



PRAYAS

JEE 2025

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Lecture - 07

Physics

Magnetism

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Topics *to be covered*

- 1 Force on current carrying wire inside \vec{B}
- 2 magnetic moment
- 3 Torque on current carrying loop in magnetic field.
- 4

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Force between Two parallel wire



Force per Unit length

$$= \frac{2K i_1 i_2}{r}$$

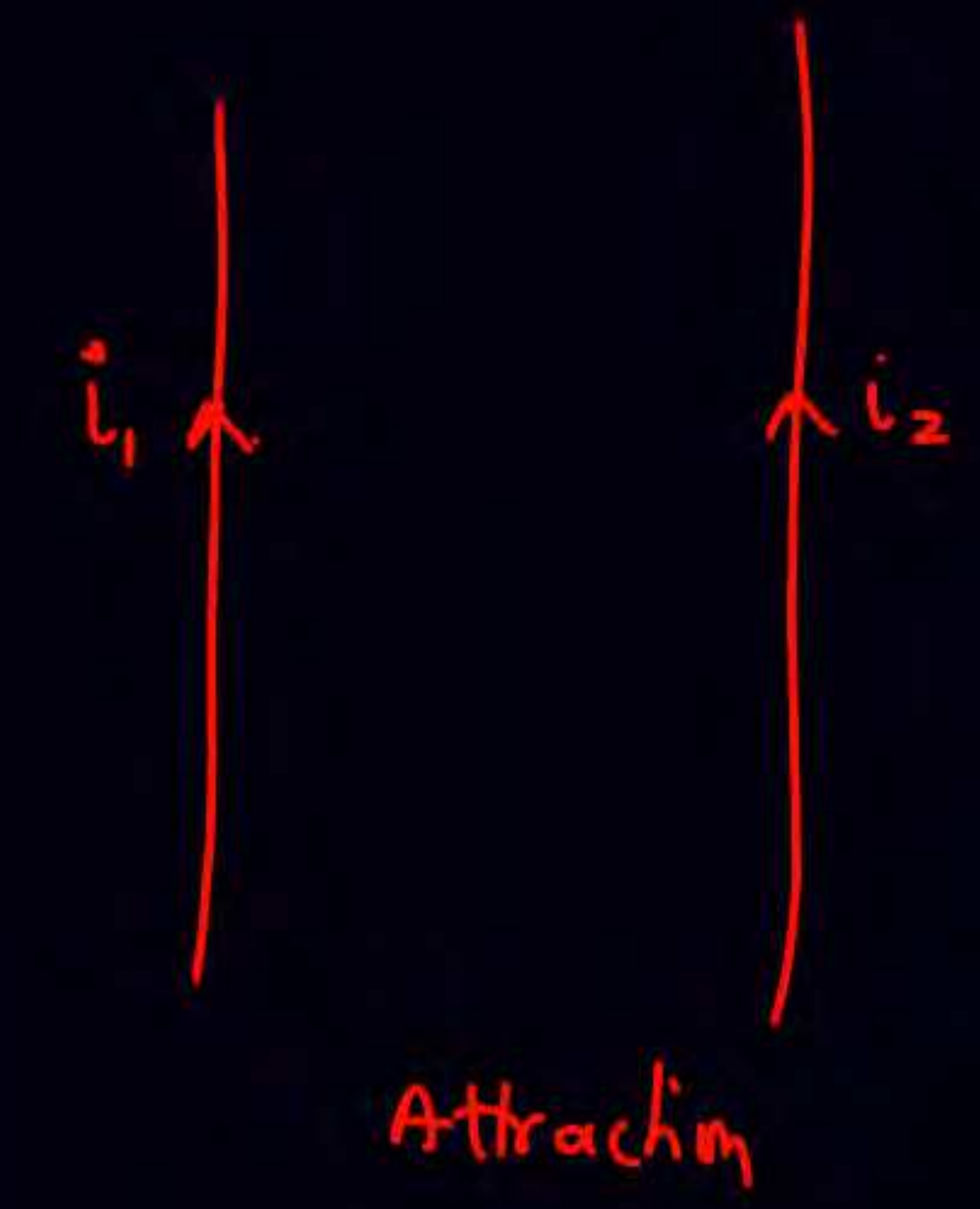


i_2 के wire को consider

$$F = i_2 l B$$

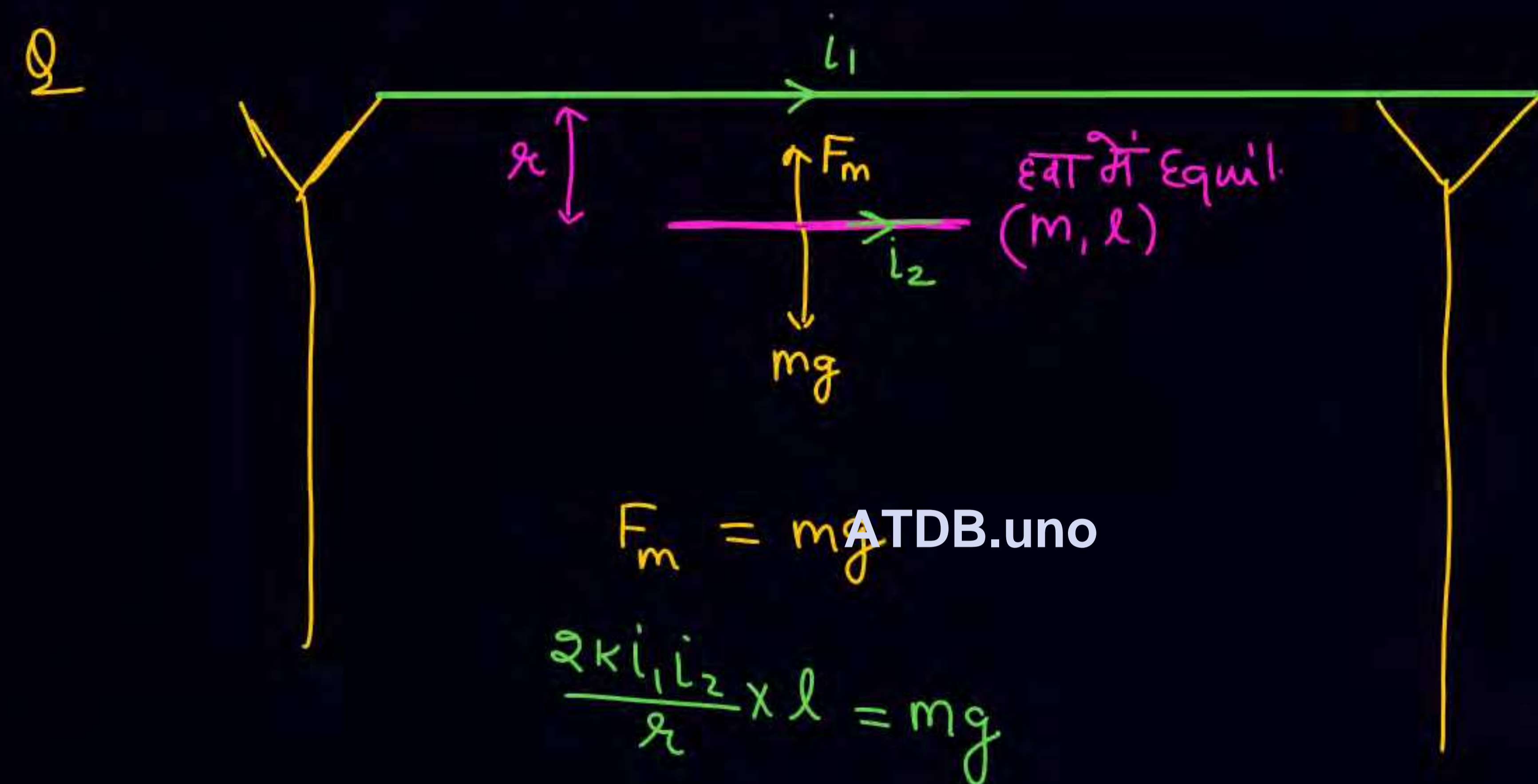
$$F = i_2 \cdot l \cdot \frac{2K i_1}{r}$$

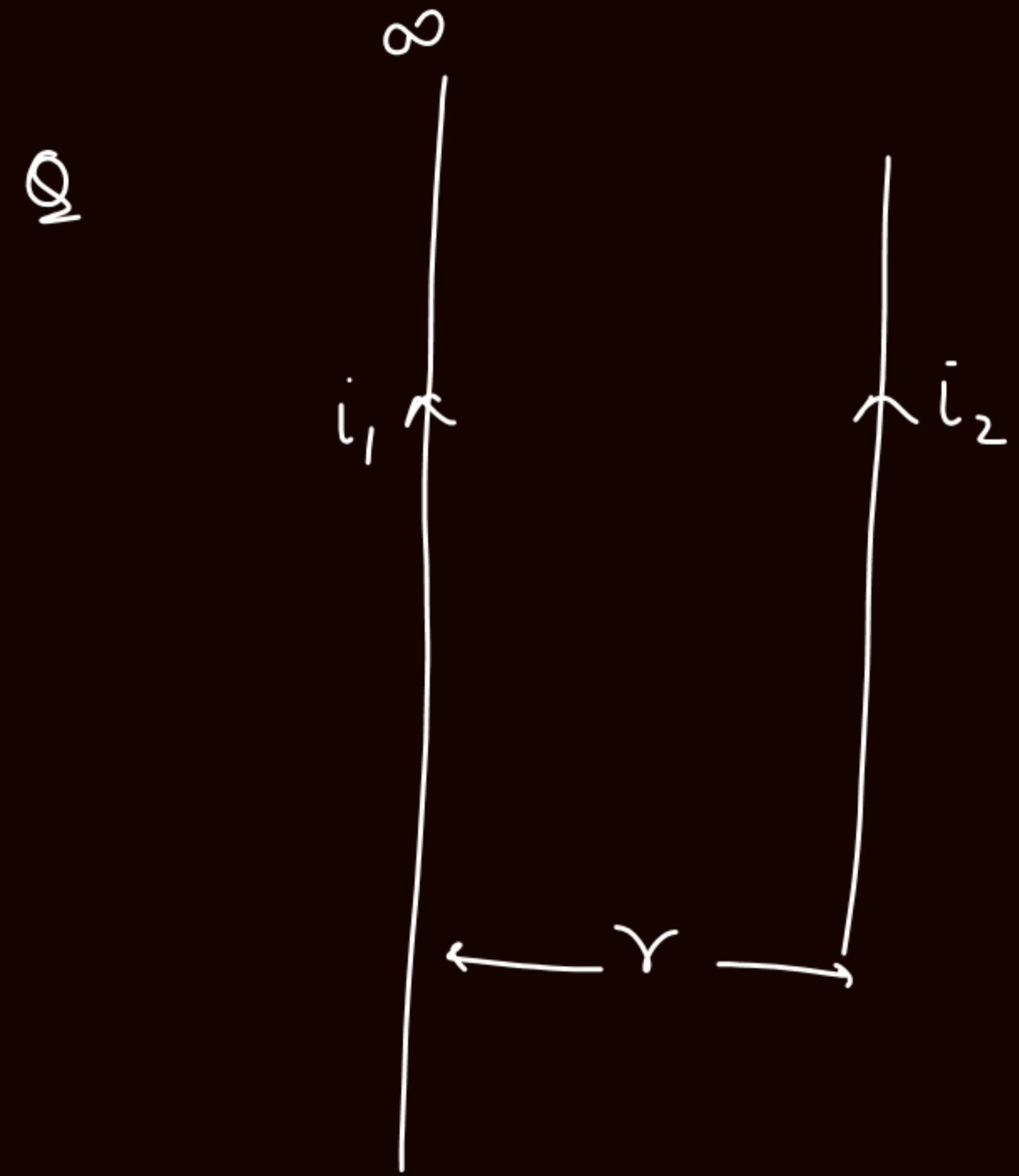
$$\frac{F}{l} = \frac{2K i_1 i_2}{r}$$



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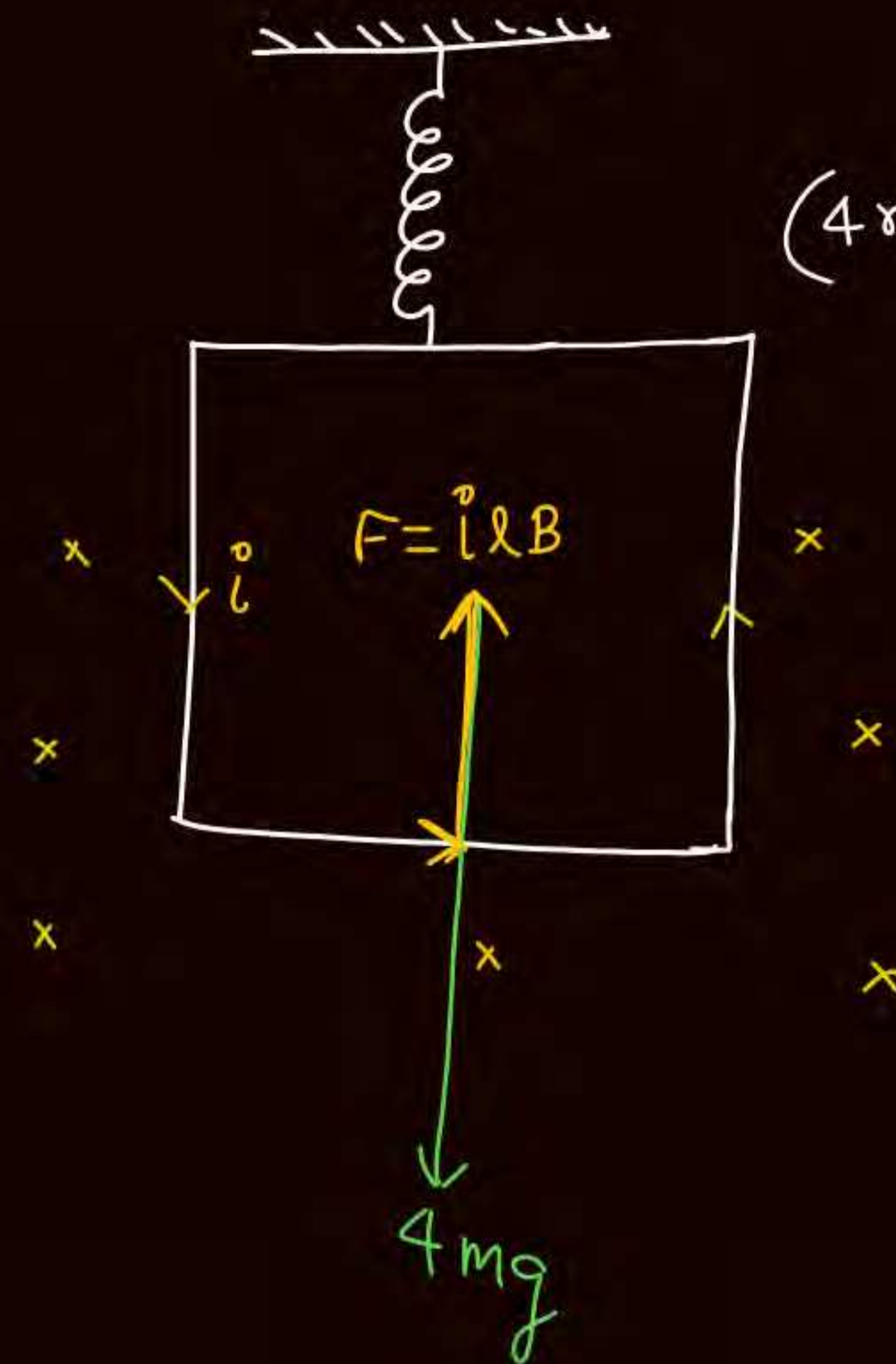




$10m \lambda \pi$ $F = \frac{2k i_1 i_2}{r} \propto 10$

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Q



(4 rod each m, l)

