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Where Minds Pollinate

Class 11
Physics

Chapter 5

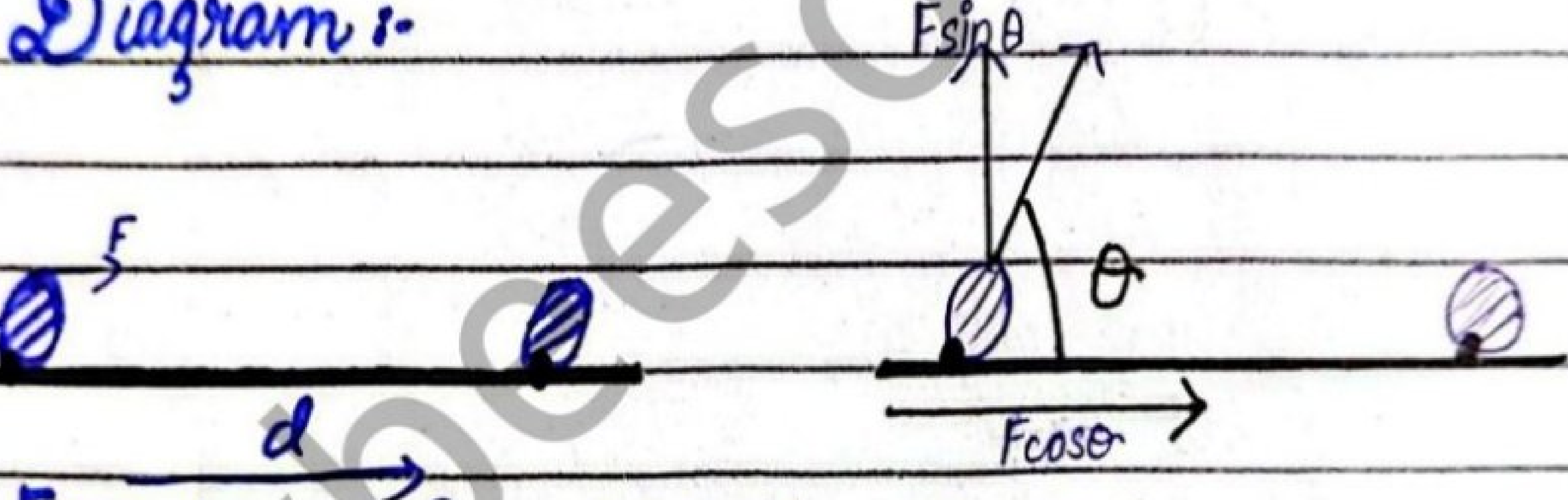
Handwritten Notes

Chapter # 05

Work and energy.

Work:- When a force acts on an object and displace it in direction of force, we say that work is done by force on that object. The dot/scalar product of force acting on object and displacement travelled by object is called work.

Diagram:-



Formula:- By definition of work

$W = \vec{F} \cdot \vec{d} = Fd\cos\theta$

$W = Fd\cos\theta = (F\cos\theta)d$

Unit:- Work is represented by W. It's a scalar quantity.

