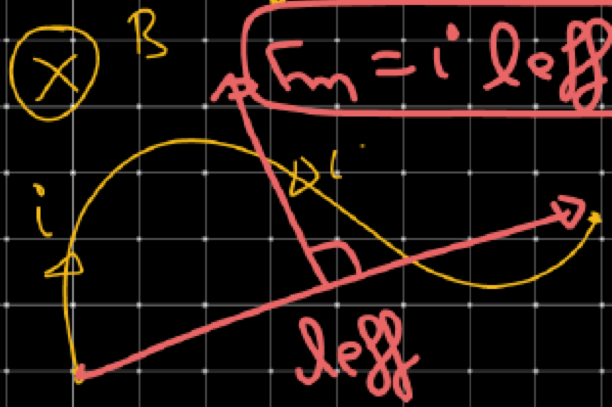
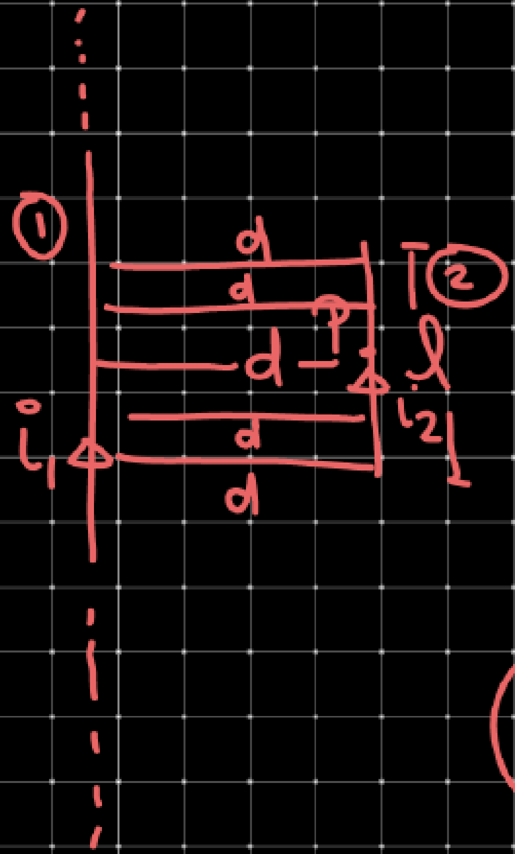
Magnetic force on current carrying wire placed in external magnetic field :-

$$F_m = i\, l_{eff}\, B \sin\theta$$



Q1)



magnetic field due to wire 1 on wire 2.

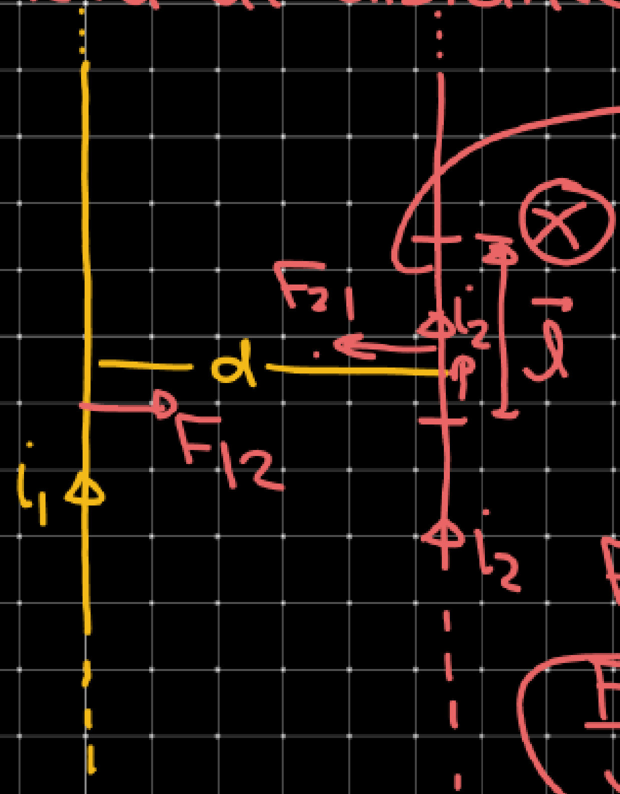
$$B = \frac{\mu_0 i_1}{2\pi d} \otimes$$

$$F_{21} = i_2 l \frac{\mu_0 i_1}{2\pi d} \sin\theta$$

$$F_{21} = \frac{\mu_0 i_1 i_2}{2\pi d} \cdot l \sin 90^\circ$$

$$\boxed{F_{21} = \frac{\mu_0 i_1 i_2}{2\pi d} \cdot l}$$

Find F per unit length on 2 due to wire 1 placed at distance d.