① Reading of spring

$$4mg - ilB = Kx$$

② If dirⁿ of current is reversed

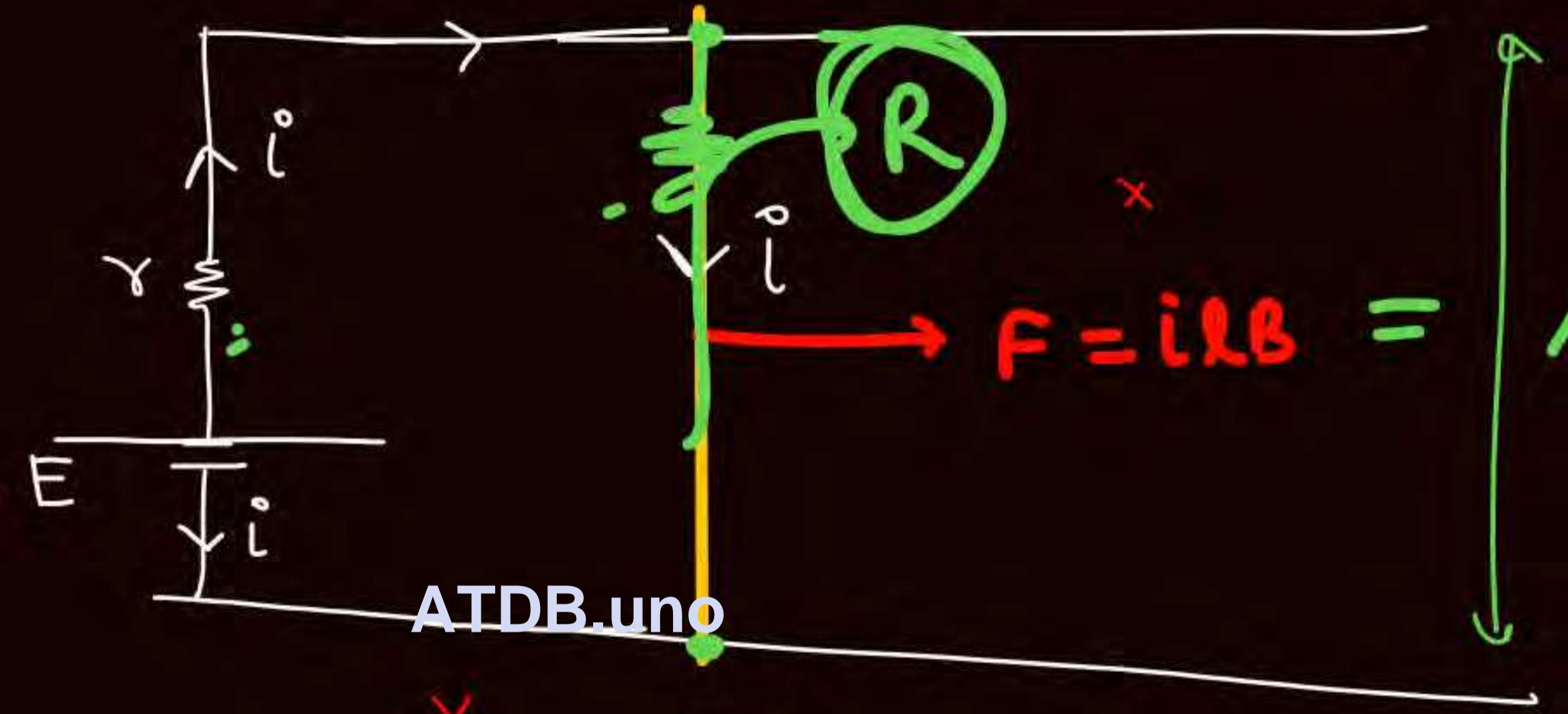
$$4mg + ilB = Kx_f$$

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Q रेलवतल Qm

$F = iLB$

$i = \frac{E}{Y+R}$



$F = iLB = \mu mg$

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$\frac{iLB}{m}$

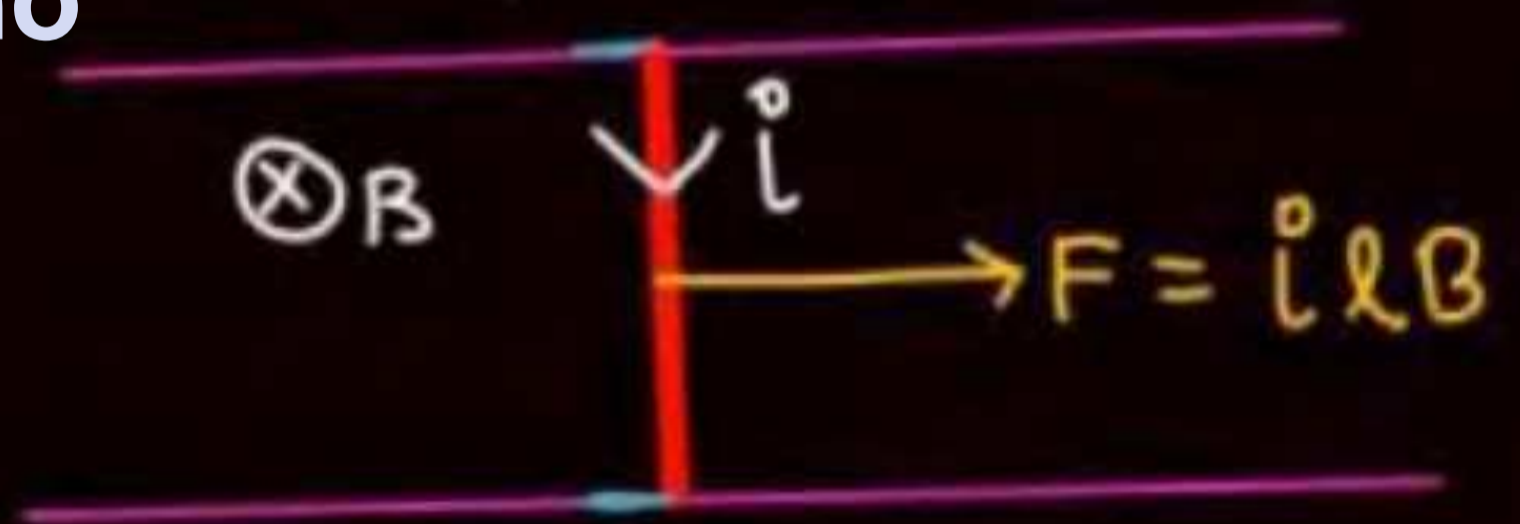
Q Two metal rails placed horizontally and parallel to each other at a separation l . A rod of mass m can slide on rail. Current in the circuit is i .



① find μ_{\min} so that it can prevent wire from sliding.

$$i l B = \mu m g \Rightarrow \mu = \frac{i l B}{m g} = \mu_{\min}$$

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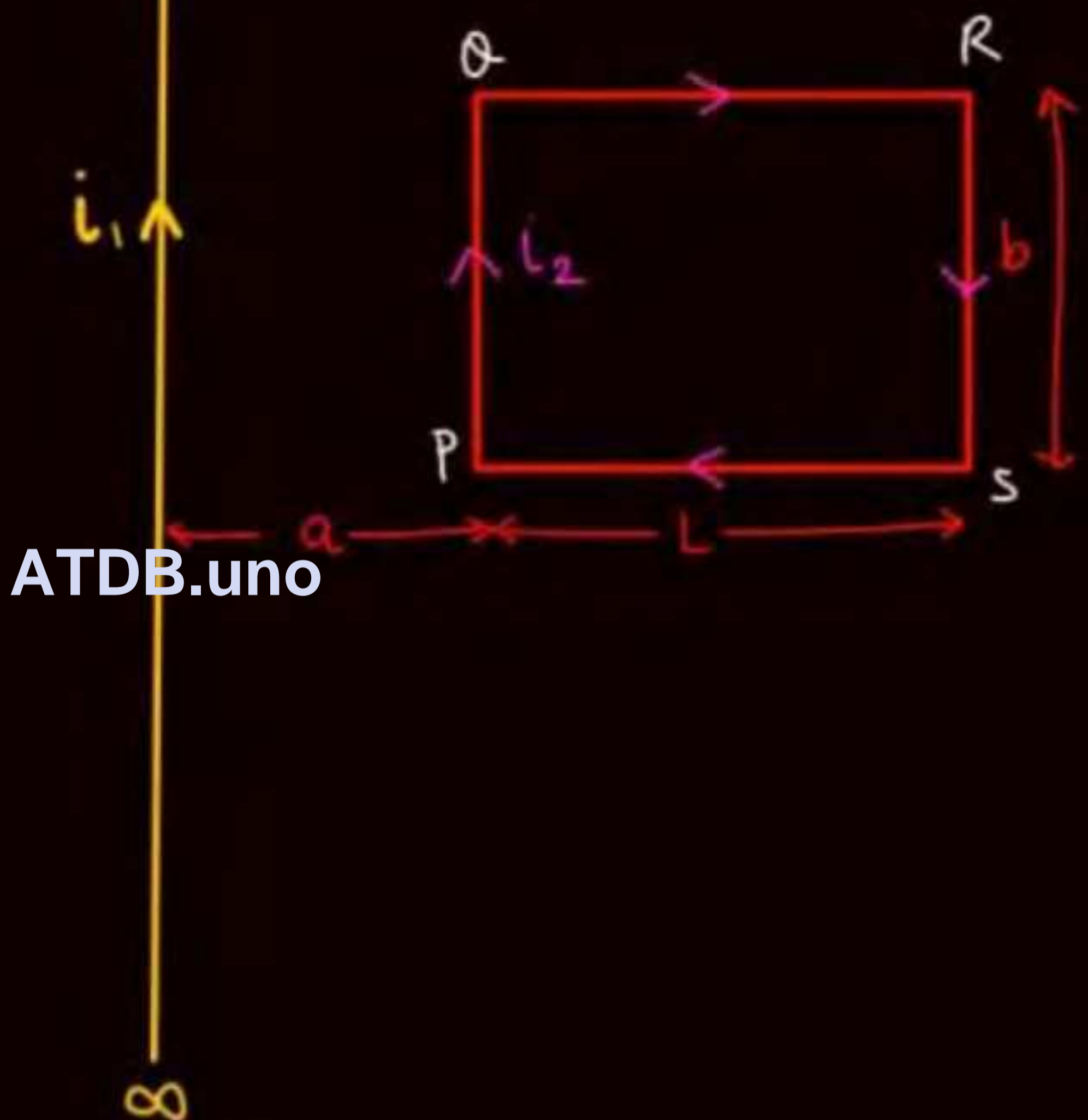


② If $\mu = \frac{\mu_{\min}}{2}$, find a_{acc} of wire.

$$a = \frac{i l B - f}{m} = \frac{i l B - \mu N}{m} = \frac{i l B - \frac{i l B}{2 m g} m g}{m} = \frac{i l B}{2 m}$$

Q

Find force applied
by ∞ wire on loop PQRS.



Q Find force applied by ∞ wire on loop PQRS.

Force on PA due to ∞ wire

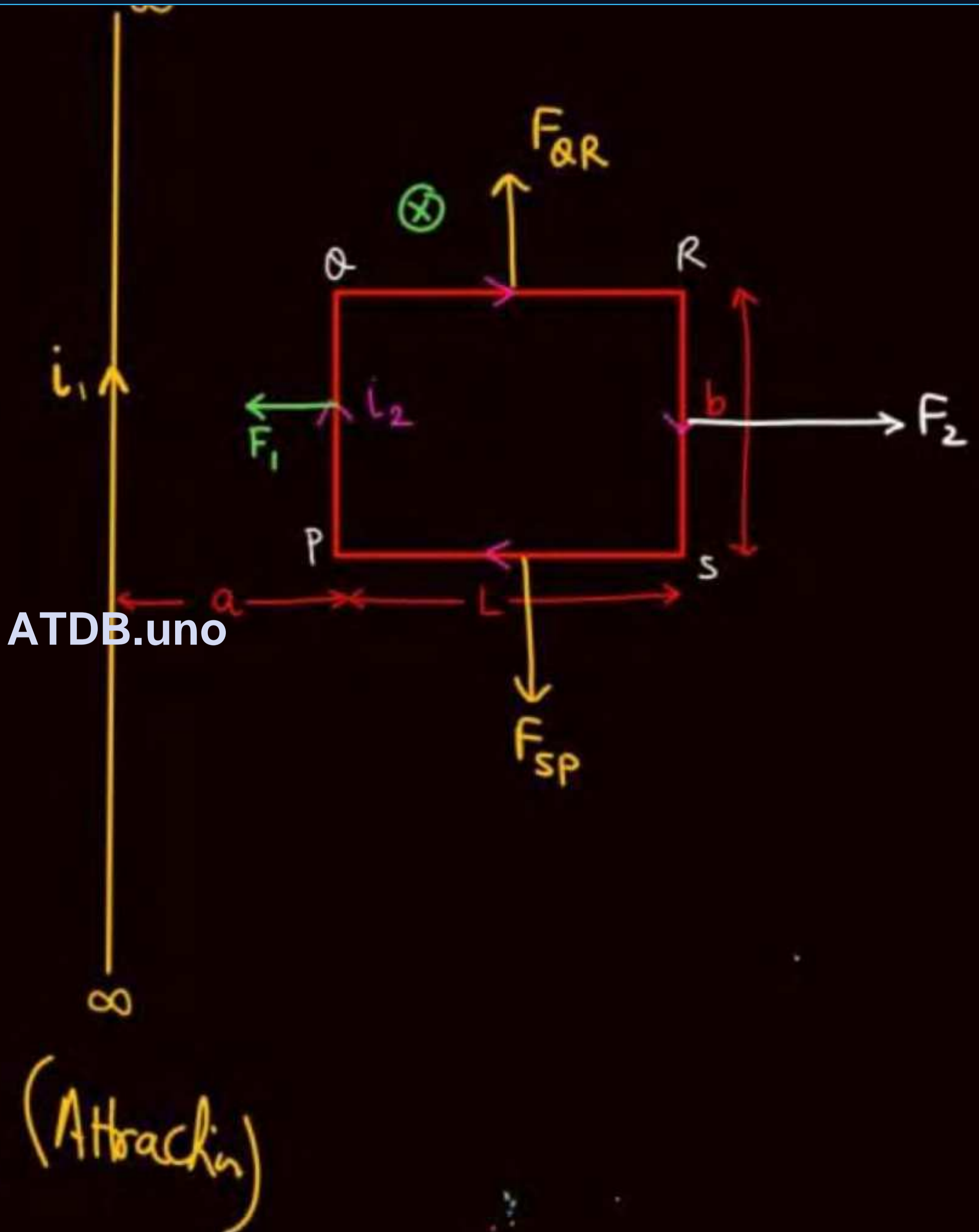
$$= \frac{2Ki_1 i_2}{a} b = F_1 \text{ (left)}$$

Force on RS due to ∞ wire

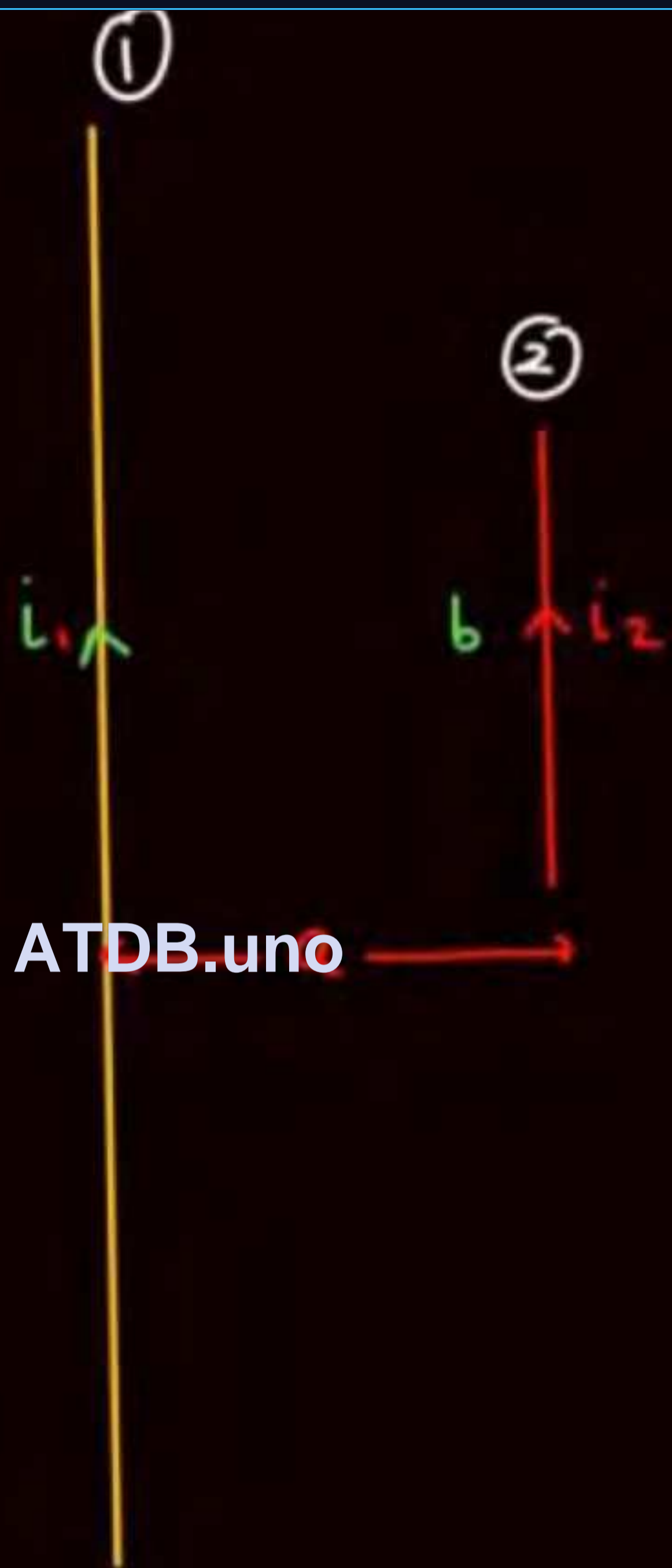
$$= \left(\frac{2Ki_1 i_2}{a+b} \right) b \text{ (Right)}$$

$$\vec{F}_{\text{net}} = \vec{F}_{PA} + \vec{F}_{RS} + \left(\cancel{\vec{F}_{QR}} + \cancel{\vec{F}_{SP}} \right)$$

$$\vec{F}_{\text{net}} = \frac{2Ki_1 i_2}{a} b - \frac{2Ki_1 i_2}{(a+b)} b \text{ (Attraction)}$$