$W = Fd\cos\theta$

$W = Nm = \text{Joule} = J$

Diamensions of work: $[ML^2T^{-2}]$

Types of Work done by a force:-

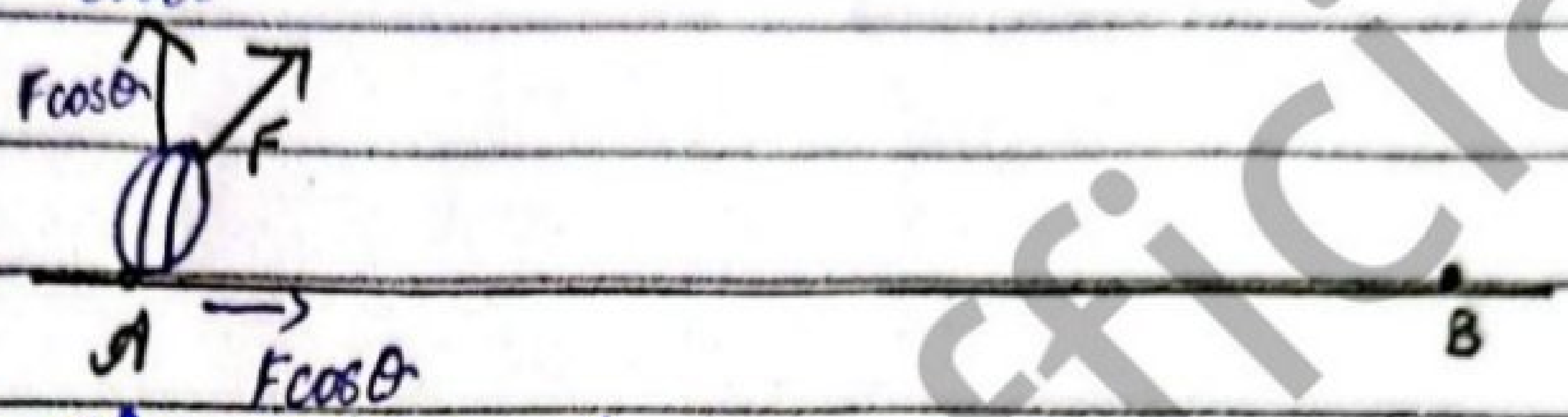
There are 4 types of work:-

i) Positive work
ii) Zero Work
iii) Negative Work
iv) Maximum Work

Positive Work:- Work done by a force on an object will be positive when atleast one component of force is in direction of displacement i.e when

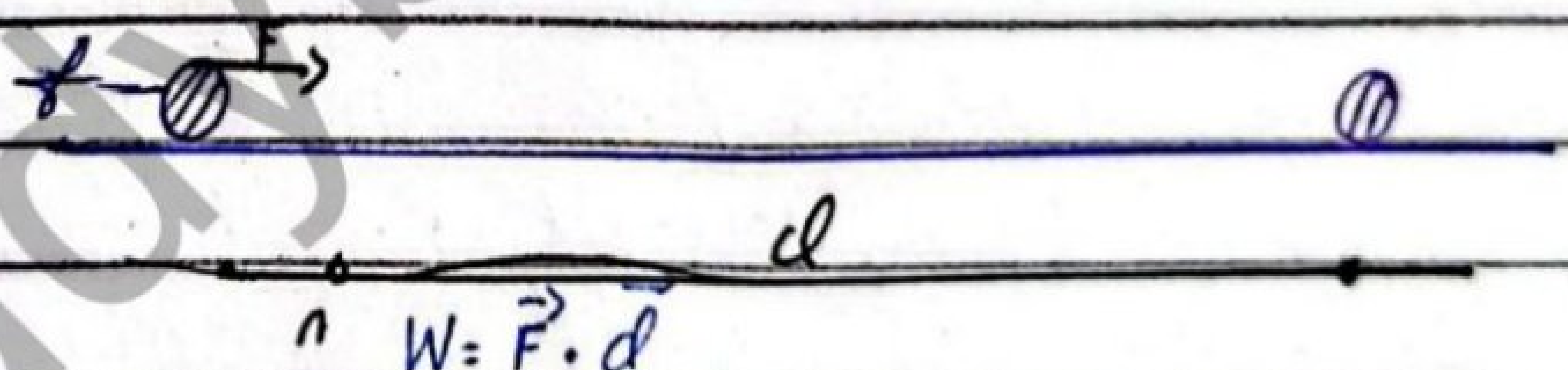
$$0^\circ \leq \theta < 90^\circ$$

Example:- Work done by force while pulling a cart



Negative Work done:- Work done by a force on an object will be negative when there is no component of force in direction of displacement. Force is in direction opposite to displacement.

Example:- Work done by friction on a sliding cart.