$$B = \frac{\mu_0 i_1}{2\pi d} \otimes$$

$$|F_{12}| = |F_{21}|$$

$$\vec{F}_{21} = -\vec{F}_{12}$$

$$\vec{F}_{21} = i_2\, \vec{l} \times \vec{B}$$

$$F_{21} = i_2 l \frac{\mu_0 i_1}{2\pi d} \sin 90^\circ$$

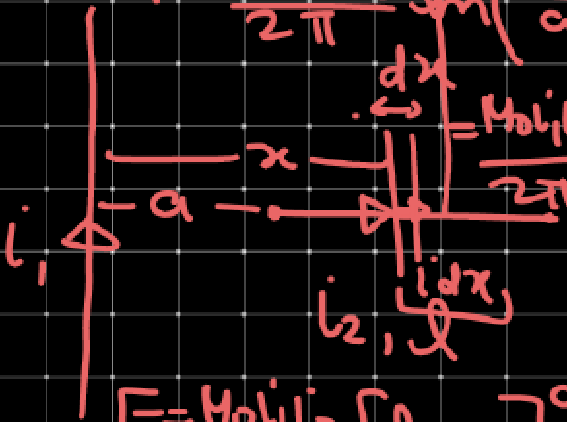
$$F_{21} = \frac{\mu_0 i_1 i_2}{2\pi d} l$$

$$\frac{F_{21}}{l} = \frac{\mu_0 i_1 i_2}{2\pi d}$$

$\Rightarrow$ $\int \frac{1}{x} dx = \ln x$ $\int \frac{dx}{x} = \ln x$ $B = \frac{\mu_0 i_1}{2\pi x}$ ⊗ $B \propto \frac{1}{x}$

$F = \frac{\mu_0 i_1 i_2}{2\pi} \ln\left(\frac{a}{a} + \frac{l}{a}\right)$

$= \frac{\mu_0 i_1 i_2}{2\pi} \ln\left(1 + \frac{l}{a}\right)$



Force on dx element due to wire 1.

$dF = i_2\, dx\, \frac{\mu_0 i_1}{2\pi x} \sin 90^\circ$

$\int dF = \int_a^{a+l} \frac{\mu_0 i_1 i_2}{2\pi x} dx$

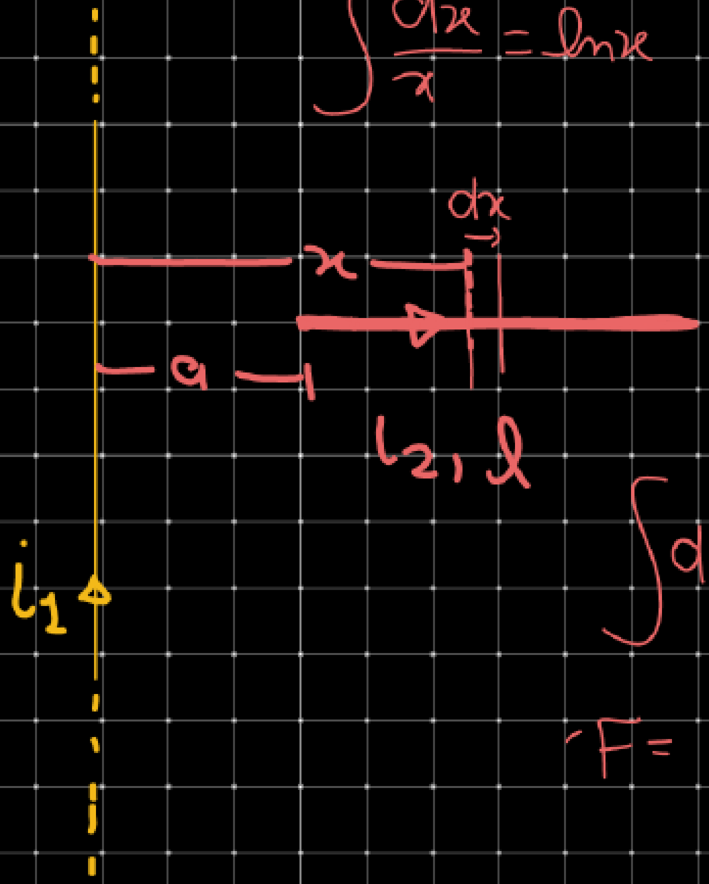
$F = \frac{\mu_0 i_1 i_2}{2\pi} \int_a^{a+l} \frac{dx}{x}$

