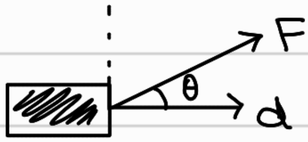
CH 4 WORK & ENERGY.

Work.

A FORCE DISPLACES or STOPS a moving body through a certain distance.

$$W = \vec{F} \cdot \vec{d} = Fd\cos\theta.$$ (W → Scalar.)



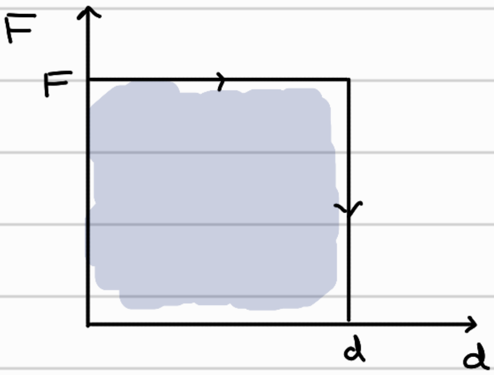
CASES:

1) $\theta < 90^\circ \Rightarrow W > 0$
2) $\theta = 90^\circ \Rightarrow W = 0$
3) $\theta > 90^\circ \Rightarrow W < 0$ → eg: friction.

SI unit: $[F] = N$ or $kg\,m\,s^{-2}$; $[d] = m$

$[W] = kg\,m^2 s^{-2}$ or Nm . $=$ Joule (J).

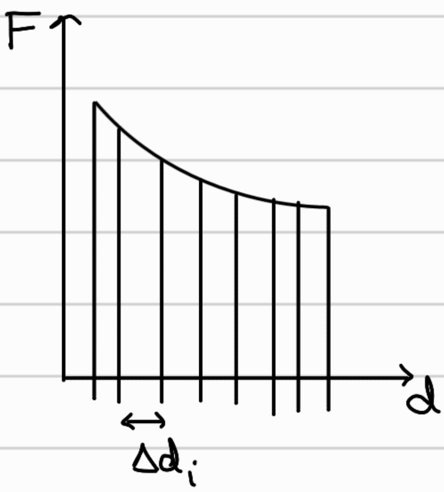
Area under a 'F' vs 'd' graph.



Area = Area of Sq. = (Side × Side).

Area: $F \cdot d = W$.

→ Work done by a Const. force.



$$\text{Area} = \lim_{\Delta d \to 0} \sum_{i=1}^{n} F_i \cos\theta_i \,\Delta d_i = W.$$

→ Workdone by a variable force.

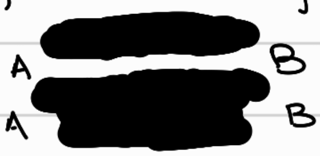
Conservative Field.

i) Workdone along a closed path = 0 ; $\oint F \cdot d = 0$.

ii) WD independent of path followed but depends on initial & final position.

eg: Gravitational & Electric field.

☆ friction is non-conservative.



Q. What is potential energy?

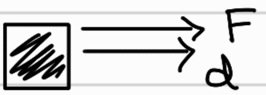
Conservative field stores energy in system. This energy is called the potential energy.

☆ Conservative ⟲ opposite.
Non conservative

Power.

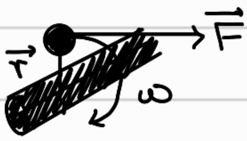
→ Time rate of doing work.

Linear:



$$P = \frac{W}{t} = \frac{\vec{F} \cdot \vec{d}}{t} = \vec{F} \cdot \vec{v}$$

Rotational:



$$P = \vec{\tau} \cdot \vec{\omega}$$

Average power: $\langle P \rangle = \frac{\langle W \rangle}{t} = \frac{\langle F \rangle d}{t}$.

Instant. Power: $P = \lim_{\Delta t \to 0} \frac{\Delta W}{\Delta t} = \frac{dW}{dt} = \dot{W}$

$$[P] = \frac{[W]}{[t]} = \frac{J}{s} = \text{Watt}.$$

$$1\,h.p = 746 \text{ watt} = 550 \text{ ft lb/s}.$$

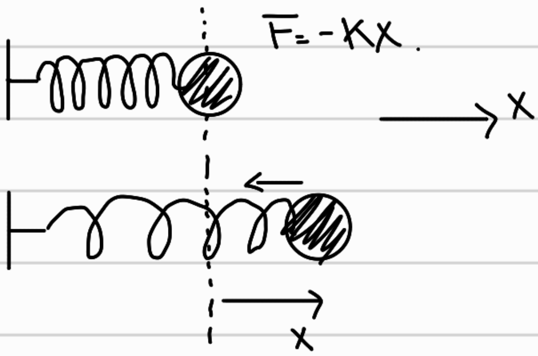
Work energy principle.

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

But what is energy?!

→ Ability to perform work.

Spring System.



By Spring:

$$W = \frac{1}{2} K x^2.$$

By ball Compressing Spring:

$$W = -\frac{1}{2} K x^2.$$

Efficiency.

$$\eta = \frac{\text{required form of output}}{\text{Total input energy}}.$$

$$\%\eta = \frac{\text{required form of output}}{\text{Total input energy}} \times 100.$$

→ Unit less.

Ideal: Output = input.

Gravitational Potential Energy.

$\rightarrow U = -\frac{GMm}{R}$

Relating K.E to Momentum.

$$KE = \frac{1}{2}mv^2.$$

$$p = mv$$

$$\rightarrow K.E = \frac{1}{2}(mv)v = \frac{1}{2}pv = \frac{p^2}{2m}$$

Escape Velocity.

$\rightarrow$ Min. initial velocity provided to escape the Gravity of the Earth.

$$V_{es} = \sqrt{\frac{2GM_e}{R_e}} = \sqrt{2g_eR}.$$

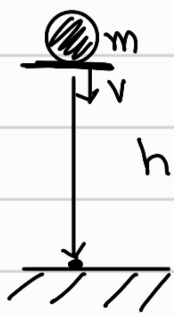
$$\frac{1}{2}\cancel{m}V^2 = \frac{GM_e\cancel{m}}{R_e}$$

$$V^2 = \frac{2GM_e}{R_e}.$$

$$V_{es} \sim 11.2\,kms^{-1}.$$

Conservation of energy.

- → Total energy is always a constant.
- → Energy may be only transformed.
- → Can't create or destroy it!



$$mgh = \frac{1}{2}mv^2.$$

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