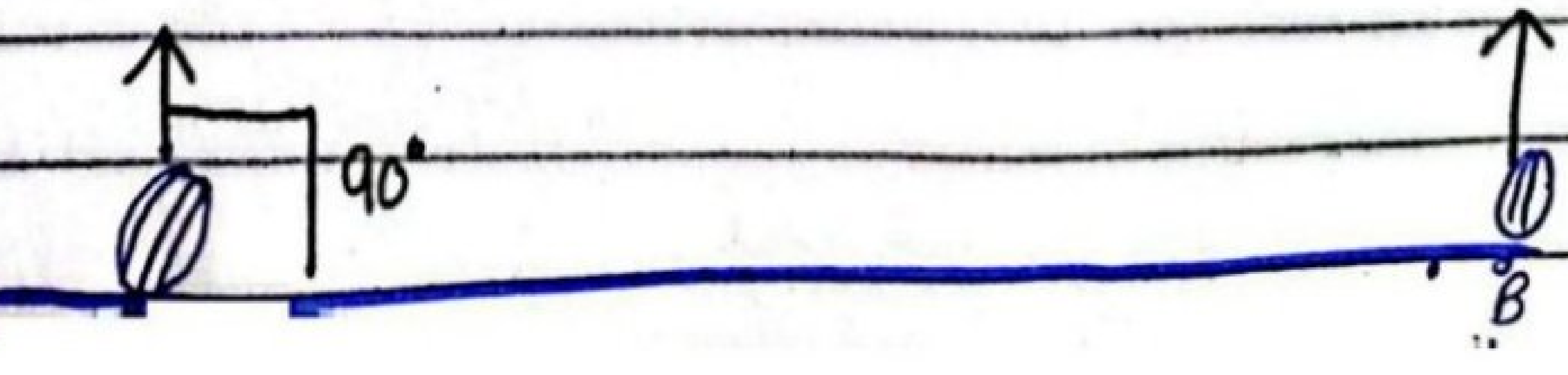
$$W = \vec{F} \cdot \vec{d}$$

$$W = Fd\cos\theta = fd\cos 180^\circ$$

$$W = -fd$$

Energy is being extracted from body.

Zero Work:- Work done by force on the object will be zero if force is perpendicular to displacement travelled.



$$W = \vec{F} \cdot \vec{d} = Fd\cos\theta$$

$$W = Fd\cos\theta = Fd\ (0) = 0$$

$$W = 0$$

4). Maximum Work done by Force:-

Work done by force on object will be maximum only when compelete force is in direction of displacement:-