$F = \frac{\mu_0 i_1 i_2}{2\pi} \left[\ln x\right]_a^{a+l}$

$F = \frac{\mu_0 i_1 i_2}{2\pi} \left[\ln(a+l) - \ln a\right]$

$F = \frac{\mu_0 i_1 i_2}{2\pi} \ln\left(\frac{a+l}{a}\right)$

$F = \frac{\mu_0 i_1 i_2}{2\pi} \ln\left(\frac{a+l}{a}\right)$



$$\int \frac{dx}{x} = \ln x$$

$$B = \frac{\mu_0 i_1}{2\pi x} \quad \left[B \propto \frac{1}{x}\right]$$

$$F = \frac{\mu_0 i_1 i_2}{2\pi}\left[\ln(a+l) - \ln a\right]$$

$$\ln a - \ln b = \ln\frac{a}{b}$$

$$dF = \mu_0 i_2\, dx \, \frac{\mu_0 i_1}{2\pi x} \sin 90$$

$$F = \frac{\mu_0 i_1 i_2}{2\pi} \ln\left[\frac{a+l}{a}\right]$$

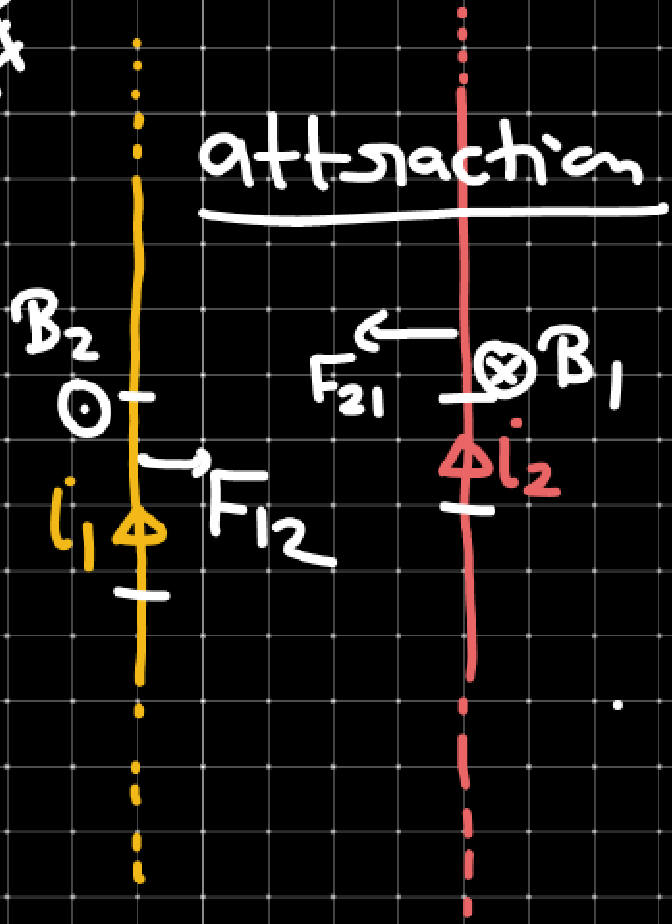
$$\int dF = \frac{\mu_0 i_1 i_2}{2\pi} \int_a^{a+l} \frac{dx}{x}$$