Q



$$(F_2)_{\text{due to 1}} = i_2 \int B_{\text{due to '1'}}$$

$$F = i_2 \cdot b \cdot \frac{2\mu_0 i_1}{a}$$

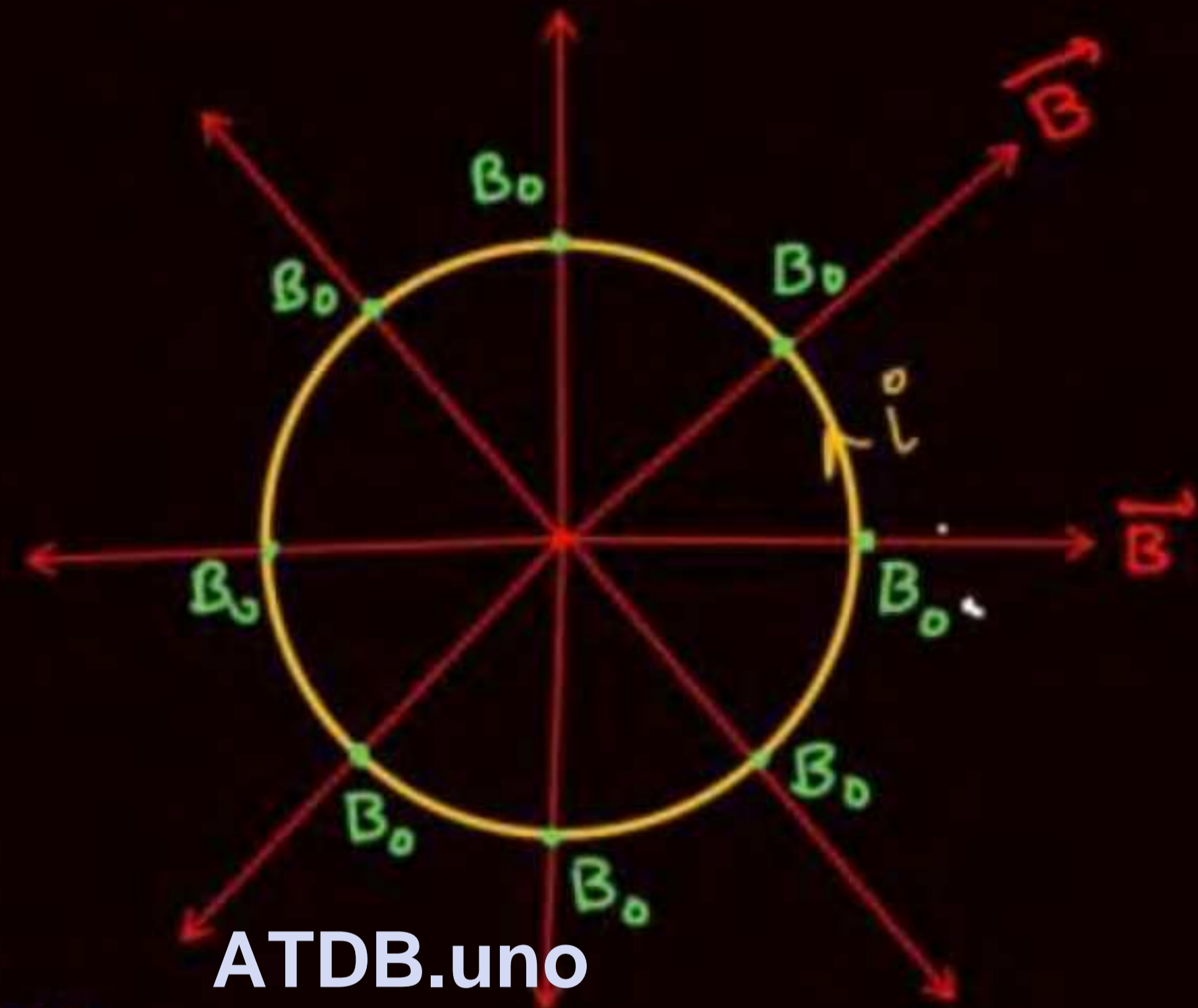
$$F = \frac{2\mu_0 i_1 i_2}{a} b$$

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Q

A current carrying circular loop is placed on x - y plane in a two dimensional magnetic field as shown in figure.

Strength of M.F. on periphery of loop is B_0 . Find magnetic force on wire.



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Ans $F_{net} = i \cdot B \cdot 2\pi R$

Solⁿforce on small element dl

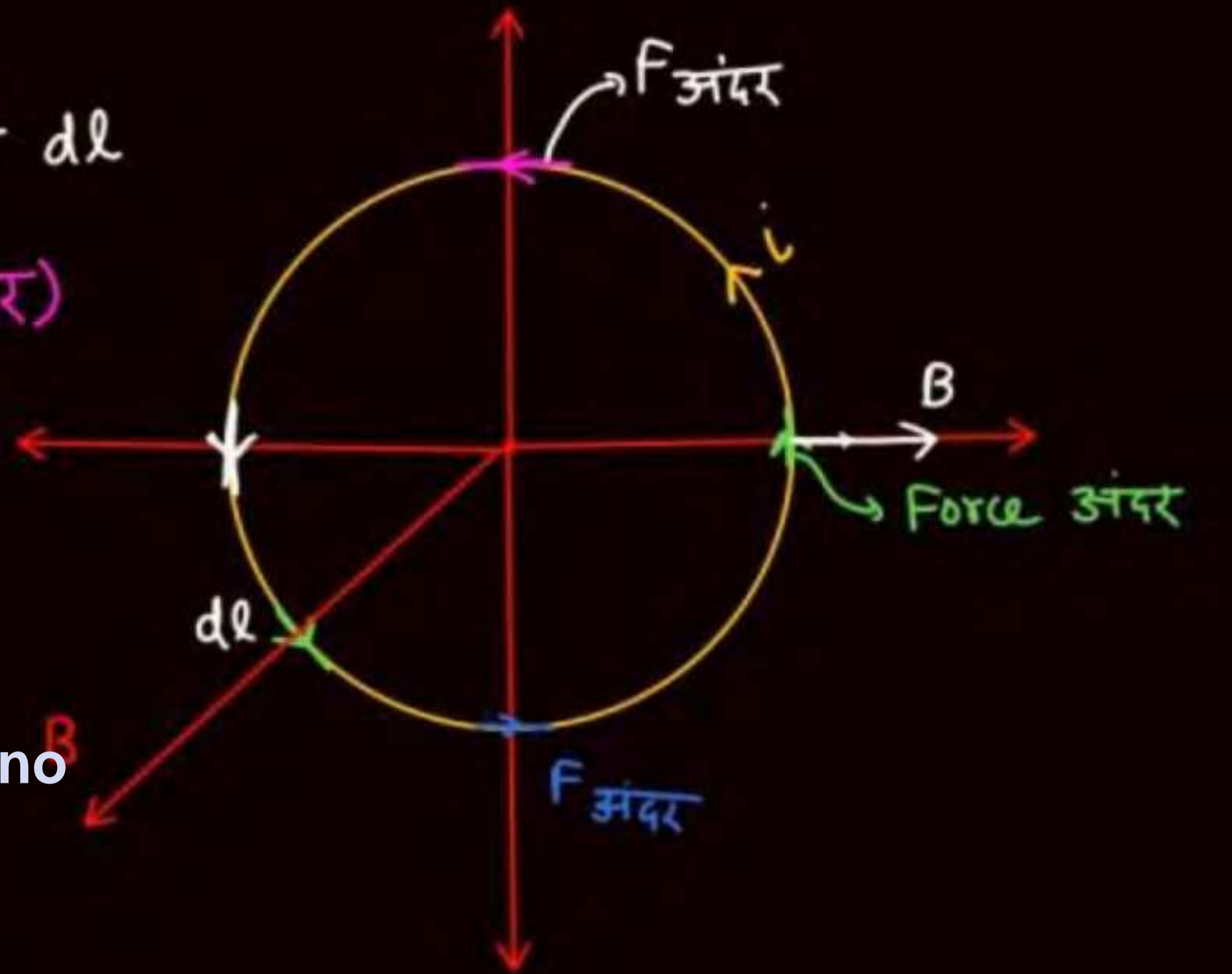
$$dF = i \cdot dl \cdot B \text{ (अंदर)}$$

$$F_{\text{net}} = \int dF$$

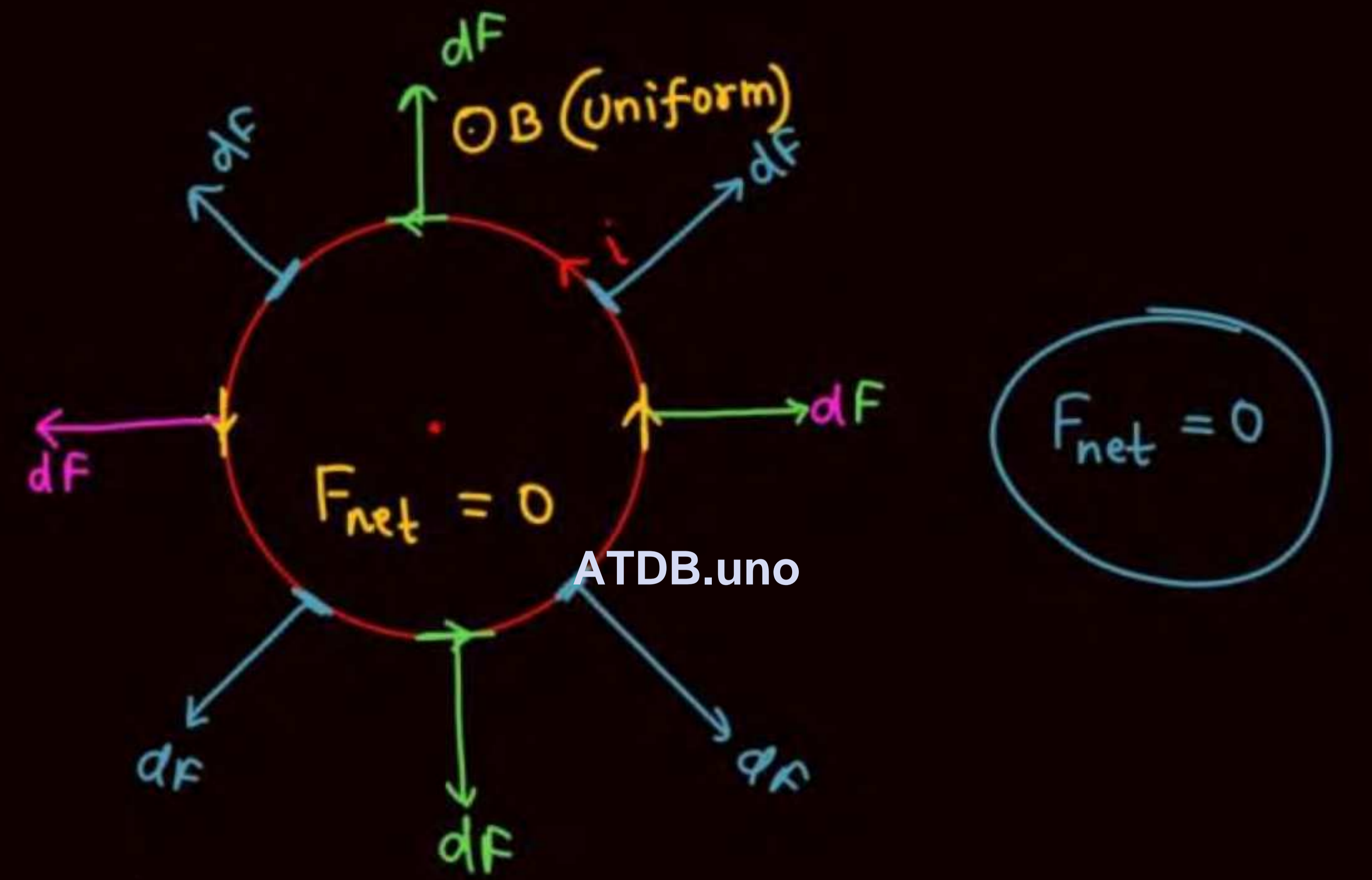
$$= \int i \cdot dl \cdot B$$

$$= i \cdot B \int dl$$

$$F_{\text{net}} = i \cdot B \cdot 2\pi R$$



Q

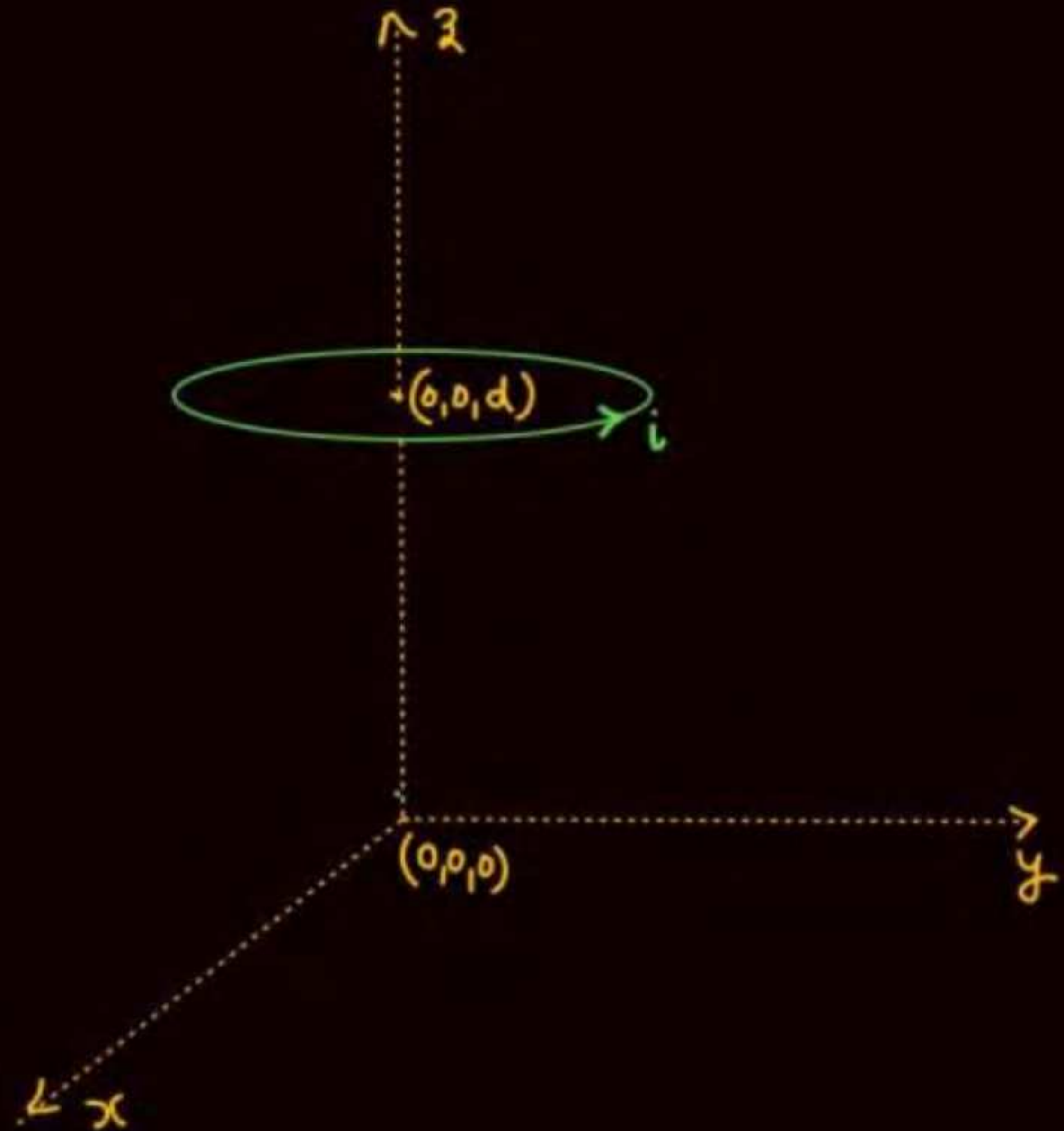


Q $\vec{B} = B_0 \vec{e}_r$ where \vec{e}_r is unit vector
along the radial direction.