$$\theta = 0$$

$$W = \vec{F} \cdot \vec{d} = Fd\cos\theta$$

$$W = Fd\cos(0)$$

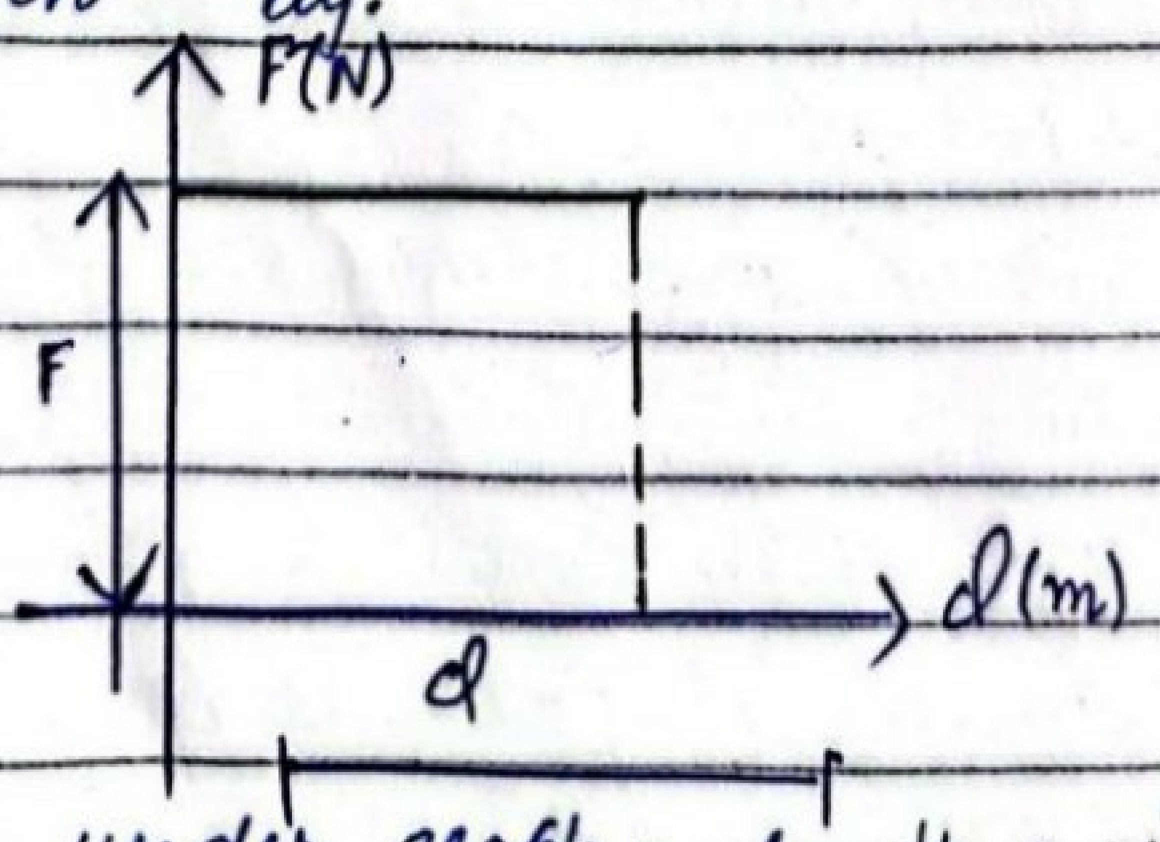
$$W = Fd(1)$$

$$W = Fd$$

Work done from displacement/force graph:-

Area under force-displacement graph gives the work done by force on object

Work done by constant force:- Suppose particle is displaced by a constant force "F" in direction on displacement, then graph is given by.



Area under graph = length x width

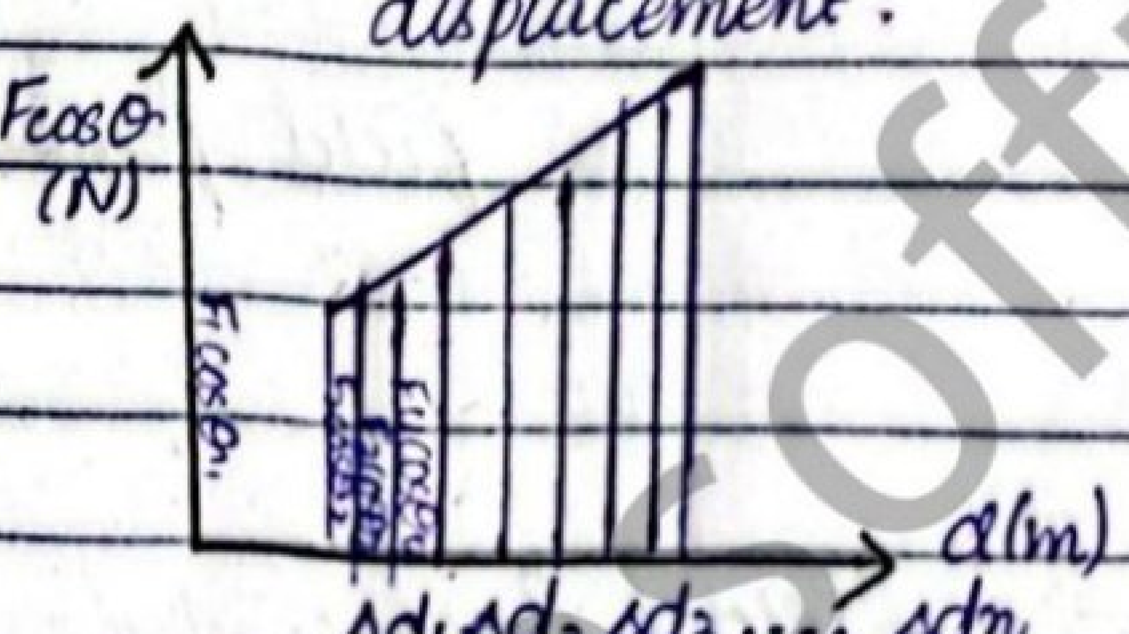
$= dF_1 = Fd =$ Work

Area under force displacement graph

$: W = F \times d$

Work done by variable force :-

If force does not remain constant during process of work done and displacement travelled, then we divide the displacement of small patches and take corresponding component of force in direction of displacement.