$$F = \frac{\mu_0 i_1 i_2}{2\pi} \ln\left[\frac{a}{a} + \frac{l}{a}\right]$$

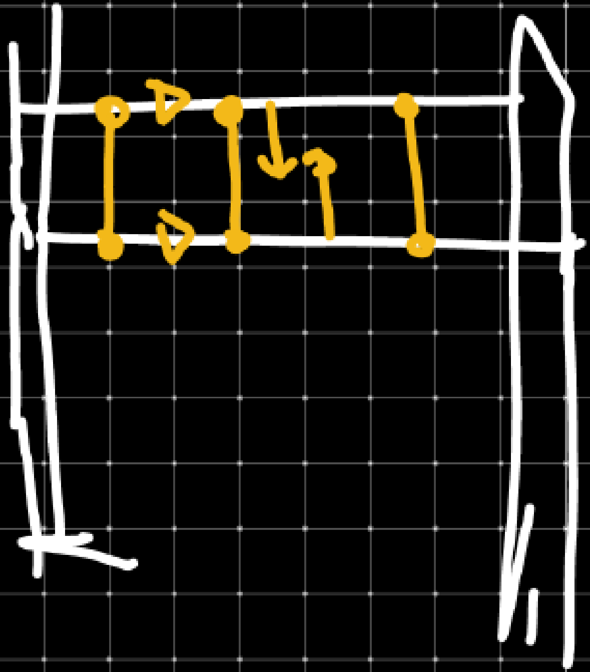
$$F = \frac{\mu_0 i_1 i_2}{2\pi} \left[\ln x\right]_a^{a+l}$$

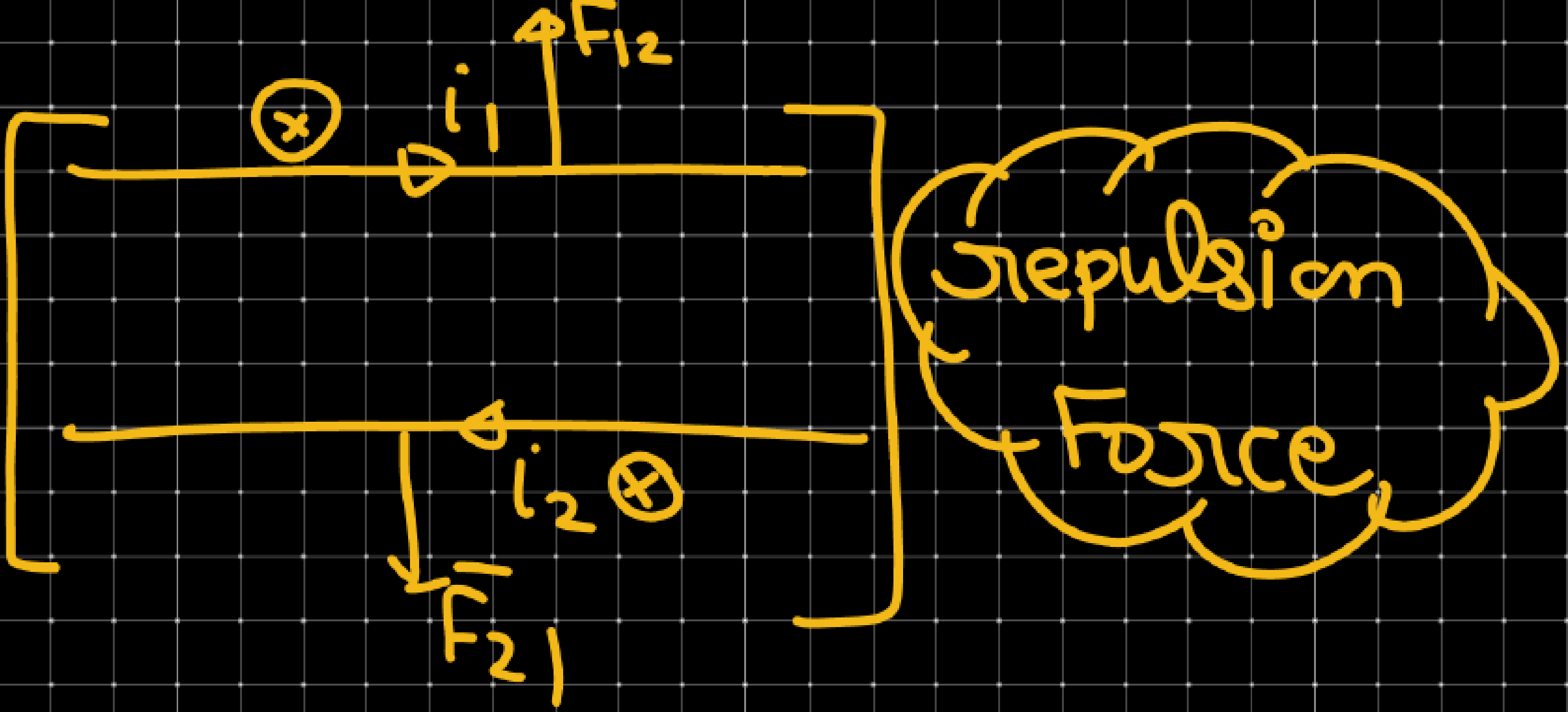
$$F = \frac{\mu_0 i_1 i_2}{2\pi} \ln\left(1 + \frac{l}{a}\right)$$