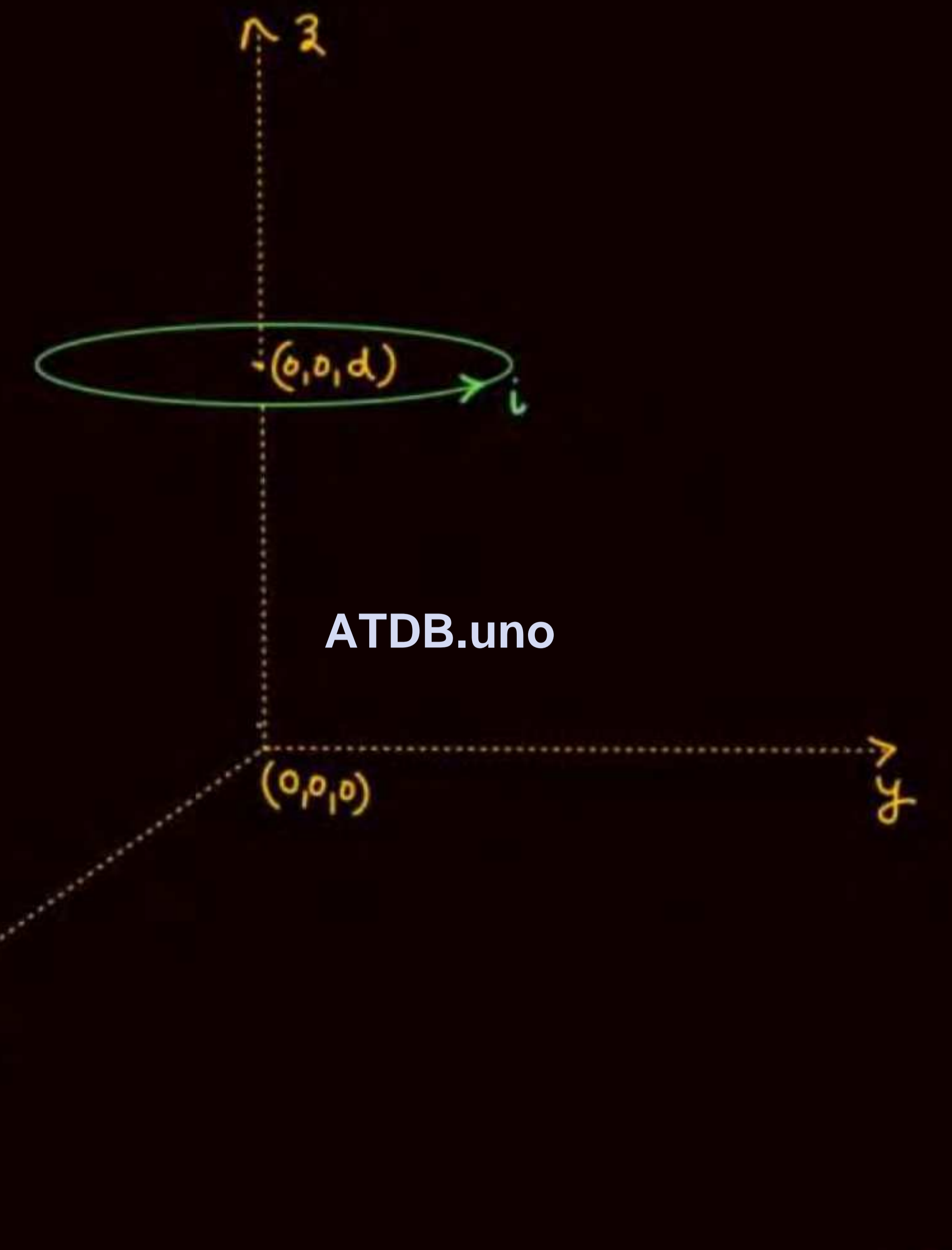
$$\vec{B} = B_0 \hat{r}$$

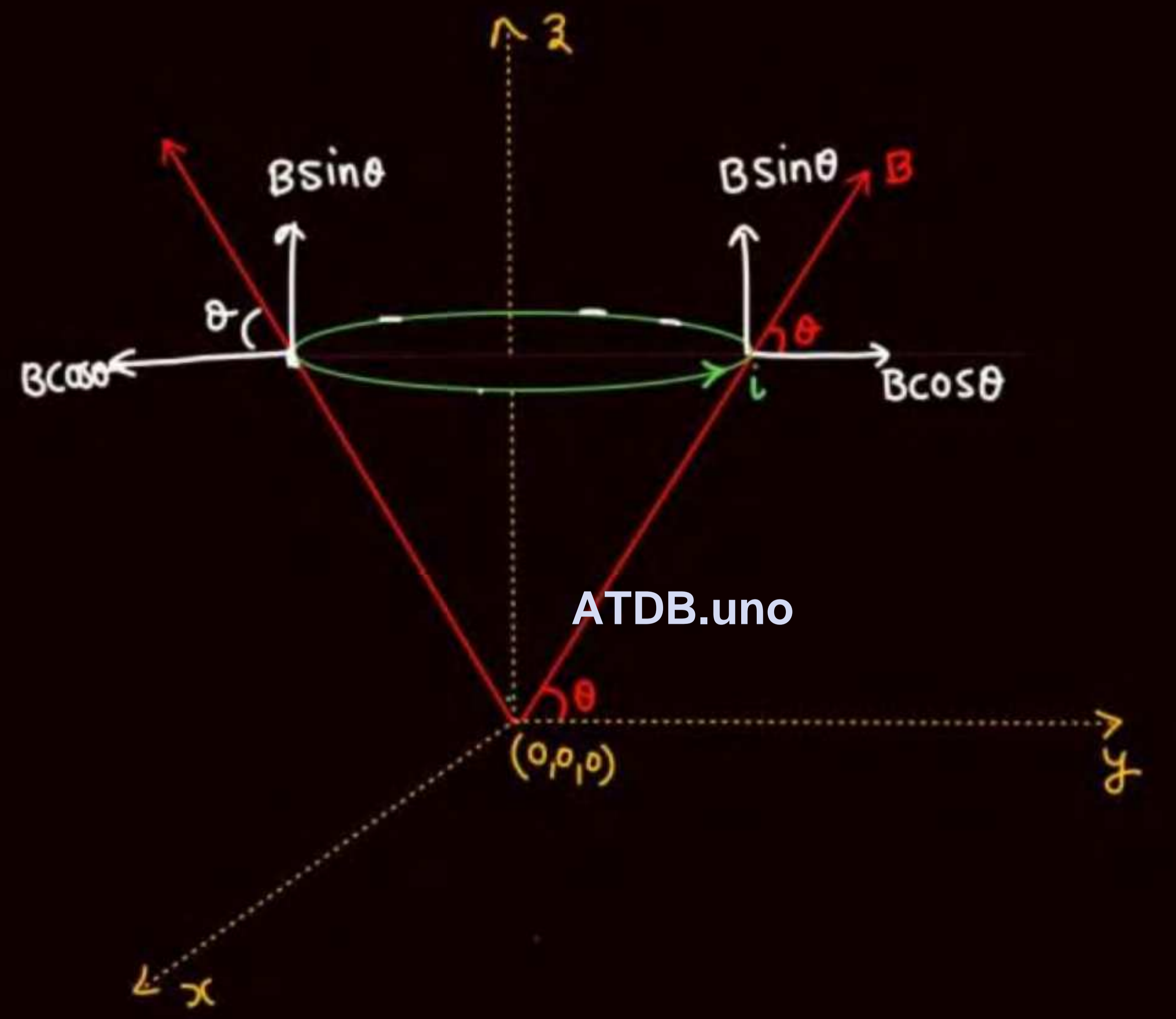
A circular loop of radius R is carrying current i is placed parallel to x - y plane and center at $(0,0,d)$. Find magnitude of magnetic force on loop.

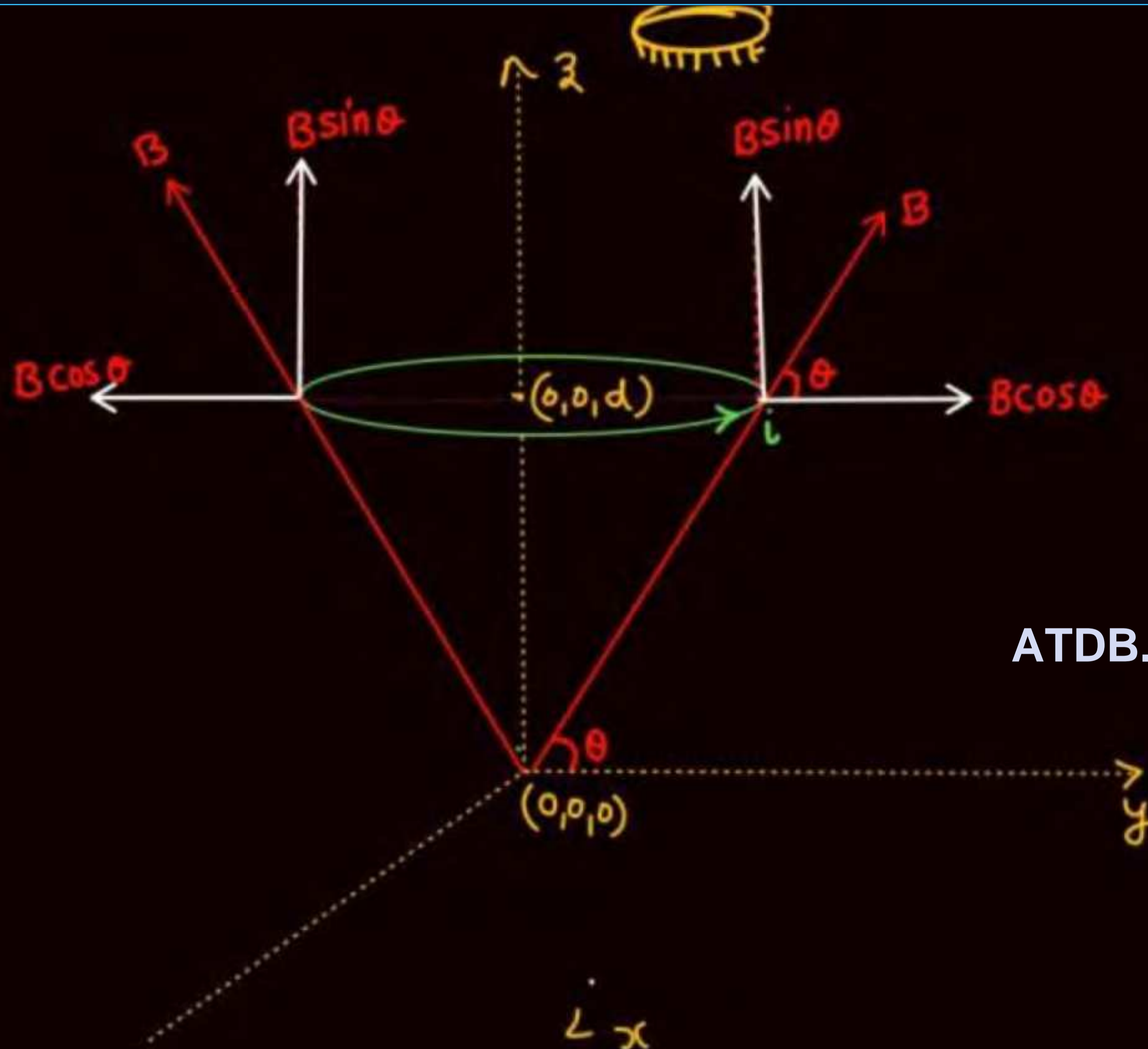
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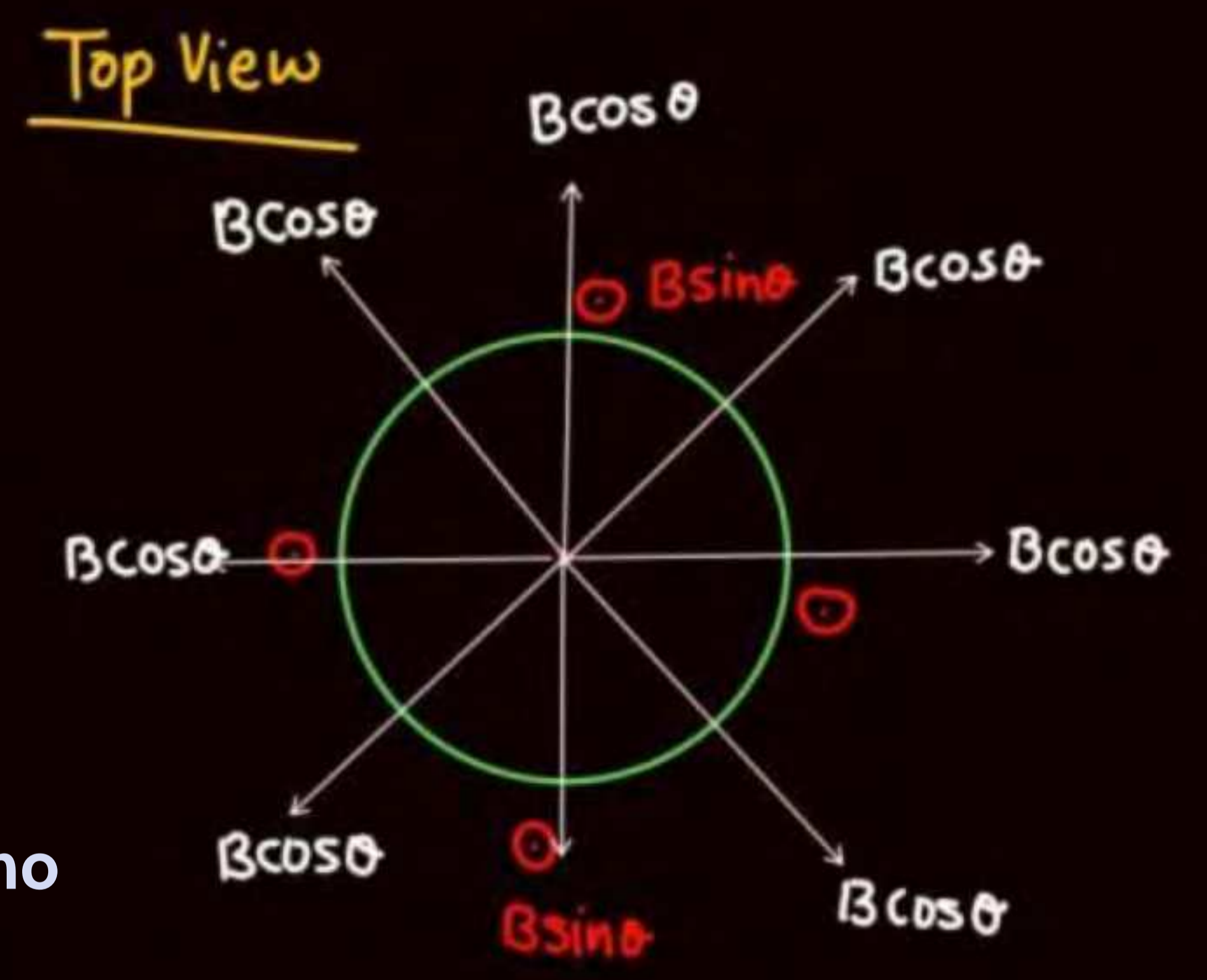
②