$W_1 = (F_1 \cos\theta_1)\Delta d_1 = F_1 \Delta d_1 \cos\theta_1$

$W_2 = (F_2 \cos\theta_2)\ \Delta d_2 = F_2 \Delta d_2 \cos\theta_2$

$W_3 = (F_3 \cos\theta_3)\ \Delta d_3 = F_3 \Delta d_3 \cos\theta_3$

$W_n = (F_n \cos\theta_n)\Delta d_n = F_n \Delta d_n \cos\theta_n$

$W_t = W_1 + W_2 + W_3 + \dots + W_n$

$= F_1 \Delta d_1 \cos\theta_1 + F_2 \Delta d_2 \cos\theta_2 + F_3 \cos\theta_3 - -$

$- - - F_n \Delta d_n \cos\theta_n$

$$W_t = \sum_{i=0}^{n} F_i \Delta d_i \cos\theta_i$$

Field:- The region or space around an object in which other objects can experience a force or influence of an object is called **field**. Energy mass, charge and magnet has a feild around itself.

Field force:- A force that does not receive any physical contact to be applied on an object is called **field force**

Example:- electric, gravitational and magnetic forces are field forces.

Conservative field / force:- A force or field that satisfies following conditions:

-> Work done on the object by this field/ force in moving it from air position to another position. Position is independent of path followed.

-> Work done by the field force on the object in moving it and a close path always remain zero.

Example:- gravitational and field forces are conservative fields.

Non-conservative field/ forces:- A force or field that satisfies following two conditions:-

-> Work done on the object by the field depends upon path followed.

-> Work done on the object by the field in a closed path is not zero

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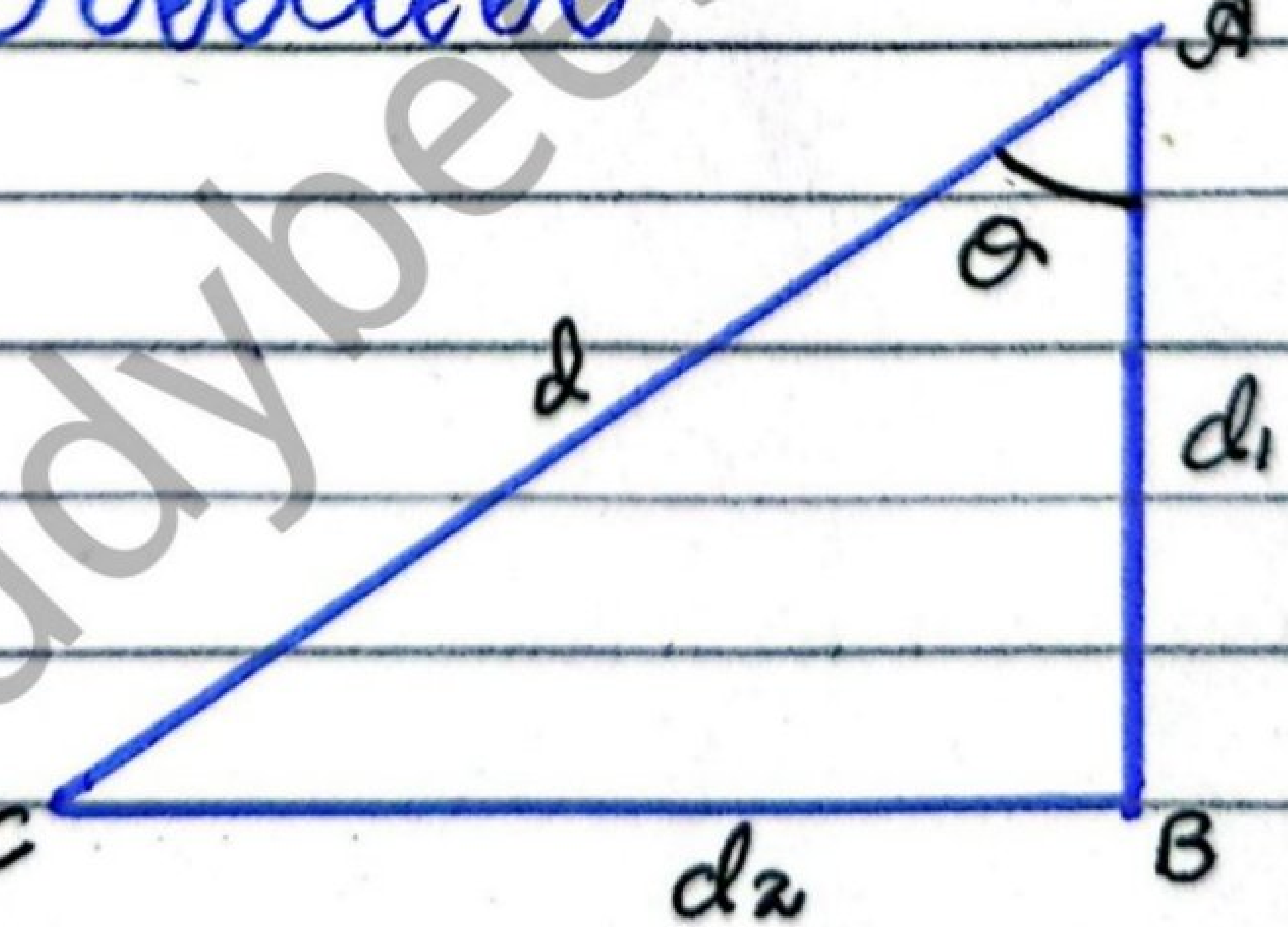
Gravitational field as conservative