#



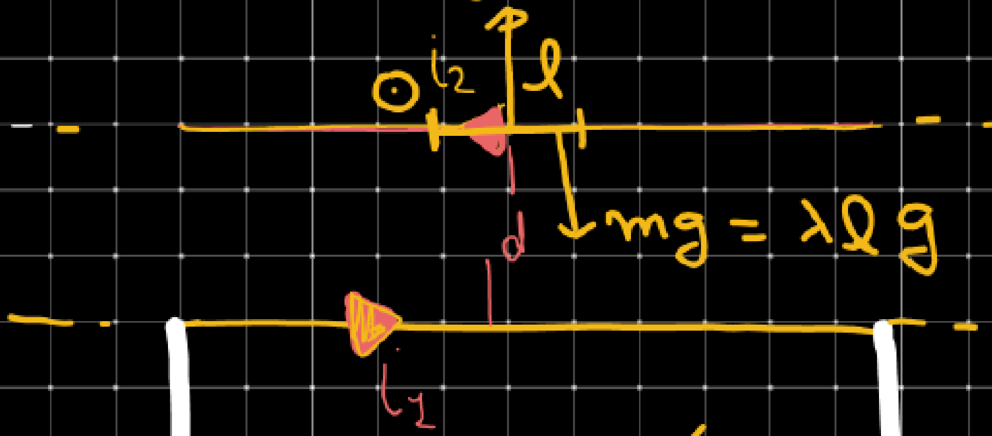
$$F = i\,l \times B$$





F12
i1
i2
F21
Repulsion Force

Equilibrium of a wire have uniform linear mass density (λ)



$$\frac{\mu_0 i_1 i_2}{2\pi d} \cdot l = \lambda l g$$

$$\lambda = \frac{\mu_0 i_1 i_2}{2\pi d g}$$

$$F_{21} = \frac{\mu_0 i_1 i_2}{2\pi d} \cdot l$$

λ = mass per unit length.