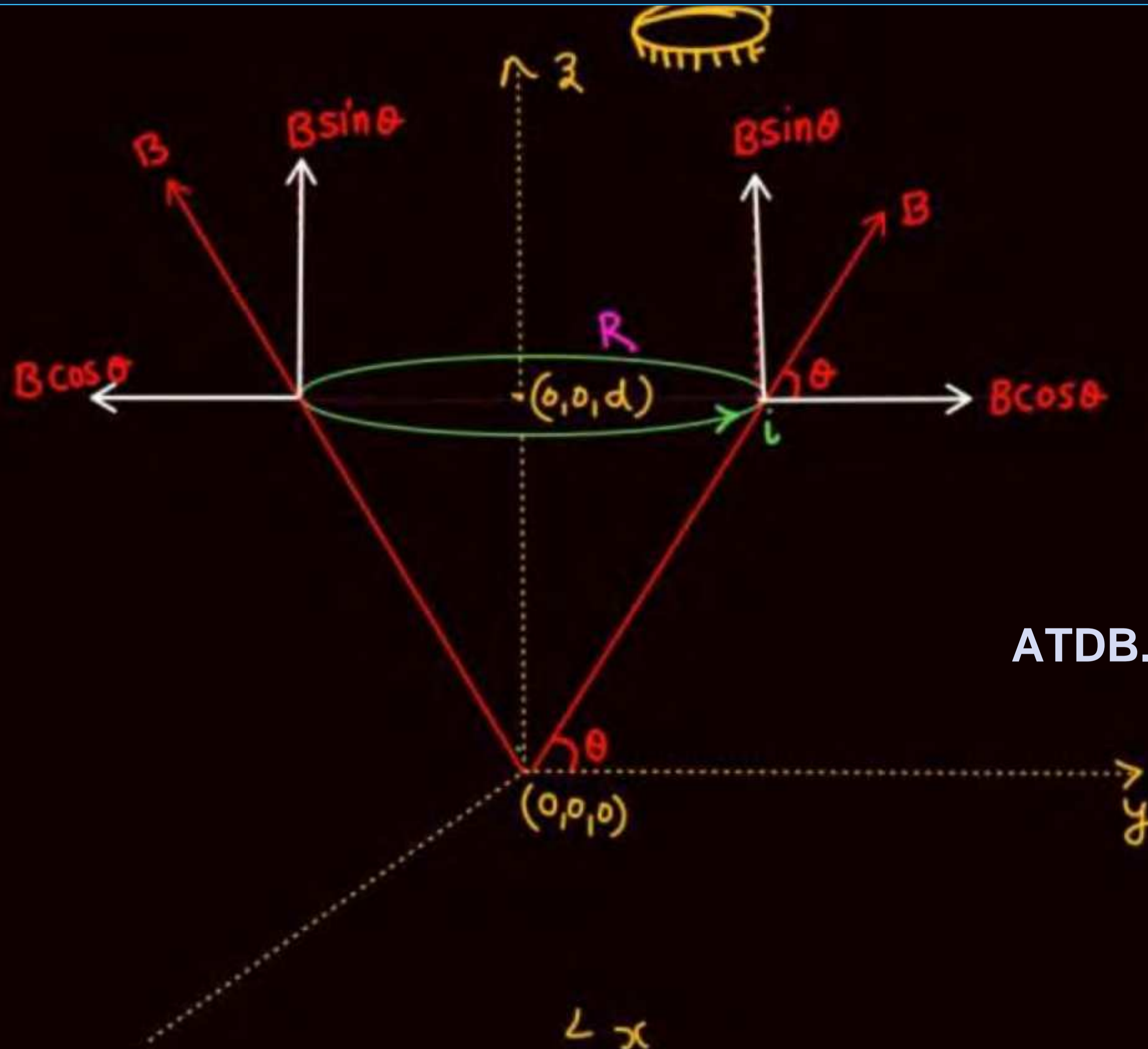






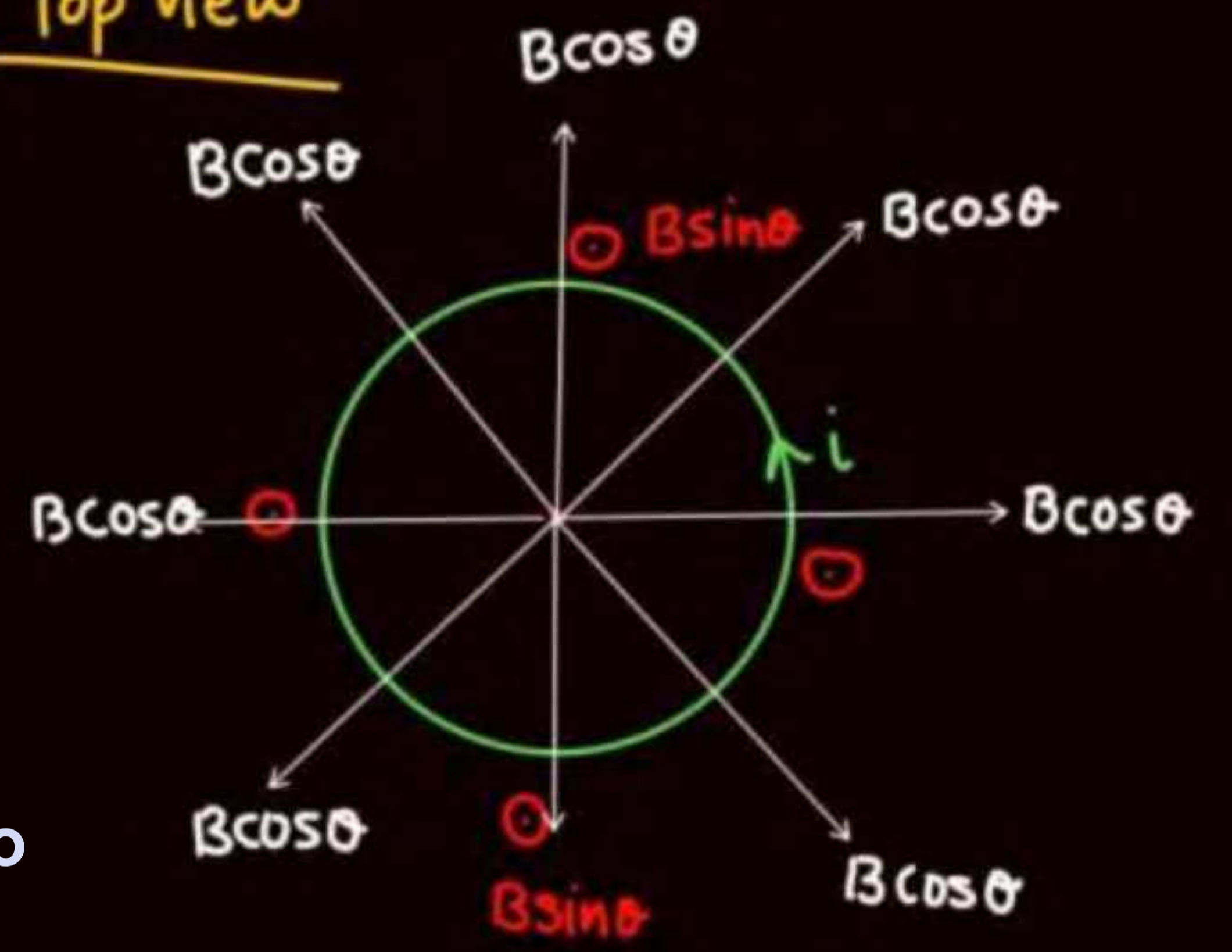
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Top View



Force due to $B \sin \theta = 0$ (उत्पत्ताग wire)

Force due to $B \cos \theta = i \cdot 2\pi R \cdot B \cos \theta$

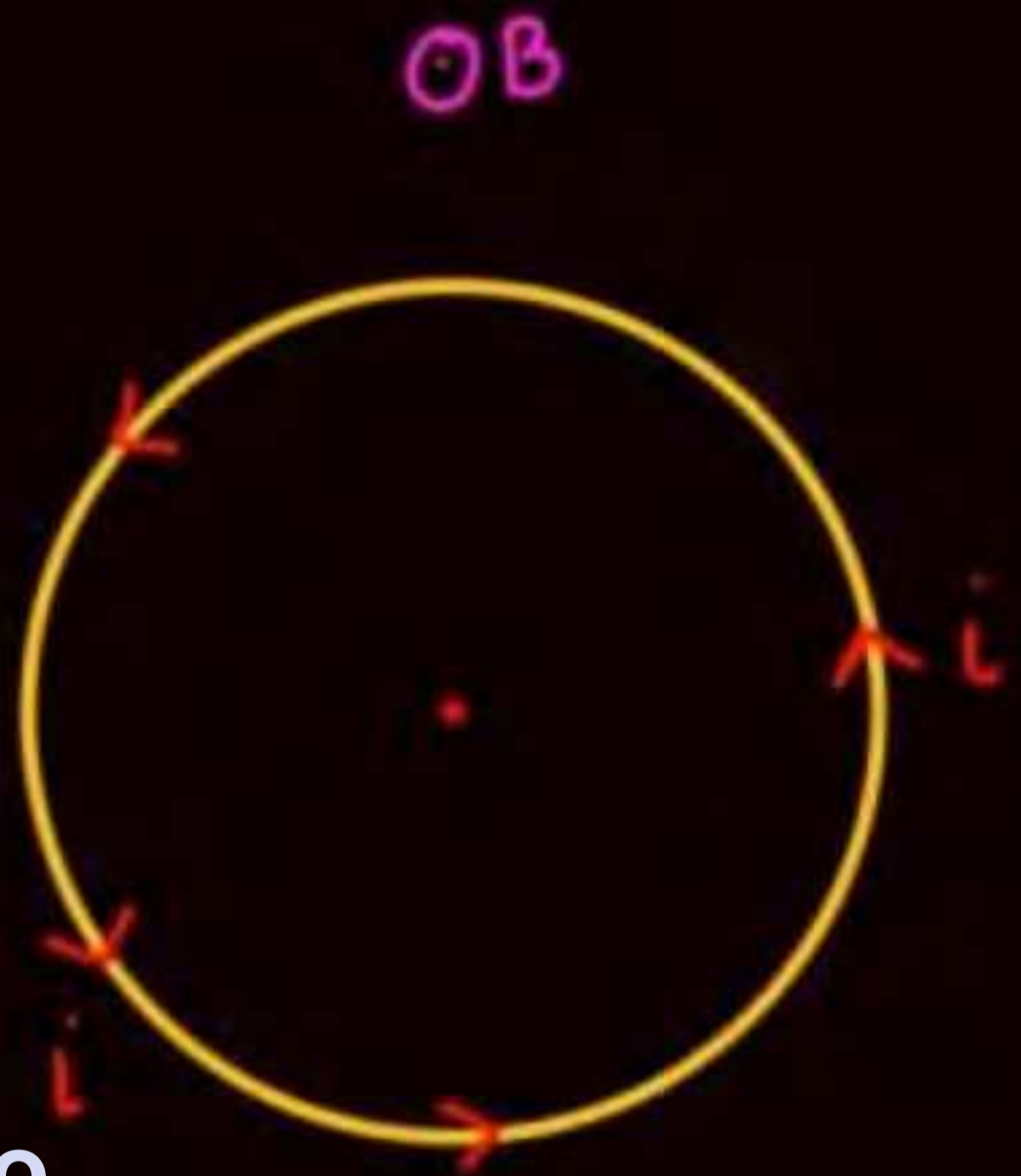
$$F_{\text{net}} = i \cdot 2\pi R B \cos \theta = \frac{i \cdot 2\pi R B R}{\sqrt{R^2 + d^2}}$$

Q ① Find net force on circular loop = 0

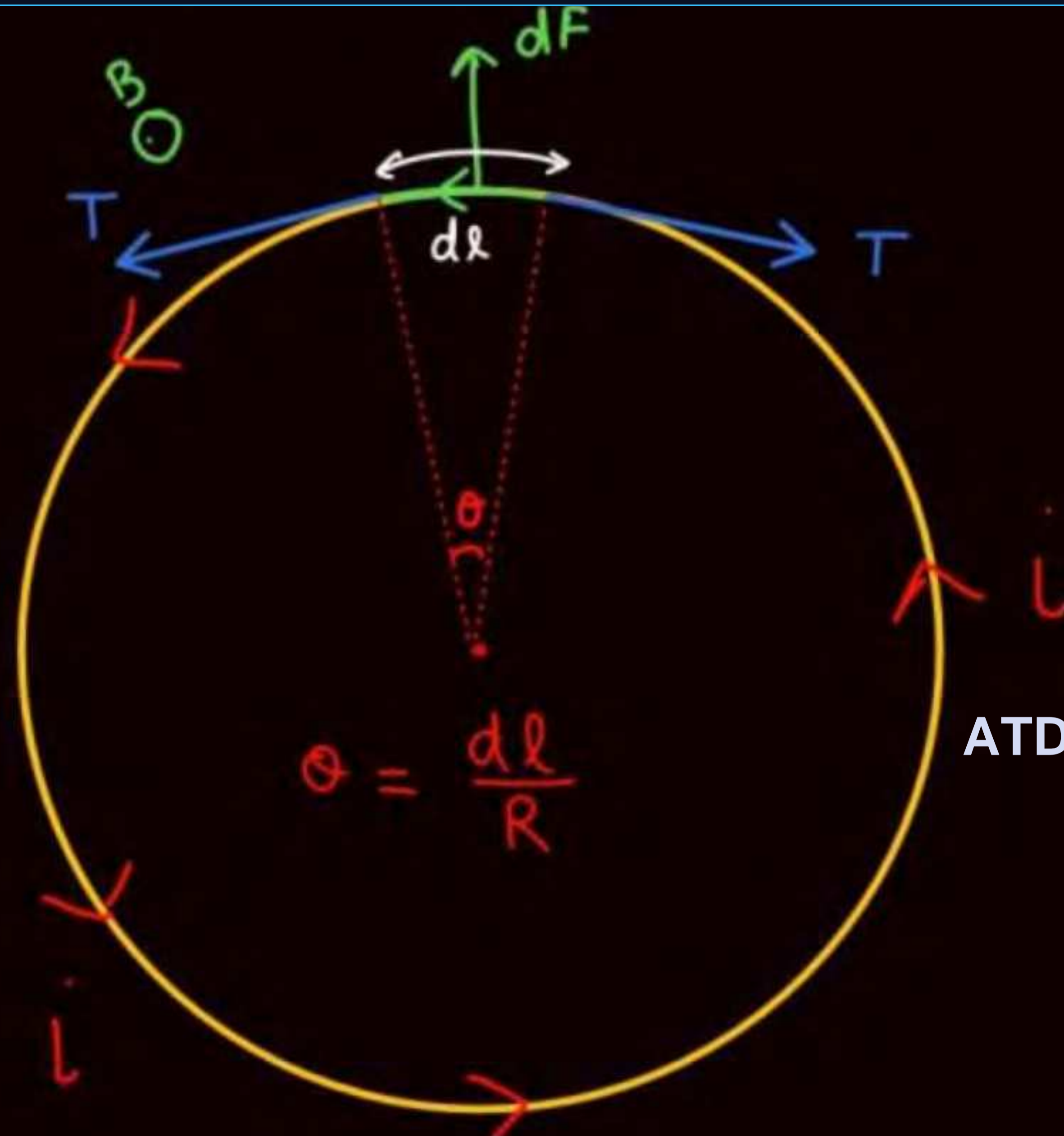
② Find tension developed in wire.

$$T = iRB \text{ (Ans)}$$

③ $\frac{T}{A} = Y \frac{\Delta R}{R}$

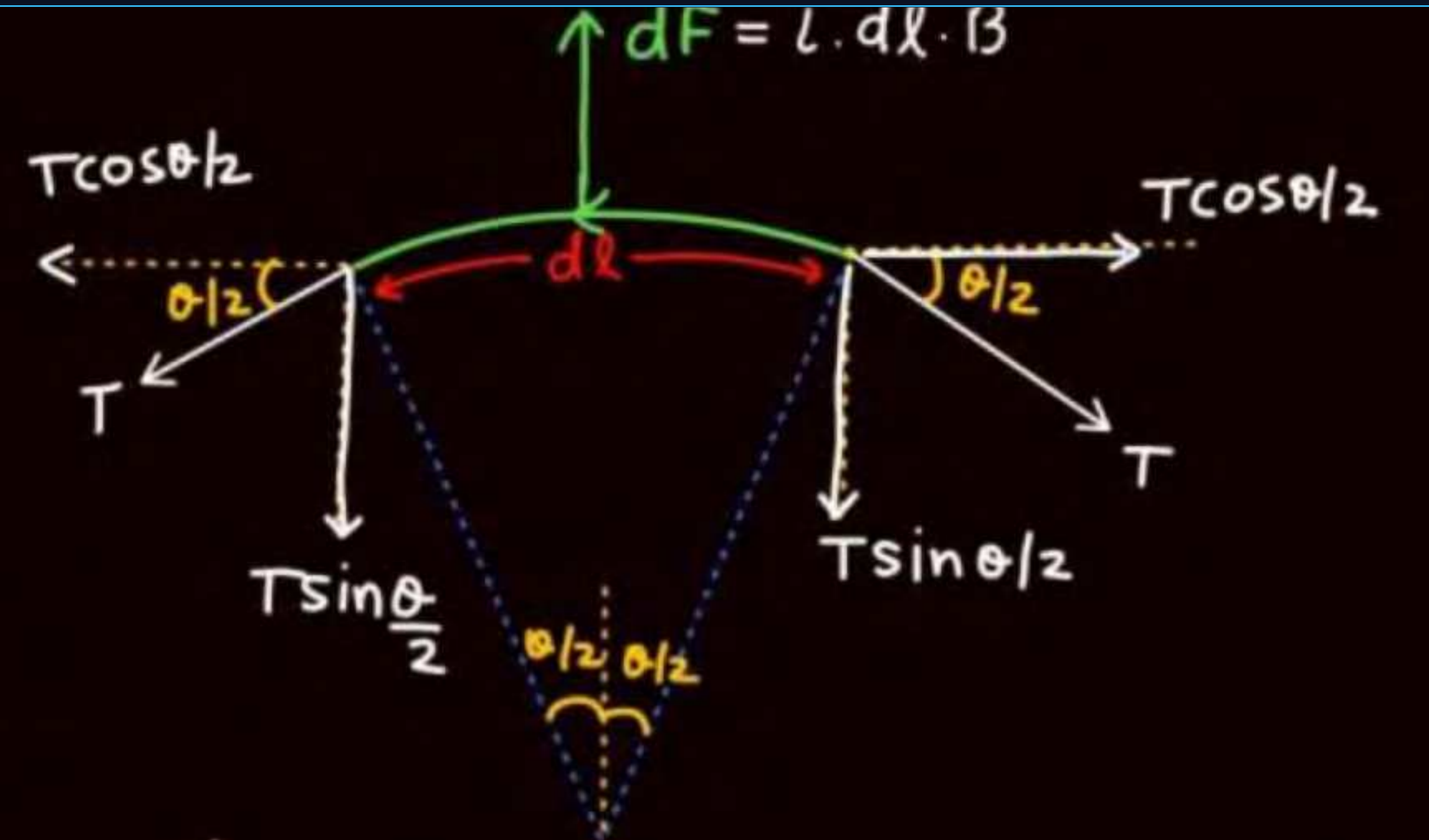


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$$\theta = \frac{dl}{R}$$

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$$dF = 2T \sin \frac{\theta}{2}$$