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a particle of mass "m" and weight $W = mg$ is moved in gravitational field from A to C. and work done on the object by gravitational field is considered. We ~~will~~ want to prove that gravitational field is a conservative field

Condition #01

Path 01:-

$W_{AB} = Fd\cos\theta$

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$W_{AB} = mgd_1 \cos(0)^\circ = mgd_1 (1)$

$W_{AB} = mgd_1$

$W_{BC} = Fd\cos\theta$

$W_{BC} = 0$

$W_T = W_{AB} + W_{BC}$

$= mgd_1 + 0$

$W_T = mgd_1$

Path 02:-

$W_{AC} = Fd\cos\theta$

$W_{AC} = (mg(d\cos\theta)$

$W_{AC} = mgd_1$

Hence, work done by gravitational field on the object is independent of path followed

Condition 02:-

$W_{CB} = Fd\cos\theta$

$= mgd_2 \cos(90)$

$W_{BC} = 0$

$W_{BA} = Fd\cos\theta$

$= +mgd_1 \cos(180) = mgd_1 (-1)$

$W_{BA} = -mgd_1$

$W_{AC} = Fd\cos\theta = mg(d\cos\theta)$

$W_{AC} = mgd_1$

$W_T = W_{CB} + W_{BA} + W_{AC}$

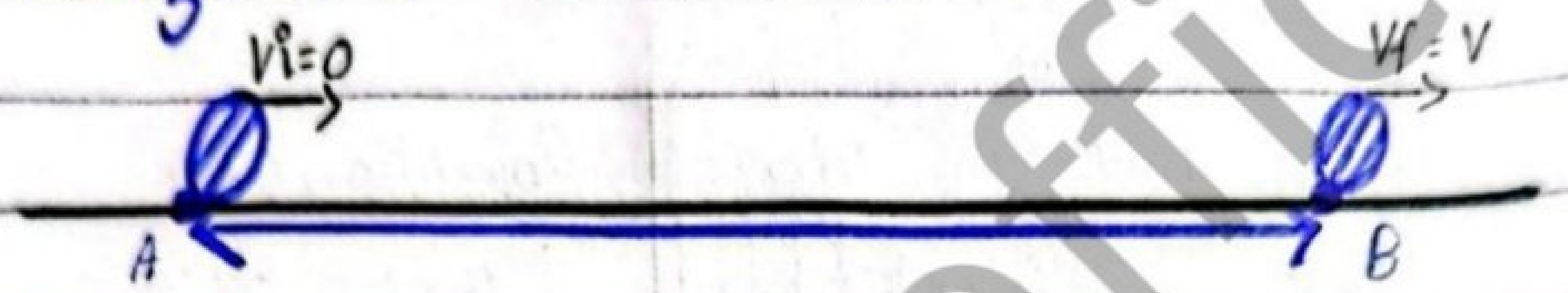
$= 0 - mgd_1 + mgd_1$

$W_T = 0$

Kinetic Energy

The energy possesed by a body due to its motion is called "Kinetic energy".
It is represented by K.E. It is a scalar quantity. It unit is Joule (J)