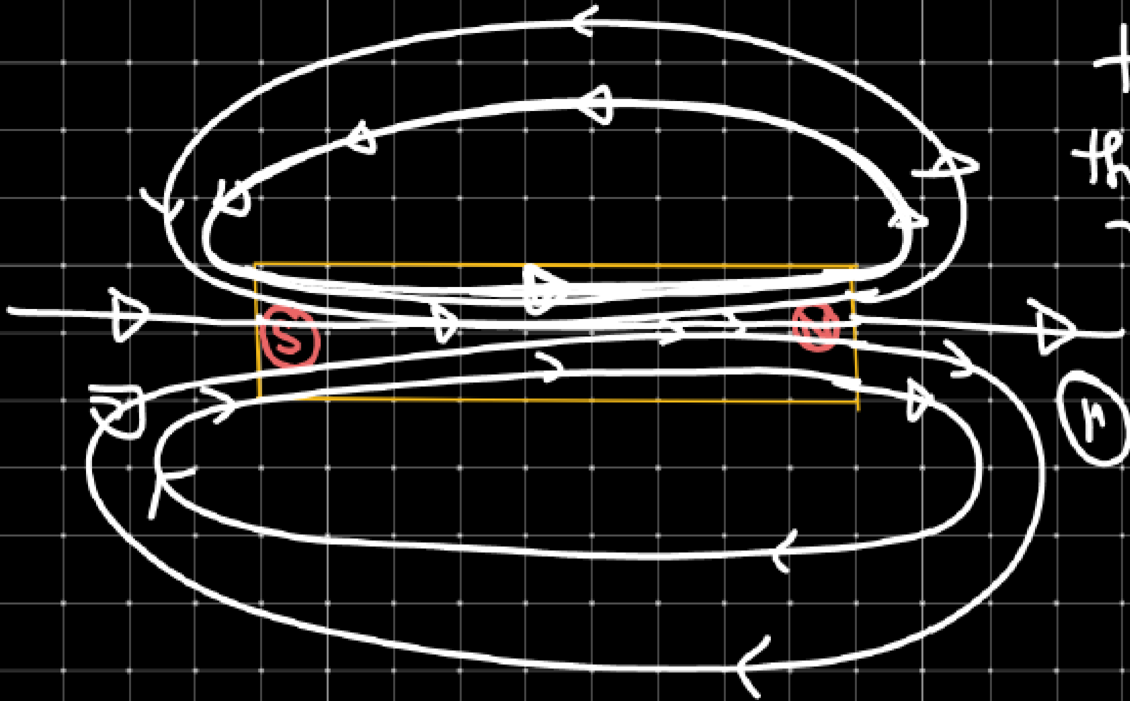
Mass of l-length = λl

$$B_1 = \frac{\mu_0 i_1}{2\pi d}$$

Force on wire 2 on l element

$$F = i_2 \times l \times \frac{\mu_0 i}{2\pi d} \times \sin 90$$

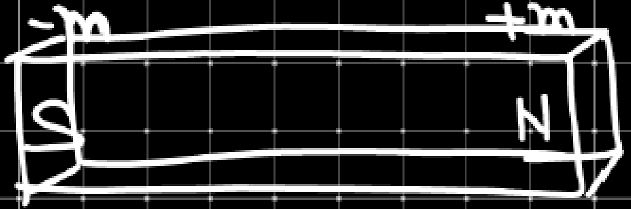
⇒ bar magnet :-



① Magnetic field line goes from North pole to South pole outside the magnet & South to north inside the magnet.

② Magnetic field lines always make close loop.

Pole strength : (m) :



$$m \propto A$$

Electrostatics

q

Electric dipole: $-q$ •—— $\vec{p}$ ——• $+q$ (separation l)

Electric dipole moment: $\vec{P} = ql$ [dirn ⊖ to ⊕]

q •—— r ——• $\vec{E} = \frac{kq}{r^2}$

$F = \frac{kq_1q_2}{d^2}$ q_1 •—— d ——• q_2

Magnet

m

$-m$ [S —— $\vec{M}$ ——→ N] $+m$ (length d) = magnetic dipole

Magnetic dipole moment: $\vec{M} = ml$

$+m$ •—— r ——• → $B = \frac{\mu_0}{4\pi}\frac{m}{r^2}$

$F = \frac{\mu_0}{4\pi}\frac{m_1m_2}{d^2}$ m_1 •—— d ——• m_2

⟹ Pole strength (m)

↳ SI Unit - A-m

⟹ Coulomb's law of magnet

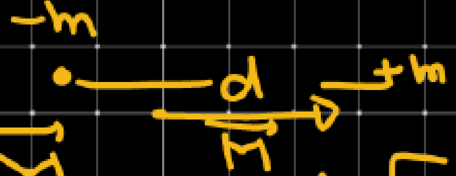
m_1 • —— d —— • m_2

$$F = \frac{\mu_0}{4\pi} \frac{m_1 m_2}{d^2}$$

[m_1 & m_2 are same nature then they repel each other]

[m_1 & m_2 - are opposite in nature) then they attract each other

Magnetic dipole

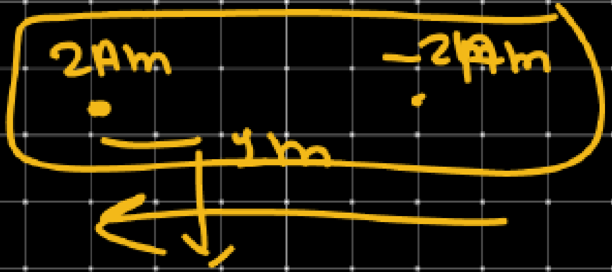


$\vec{M} = m d$

→ It is a vector quantity
[dir^n → −m to +m]

→ SI unit = (A-m) m = A-m^2

Q1)



M = ?

M = 2×1 A-m^2

dir [←]