$$\sin \frac{\theta}{2} \approx \frac{\theta}{2}$$

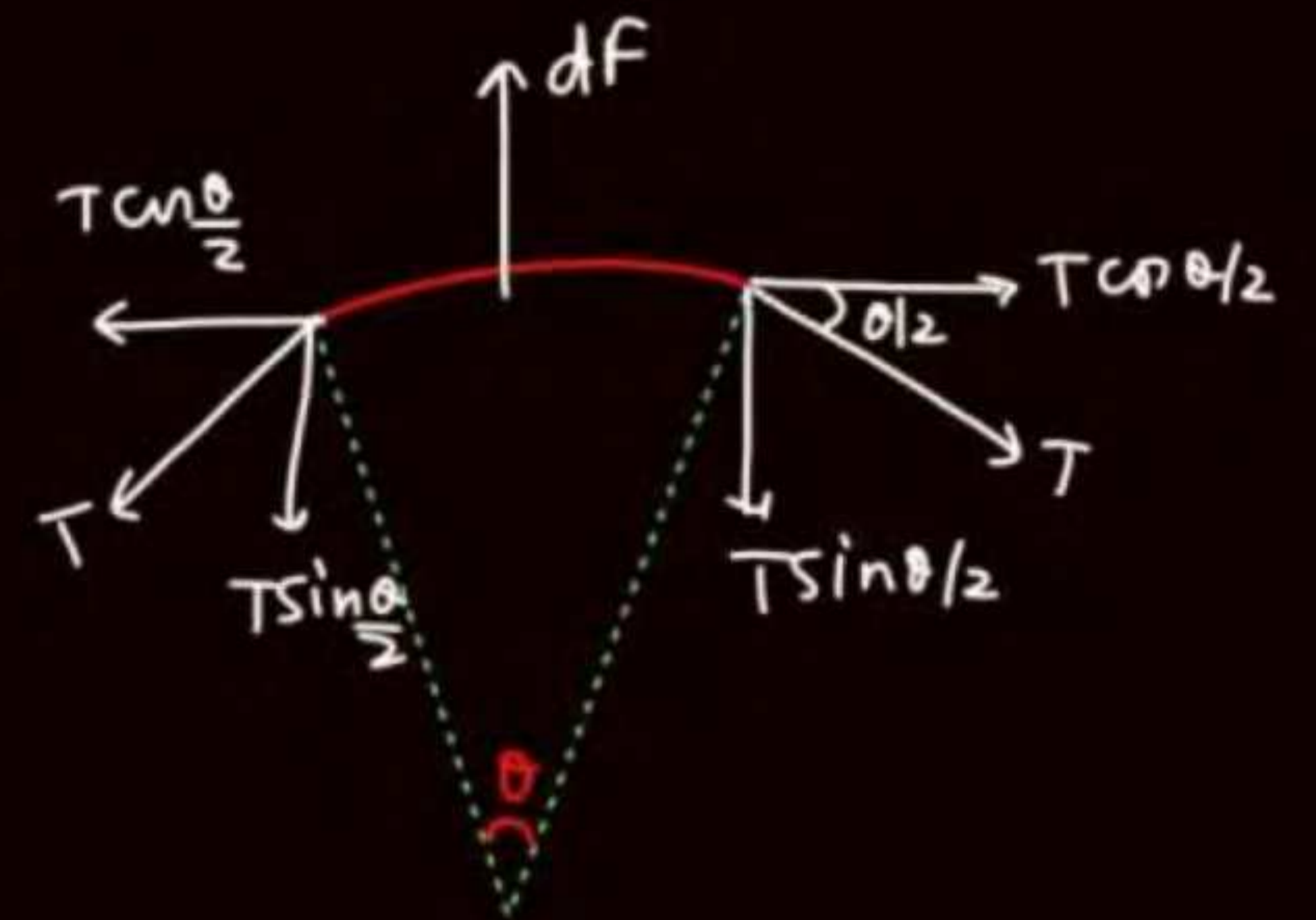
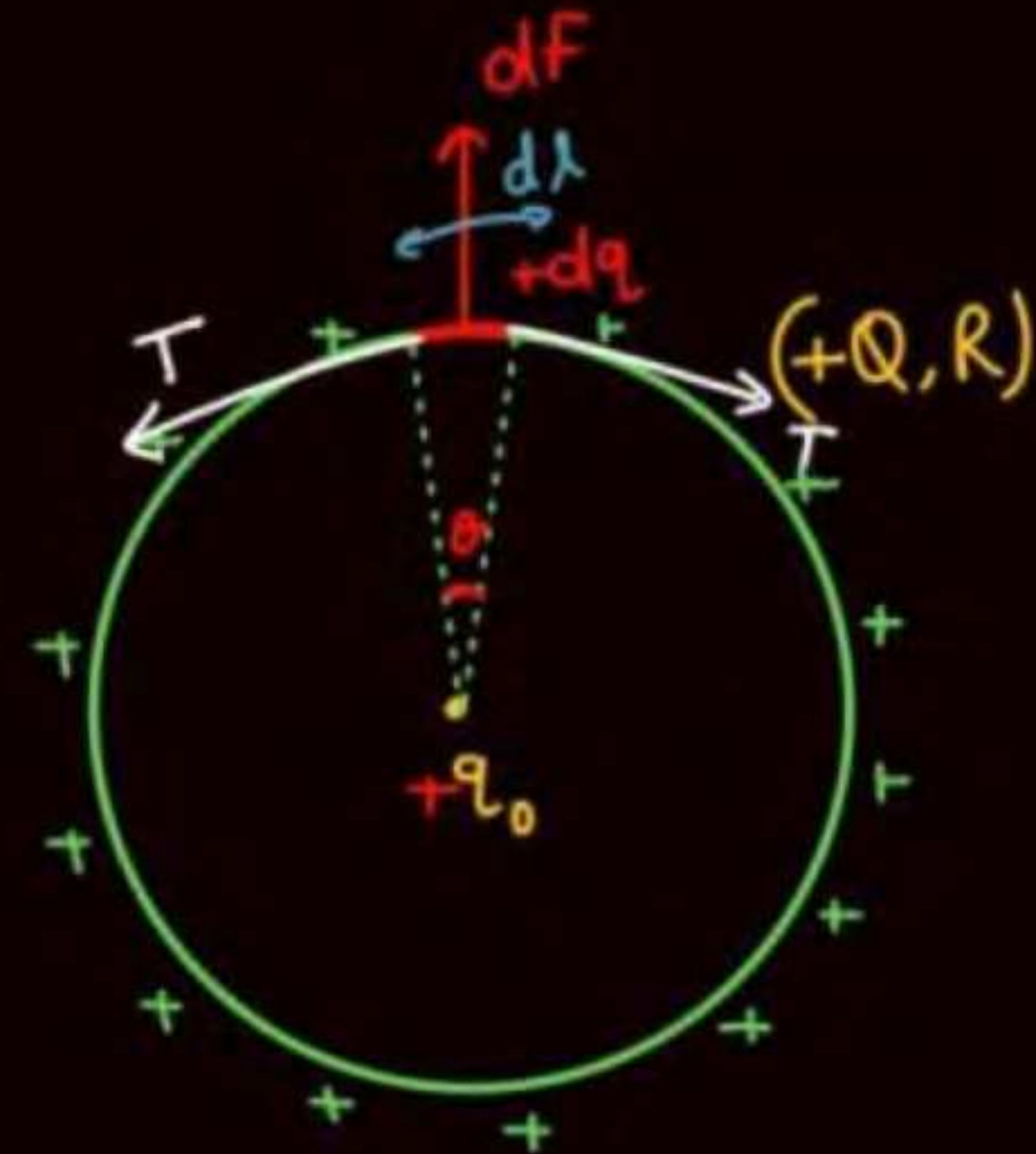
$$dF = 2T \frac{\theta}{2}$$

$$i \cdot dl \cdot B = T \theta = T \frac{dl}{R}$$

$$i \cancel{dl} B = T \frac{\cancel{dl}}{R}$$

$$T = I R B$$

Exo 5
Q

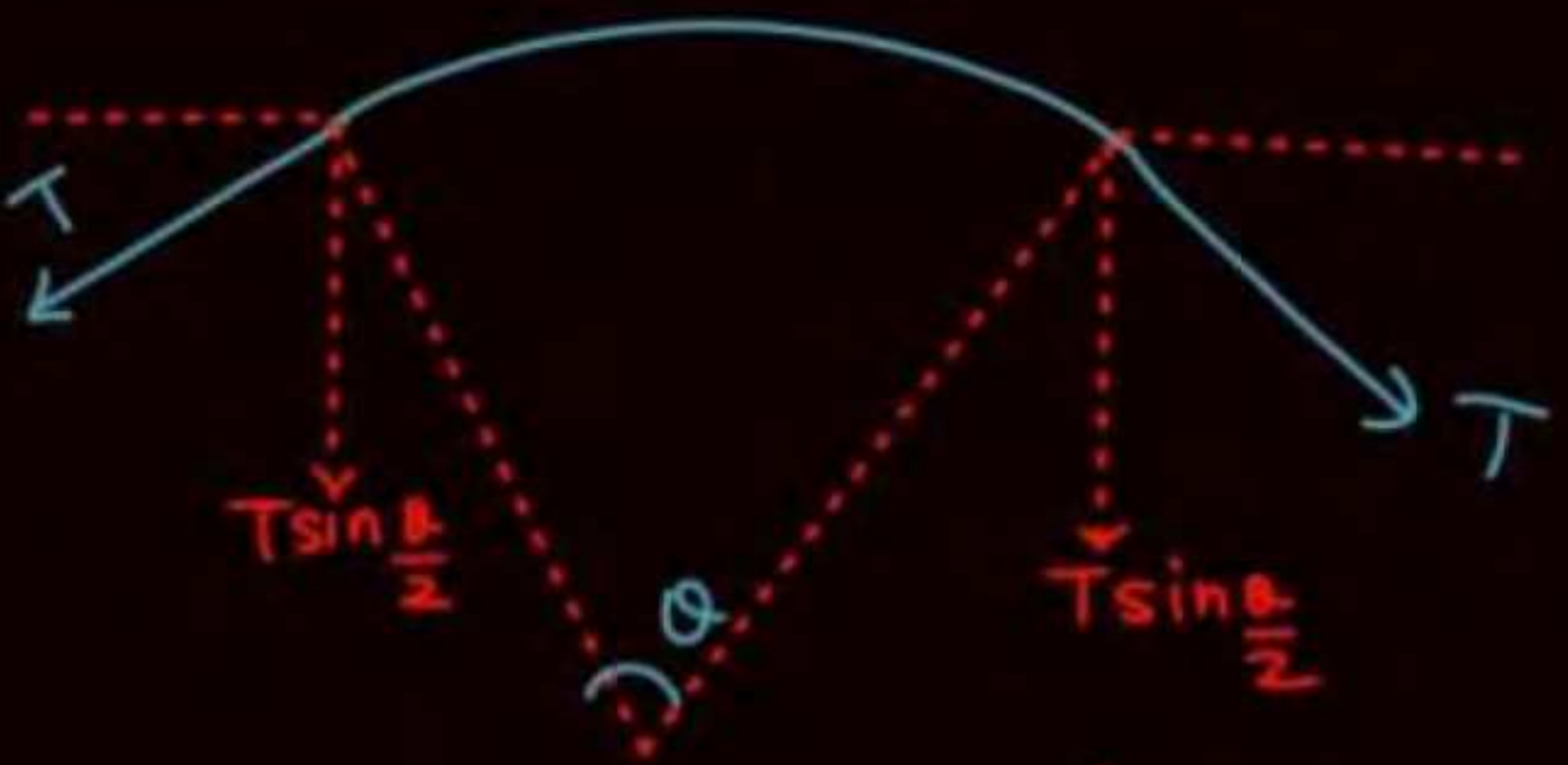
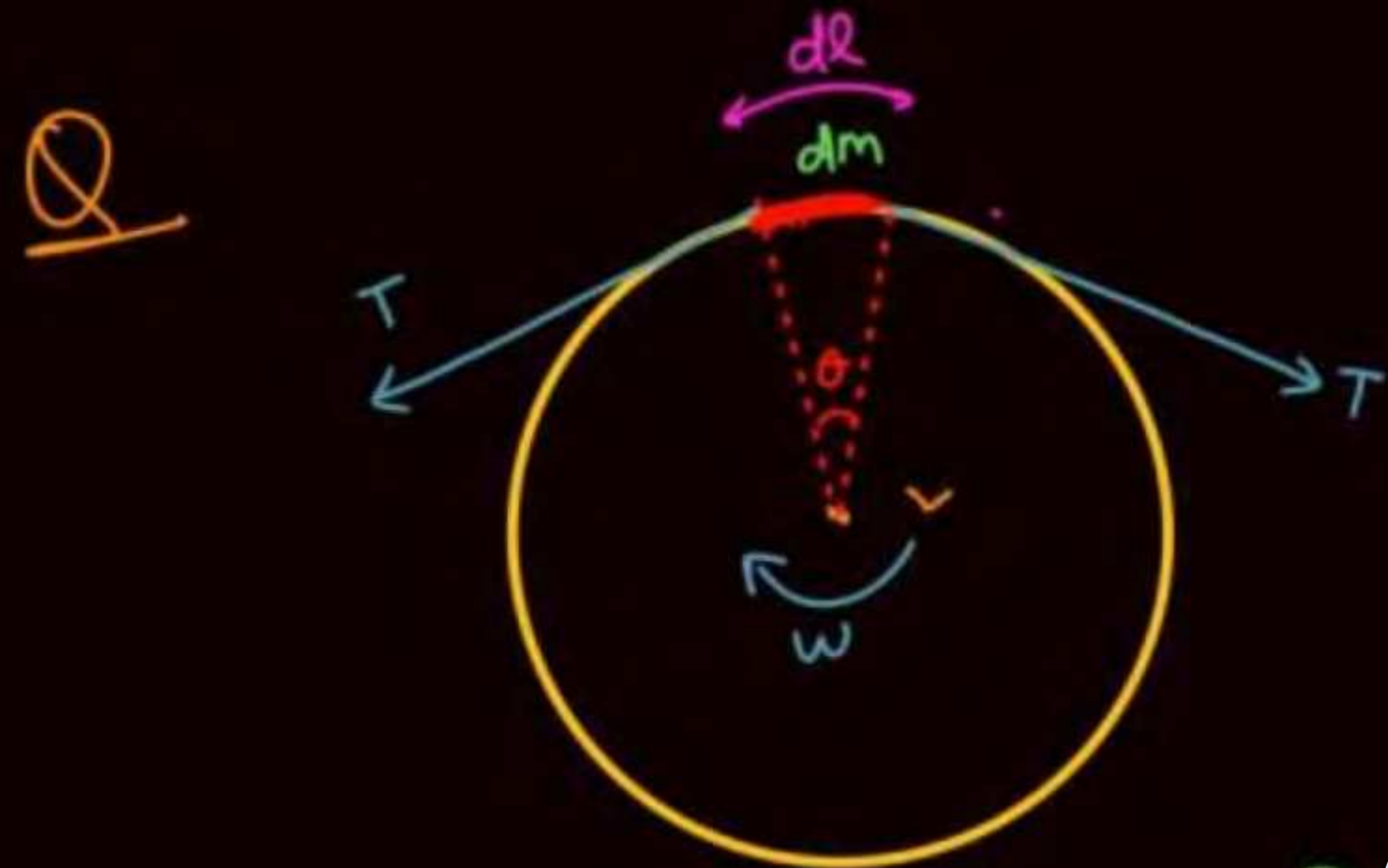


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$$dF = 2T \sin \theta/2 = T \theta$$

$$\frac{kq_0 dq}{R^2} = T \frac{dl}{R}$$

$$\frac{kq_0}{R} \left(\frac{dq}{dl} \right) = T = \frac{kq_0 \lambda}{R}$$



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$$2T \sin \frac{\theta}{2} = (dm) R \omega^2$$

$$2T \frac{\theta}{2} = dm \cdot R \omega^2$$

$$T \cdot \frac{dl}{R} = dm R \omega^2$$

$$T = \left(\frac{dm}{dl} \right) R^2 \omega^2$$

$$T = \lambda R^2 \omega^2$$



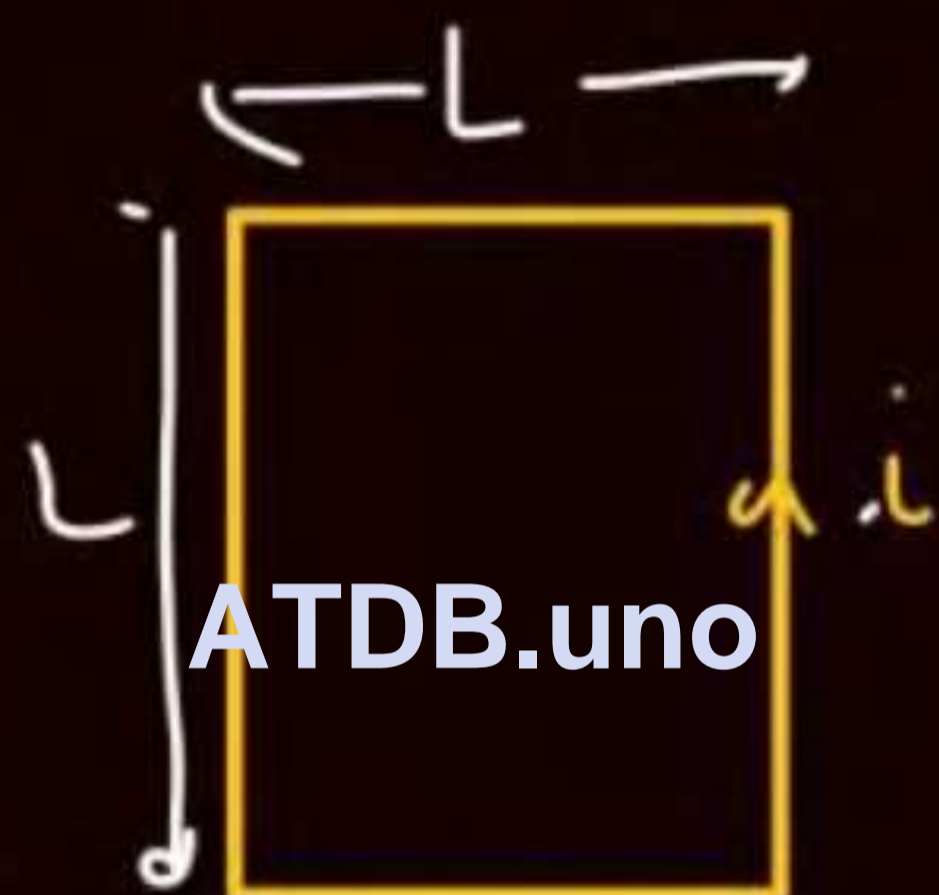
magnetic moment

$$\vec{M} = i \vec{A}$$



$$M = i \pi R^2$$

$$\vec{M} = i \pi R^2 \times \hat{k}$$



$$i \times L^2 \times \hat{k}$$

magnetic dipole moment / magnetic moment

x-y plane \hat{k}
current (cw \Rightarrow) \hat{k}
 \vee ACW \Rightarrow $-\hat{k}$