Diagram:-



Consider a particle of mass "m" which is at rest at point A. Now, A constant force "F" acts on the particle and move through a distance "S". During this work is done on the particle and this work appears as K.E at particle

By definition:-

$$K.E = W$$

$$K.E = F \times S \rightarrow (A)$$

We know that:-

$$F = ma \rightarrow \text{equation}(1)$$

$$2as = Vf^2 - Vi^2$$

$$S = \frac{Vf^2 - Vi^2}{2a} \rightarrow \text{equation}(2)$$

$$K.E = FS$$

$$= (ma)\frac{(Vf^2 - Vi^2)}{(2a)}$$

$$= m\frac{(Vf^2 - Vi^2)}{2}$$

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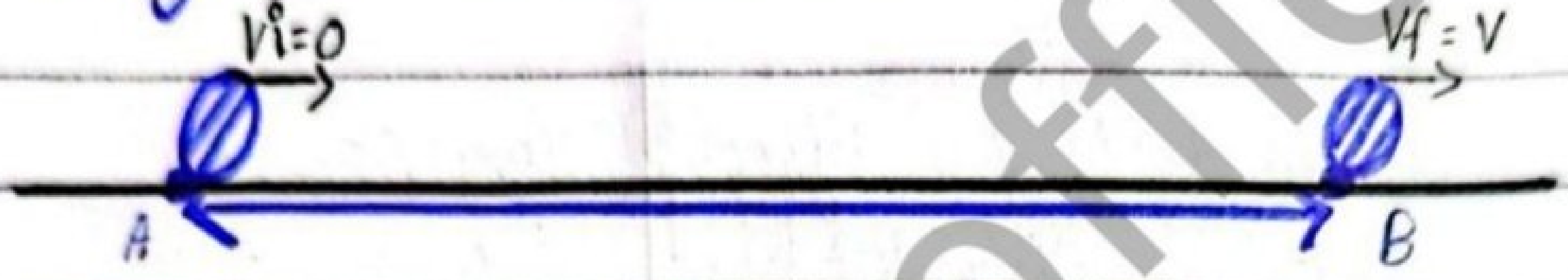

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$$S = \frac{V_f^2 - V_i^2}{2a} \rightarrow \text{equation (2)}$$

$$K.E = FS$$

$$= (ma)\frac{(V_f^2 - V_i^2)}{(2a)}$$

$$= m\,(V_f^2 - V_i^2)$$

9 October, 2025 Thurs

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$$= \frac{mV_f^2 - mV_i^2}{2}$$

$$K.E = \frac{mV_f^2}{2} - \frac{mV_i^2}{2}$$

But; $V_i = 0$, $V_f = V$

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

- **Work- Kinetic energy theorem:-** Work done by particle by an external force in an absence of any resistive force is equal to change in Kinetic energy of particle. This statement is called Work- kinetic energy theorem.

Mathematically:-

We know that :-

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

But $K.E = W$

Therefore

$$W = \tfrac{1}{2}mV_f^2 - \tfrac{1}{2}mV_i^2$$

$$W = (K.E)_f - (K.E)_i$$

$$W = \Delta K.E$$

- **In presence of resistive forces:-** Work done by all the forces (conservative and non-conservative) on an object is equal to change kinetic energy of the particle. This is statement of unit - Kinetic Theorem in presence of resistive (non- resistive) forces

Mathematically:-

We know that:-

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

But :- $K \cdot E = W$

$$W_f = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2$$

$$W + W_r = (K \cdot E)_f - (K \cdot E)_i$$

$$W + (-W_r) = \Delta K \cdot E$$

$$W - W_r = \Delta K \cdot E$$

$$W = \Delta K \cdot E + W_r$$

$$\Delta K \cdot E = W - W_r$$

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Input of mechanical machines:-

The energy supplied to the machine to perform some specific task is called "input of a machine".

The Formula for input :- $P \times d = F_i \times d_i$

Input :- $P \times d = F_{in} \times d_{in}$

Output of mechanical machine :-

The useful work done by the machine for us on the expanse of our input is called output of machine.

