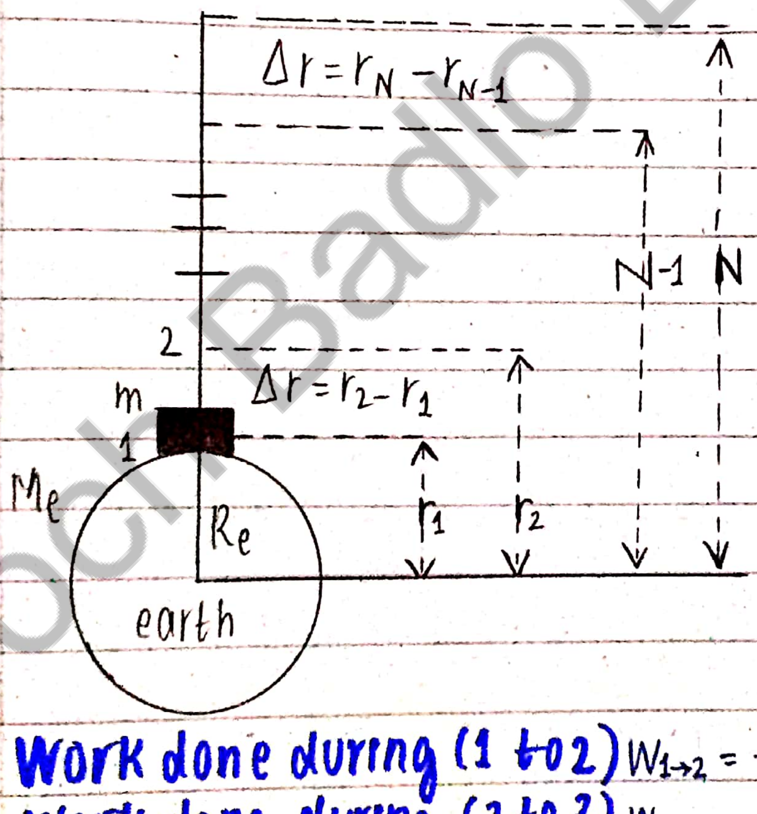
→ **definition:**

- The potential energy possessed by a body at a certain height in a gravitational field with respect to reference point of zero potential is known as absolute potential energy.

→ **formula:**

Absolute potential energy $= -\dfrac{GmM_e}{R_e}$

→ **figure:**



→ **Work done during (1 to 2)** $W_{1\to2} = -GMm\left[\frac{1}{r_1} - \frac{1}{r_2}\right]$

→ **Work done during (2 to 3)** $W_{2\to3} = -GMm\left[\frac{1}{r_2} - \frac{1}{r_3}\right]$

→ **work done during (N-1 to N)** $W_{N-1\to N} = -GMm\left[\frac{1}{r_{N-1}} - \frac{1}{r_N}\right]$

→ **work done during point 1 to N** $\Delta W_{1\to\infty} = -\frac{GmM_e}{r_1}$

$$\boxed{U = -\frac{GM_em}{r}} \qquad \boxed{U_g = -\frac{GM_em}{R}}$$

ESCAPE VELOCITY:

→ **definition:**

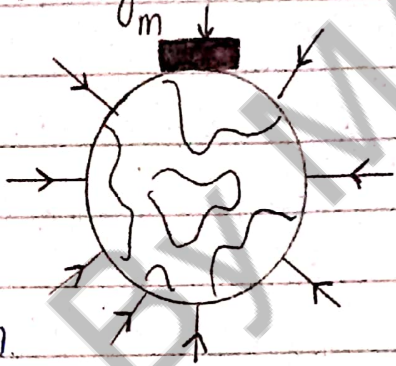
- The initial velocity, which a projectile must have at the earth's surface in order to go out of earth's gravitational field, is known as escape velocity.

→ **formula:**

- $V_{esc} = \sqrt{2gR_e}$

∴ value of escape velocity on earth = 11.2 km/s

→ **factors:**



→ It depends upon:

a. Mass of planet

b. Radius of planet

c. Gravitational acceleration.

→ Work energy theorem in resistive medium:

Hammer falling on the nails by driving it into wood

→ Consider a hammer is lifted to height "h" from A to B. As it moved with uniform velocity i-e in equilibrium so applied force = mg. Work done on hammer is:

Work done on hammer = (Force)(displacement)

(in equilibrium $f = mg$) $= (mg)(h) = mgh$

→ Conservation of energy:

Energy can neither be created nor destroyed but can be transformed from one form into another, but total amount of energy remains constant.

Renewable resources	Non-renewable resources
definition	
• Non-conventional sources of energy are ~~also~~ called renewable resources (continously renewed by nature)	• conventional sources of energy are called non-renewable resources
renovation	
• These resources can be easily replenished.	• These resources take reasonable time for their renewable.
also known as	
• They are also known as inexhaustible resources.	• They are also known as exhaustable resources.
effects on environment	
• They are environmental friendly	• They cause pollution.
quantity	
• They are abundant.	• These resources are scarce.
example	
• Examples: air, wind, water, soil, solar energy. wind energy	• Examples: minerals, fossil fuels, nuclear energy, oil, natural gas.