- magnetic dipole moment of a current carrying loop is given by

$$\vec{M} = i \vec{A}$$

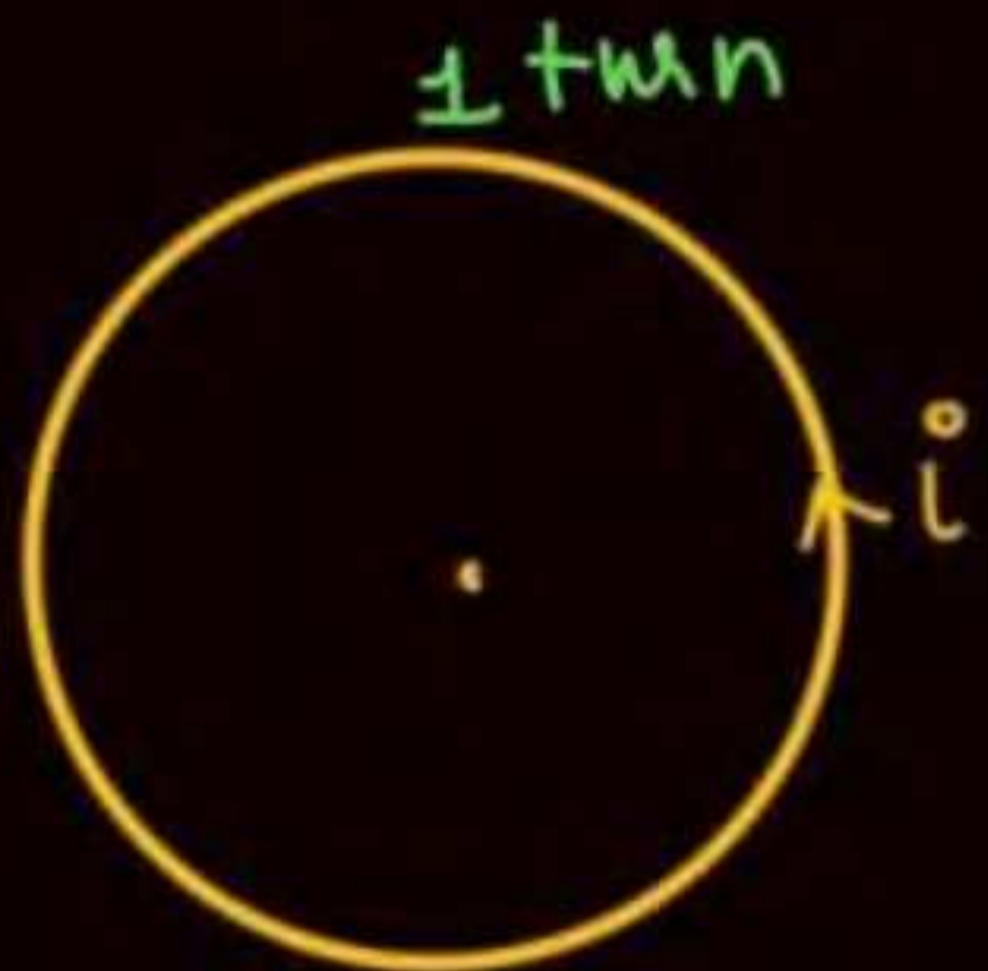
For n loop

$$\vec{M} = i n \vec{A}$$

if n \rightarrow no. of turn

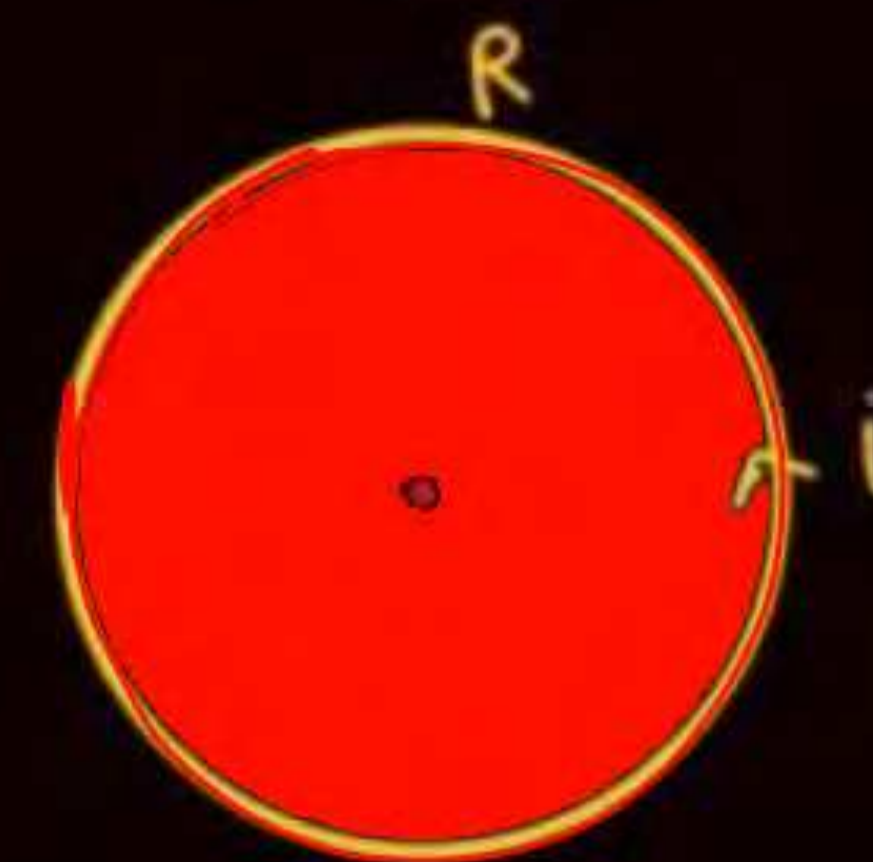
$$\vec{M} = i \vec{A} \cdot n$$

* Dirⁿ of \vec{M} is given by right hand thumb rule.



$$\text{magnetic dipole moment} = \vec{M} = i \pi R^2 (\hat{k})$$

$$m = i \pi R^2 \text{ (magnitude)}$$

\mathcal{Q} 

$$\vec{m} = i \pi R^2 \hat{k}$$

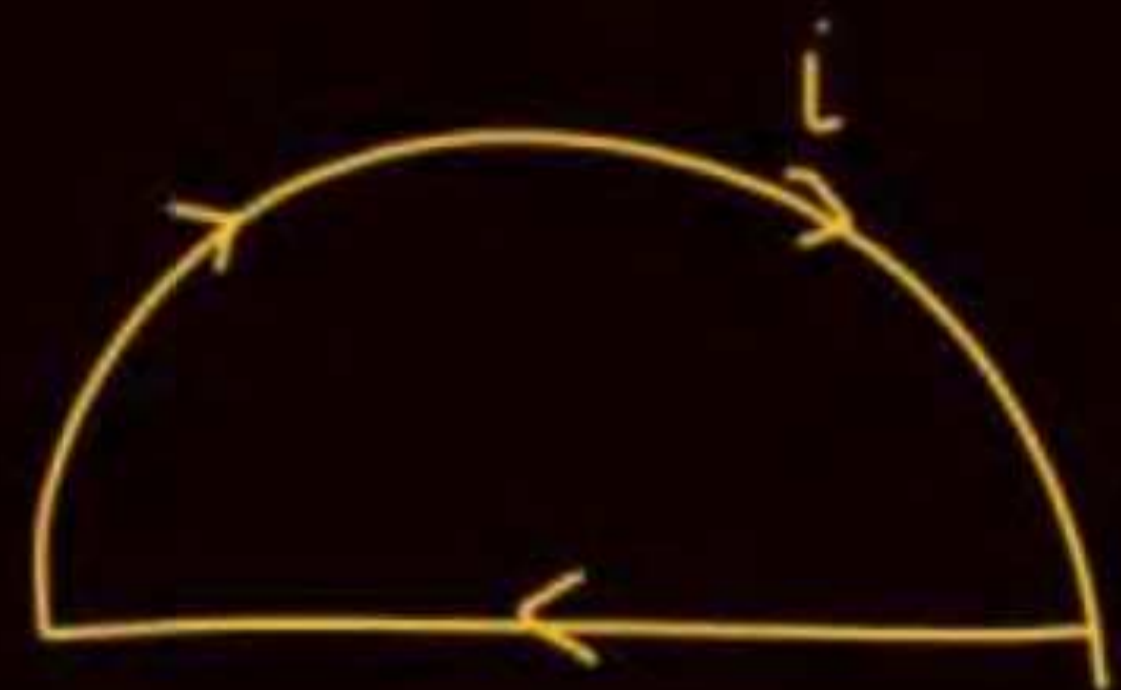
 \mathcal{Q} (Square L)

$$\vec{m} = i L^2 (-\hat{k})$$

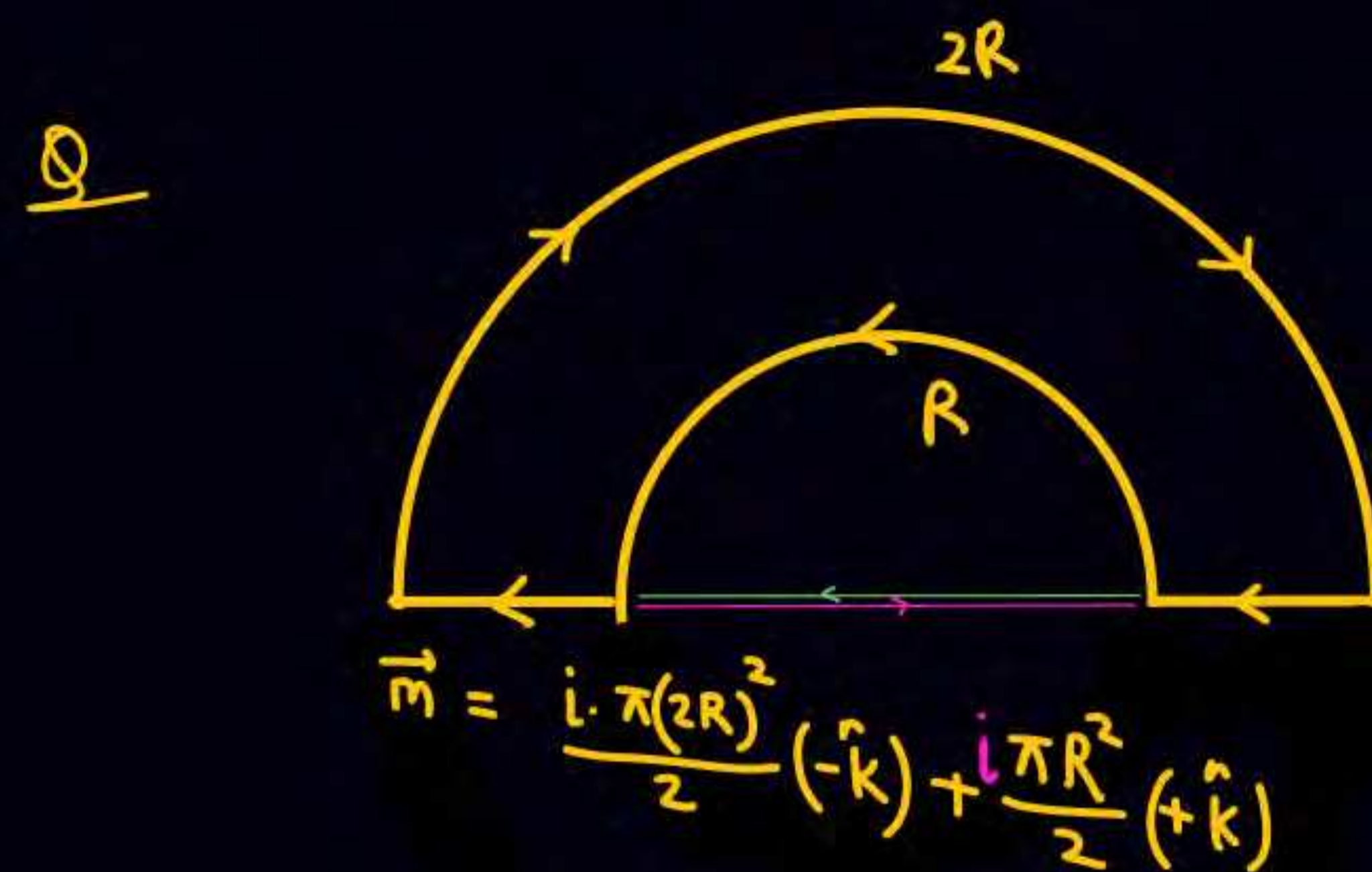
 \mathcal{Q} (Rectangle L, b)

$$\vec{m} = i L b (\hat{k})$$

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 \mathcal{Q} 

$$\vec{m} = i \frac{\pi R^2}{2} (-\hat{k})$$



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$\vec{M} = \left[\frac{i \pi (2R)^2}{2} + \frac{i \pi R^2}{2} \right] (-\hat{k})$

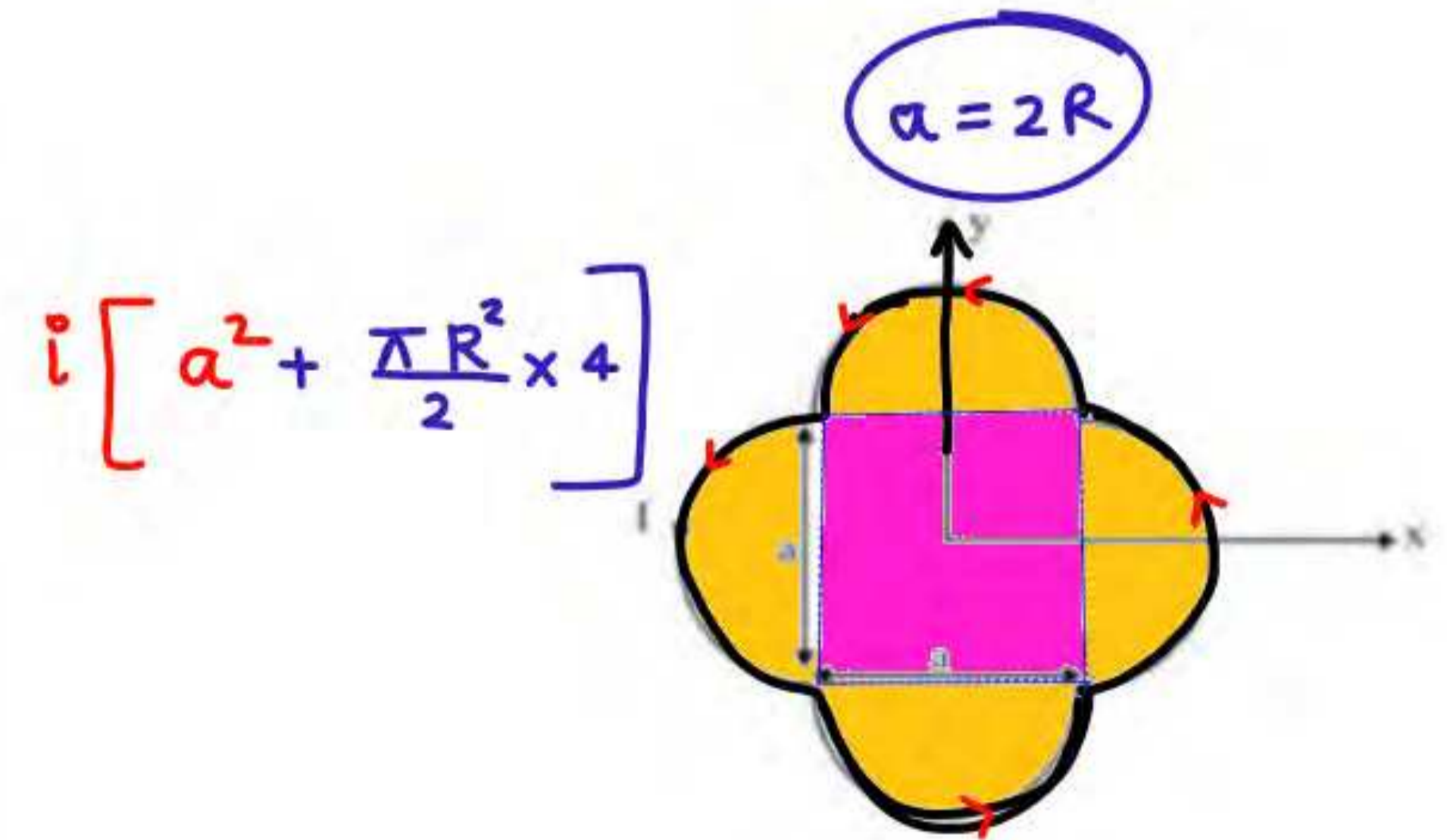
of the plane of the paper. The magnetic moment of the current loop is