The formula of output $= W \times D = F_o \times d_o$

Output $= W \times D = F_o \times d_o$

Efficiency:-

The capability of a machine to convert input to useful output is called efficiency of any machine. It is ratio of useful output of machine and Total input given to machine.

Formula:-

$$\text{Efficiency} = \frac{\text{useful output}}{\text{Total input}}$$

$$n = \frac{W \times D}{P \times d}$$

$$\% n = \left(\frac{W \times D}{P \times d} \right) \times 100\%$$

Efficiency is ratio of two similar quantities ... units and dimensions

Ideal machine:-

A hypothetical machine that has no- friction and energy losses. It converts all the inputs given to it, compeletely into useful outputs. It has 100% or 1% efficiency. For it,

input = useful output

Problem # 01

Given Data:- $m = 1500\ kg$

$\theta = 30^\circ$

$H = 2m$

To find:- $W = ?$

Calculation:- Work done by the gravity is eqiual to change in potential energy.

$W = FS\cos\theta = mgh \cos\theta^\circ$

$W = mgh$

$W = (1500)(9.8)(2)$

$W = 29,400\ J$

Problem 02

Given Data:-

$V_i = 11.11\ ms^{-1}$

$V_f = 0$

$m = 1500\ kg$

To find:- $W = ?$

Calculations:- Work required is equal to the change in kinetic energy

$$W = \frac{1}{2} m V_f^2 - \frac{1}{2} m V_i^2$$

$$W = 1/2 (1500)(0)^2 - 1/2 (1500)(11.11)^2$$

$$W = -92.6 KJ$$

Problem # 03

Given Data:- $f = 0.4N$

$m = 0.1 kg$

$h = 30m$

To find:-

Kinetic energy = ?

Calculations:-

According to conservation of energy:-

K.E = Total energy - friction loss

$K.E = mgh - fh$

$K.E = (0.1)(9.8)(30) - (0.4)(30)$

$K.E = 17.4 j$

Problem # 04

Given Data:- $m = 1200 kg$

$V_i = 20 ms^{-1}$

$V_f = 0$

$S = 50 m$

To find:- Kinetic energy = ?

$F = ?$

Calculations:-

a).

We know that:-

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

$K.E = \frac{1}{2} (1200)(20)^2$

$K.E = 240,000 \, j$

b).

$W = \frac{1}{2} mv_f^2 - \frac{1}{2} mv_i^2$

$FS = \frac{1}{2} (1200)(0)^2 - \frac{1}{2} (1200)(20)^2$

$FS = -240,000$

$F = \frac{-240,000}{50}$

$F = -4800 \, N$

Problem # 05

Given Data:- $m = 500 \, kg$

$V = 5ms^{-1}$

$h = 30m$

To find:- $V = ?$

Calculations:-

Total energy = K.E + P.E

$T.E = 1/2 \, mv^2 + mgh$

$T.E = \frac{1}{2} (500)(5)^2 + (500)(9.8)(30)$

Total energy:- 153250 j

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(b)

Final kinetic energy = Total energy

$$(K \cdot E)_f = T \cdot E$$

$$\frac{mV_f^2}{2} = T \cdot E$$

$$V_f = \sqrt{\frac{2(T \cdot E)}{m}}$$

$$V_f = \sqrt{\frac{2 \times 153250}{500}}$$

$$V_f = 24 \cdot 76\, ms^{-1}$$

Problem #06

Given Data:- $\eta = 0.26$

output = 50,000 j

To find:- input = ?

Calculation

We know that

$$\eta = \frac{output}{input}$$

$$input = \frac{output}{\eta}$$

$$input = \frac{50,000}{\eta}$$

$$input = \frac{50,000}{0.25}$$

$$input = 200,000\, j$$

Problem # 07

Given Data:-

$P_i = 600\,W$

$\eta = 15\%$

$t = 3600\,s$

To find:- useful output = ?

Calculations:-

Total input $= P_i \times t$

$= 600 \times 3600$

input $= 216000\,J$

output $= 15\% \times$ input

$= \frac{15}{100} \times 216000$

output $= 324000\,J$