[JEE 2012]

चित्र में दर्शाये अनुसार एक लूप x-y तल में है और उस धारा I बह रही है। एकांक-सदिश \hat{k} पृष्ठ के सम्बन्धित \hat{k} की ओर है। लूप का चुम्बकीय आघूर्ण है



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- (A) $a^2 \hat{k}$
- (B) $\left(\frac{\pi}{2} + 1\right) a^2 \hat{k}$
- (C) $-\left(\frac{\pi}{2} + 1\right) a^2 \hat{k}$
- (D) $(2\pi + 1) a^2 \hat{k}$

Current carrying loop in magnetic field (Uniform)

Force on PQ = 0

Force on RS = 0

Force on QR = iLB अंदर

" " SP = iLB बाहर

$F_{net} = 0$

$$(\vec{\tau})_{abt\ SP} = FL = iLB L$$

$$= iL^2 B (+\hat{j})$$

$$= mB(\hat{j})$$

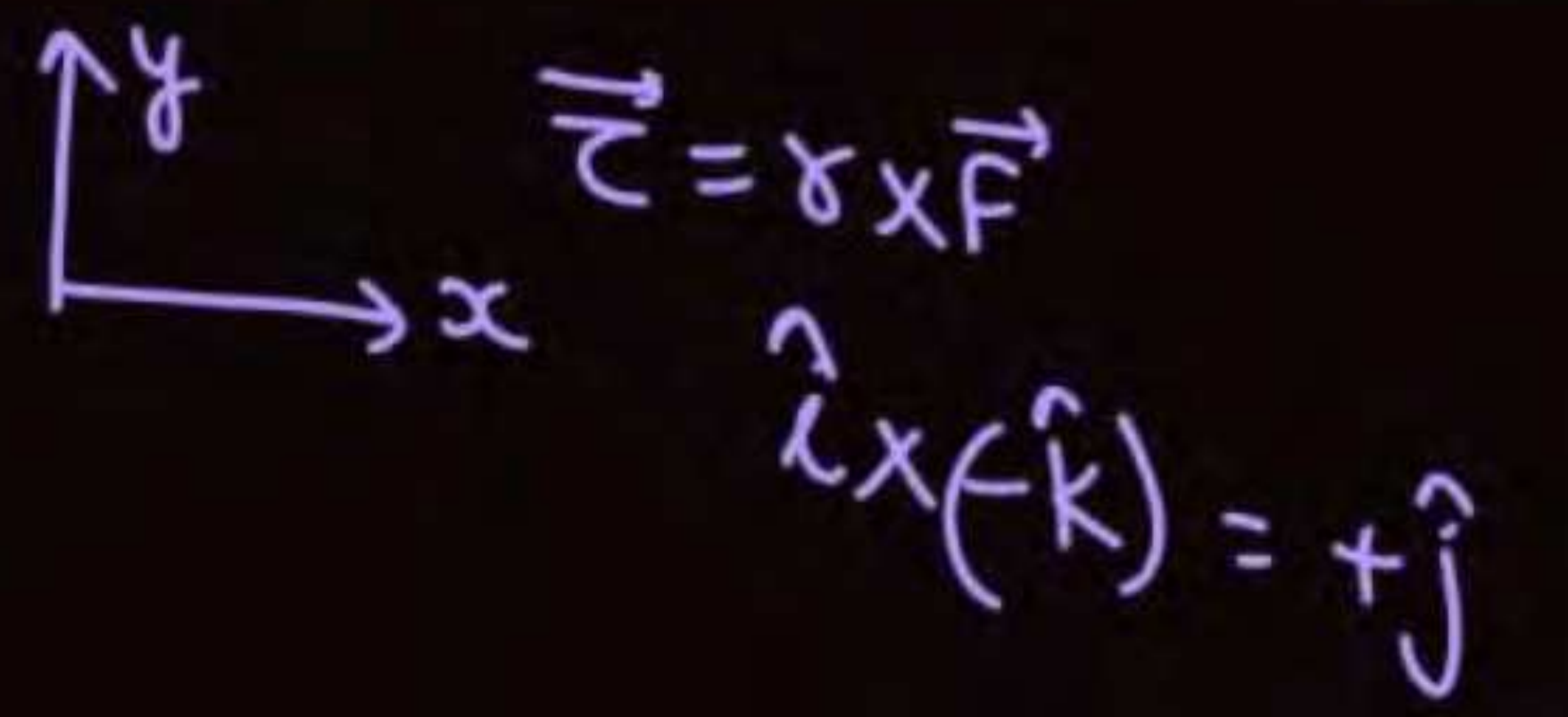
$$\boxed{\vec{\tau} = \vec{m} \times \vec{B}}$$

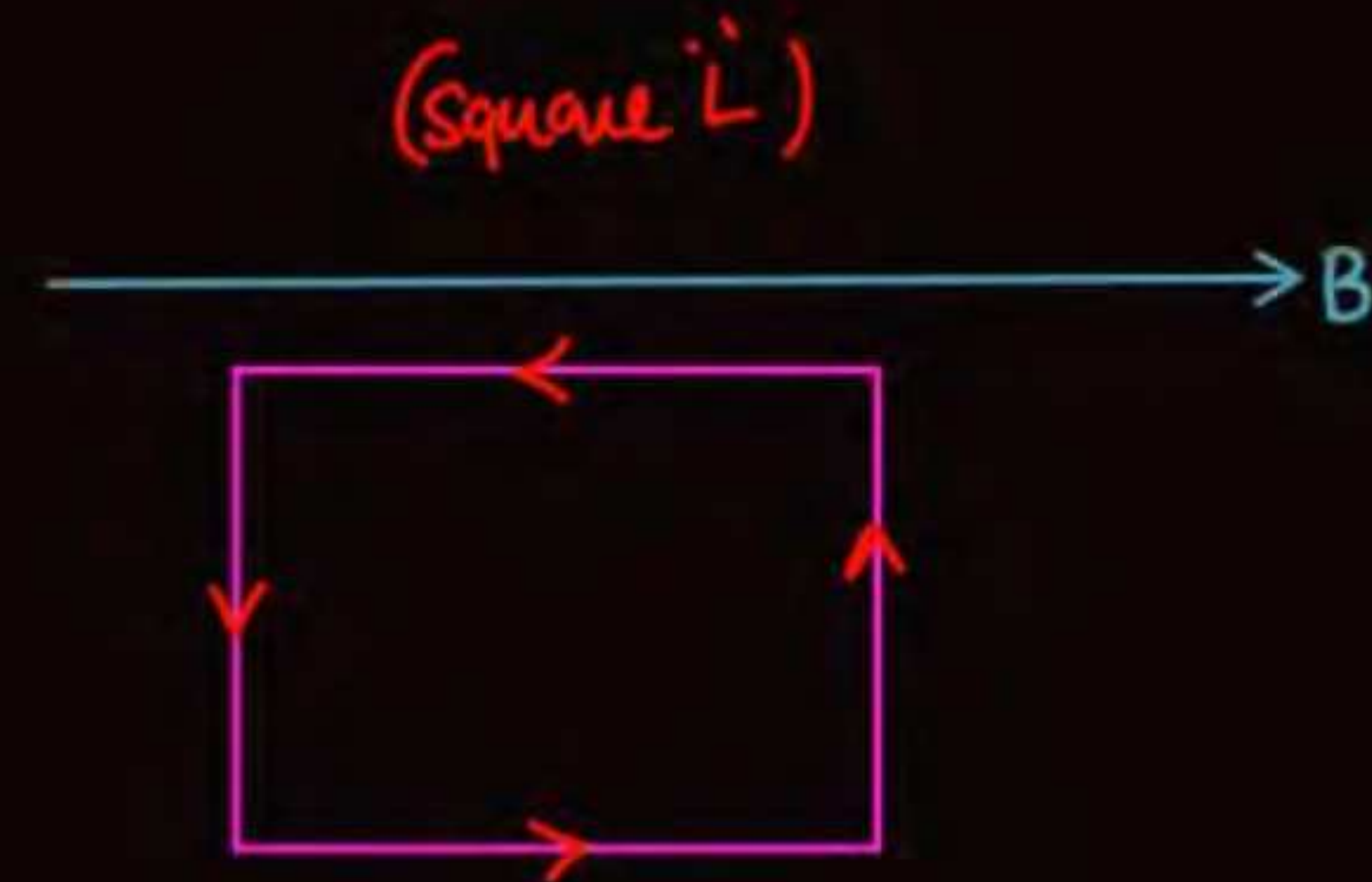
$$\tau = F \frac{L}{2} + F \frac{L}{2} = FL = iL^2 B$$

$$\vec{F} = i\vec{L} \times \vec{B}$$



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$$\vec{\tau} = \vec{m} \times \vec{B}$$

$$\vec{m} = IL^2 \hat{k}$$

$$\vec{B} = B \hat{i}$$

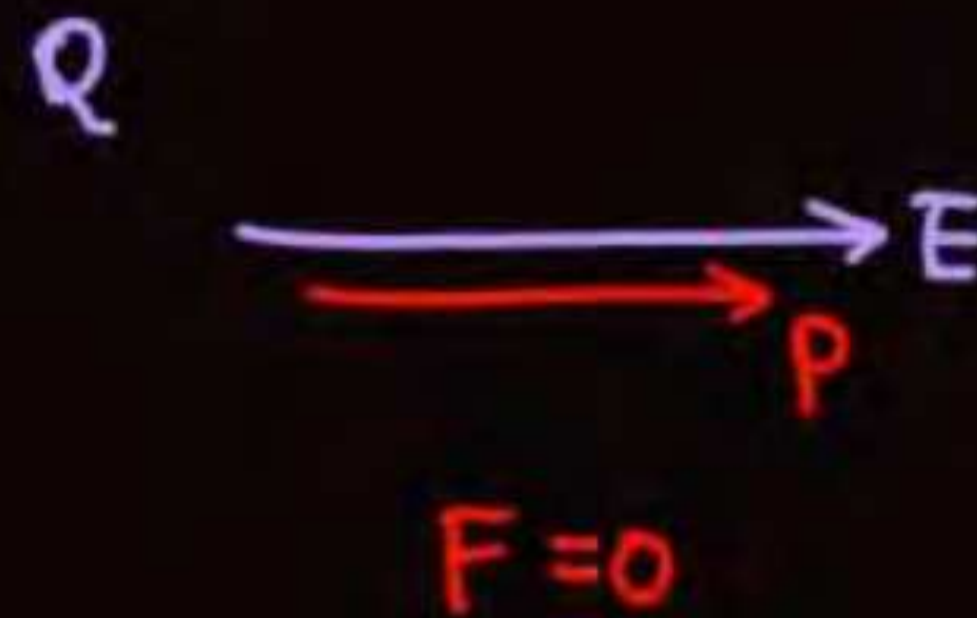
$$\begin{aligned} \vec{\tau} = \vec{m} \times \vec{B} &= (IL^2 \hat{k}) \times (B \hat{i}) \\ &= IL^2 B (\hat{j}) \end{aligned}$$

Electric dipole moment

$$\vec{p}, \vec{E} \quad \vec{\tau} = \vec{p} \times \vec{E}$$

$$* T = 2\pi \sqrt{\frac{I}{pE}}$$

- * $\theta = 0, F=0, \tau=0, U_{\min}$ → Stable Equil.
- * $\theta = 180, F=0, \tau=0, U_{\max}$ → Unstable Equil.



small angle rotate & release

$$T = 2\pi \sqrt{\frac{I}{pE}}$$

magnetic dipole moment

$$\vec{\tau} = \vec{m} \times \vec{B}$$



$$\vec{\tau} = \vec{p} \times \vec{E} \quad \rightarrow \quad \vec{\tau} = \vec{m} \times \vec{B}$$

$$U = -\vec{p} \cdot \vec{E} \quad \rightarrow \quad U = -\vec{m} \cdot \vec{B}$$

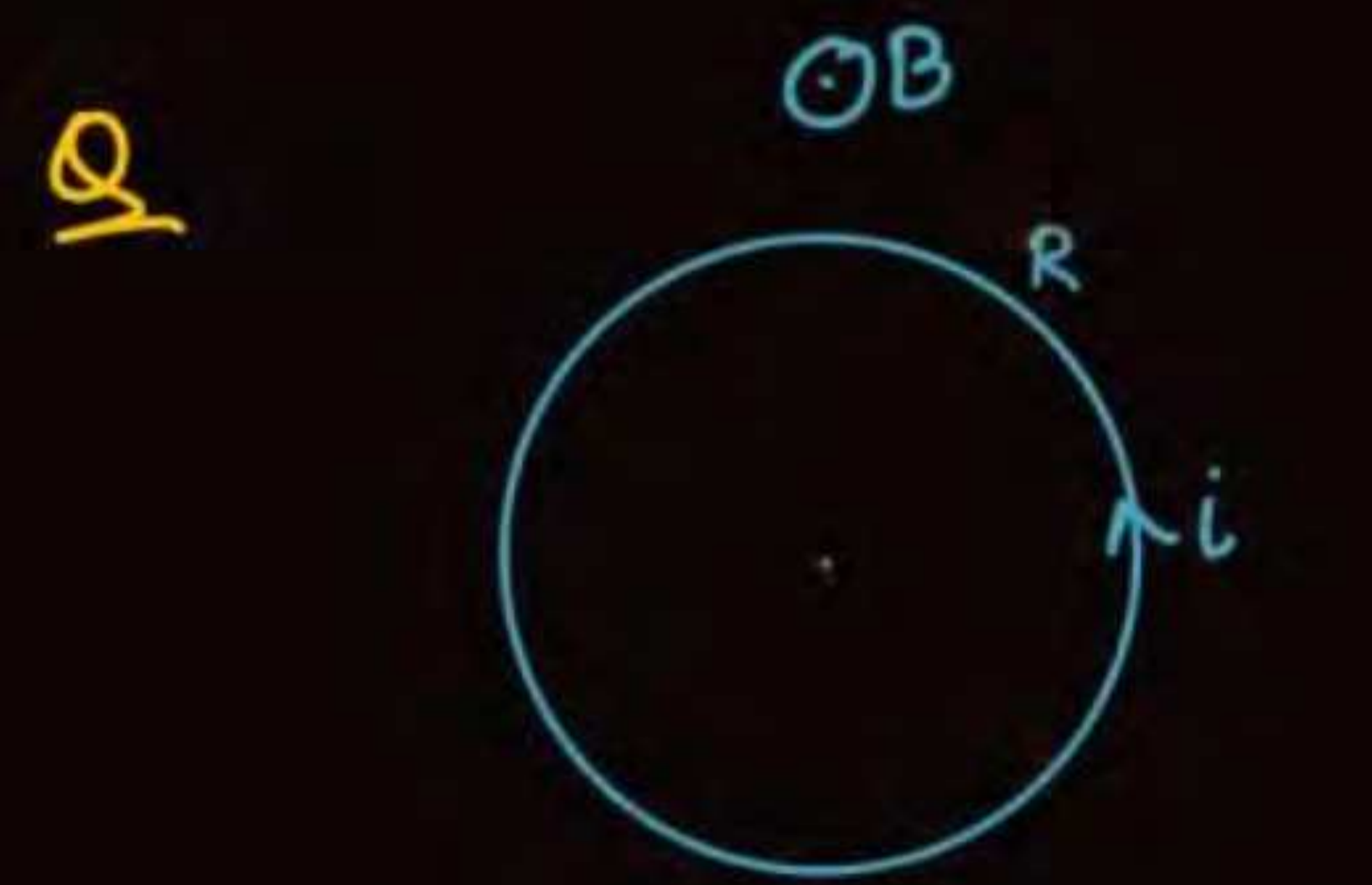
$$U = -mB \cos \theta$$

$$\theta = 0, F=0, \tau=0, U_{\min} \text{ (Unstable)}$$

$$\theta = 180, F=0, \tau=0, U_{\max} \text{ (Unstable)}$$

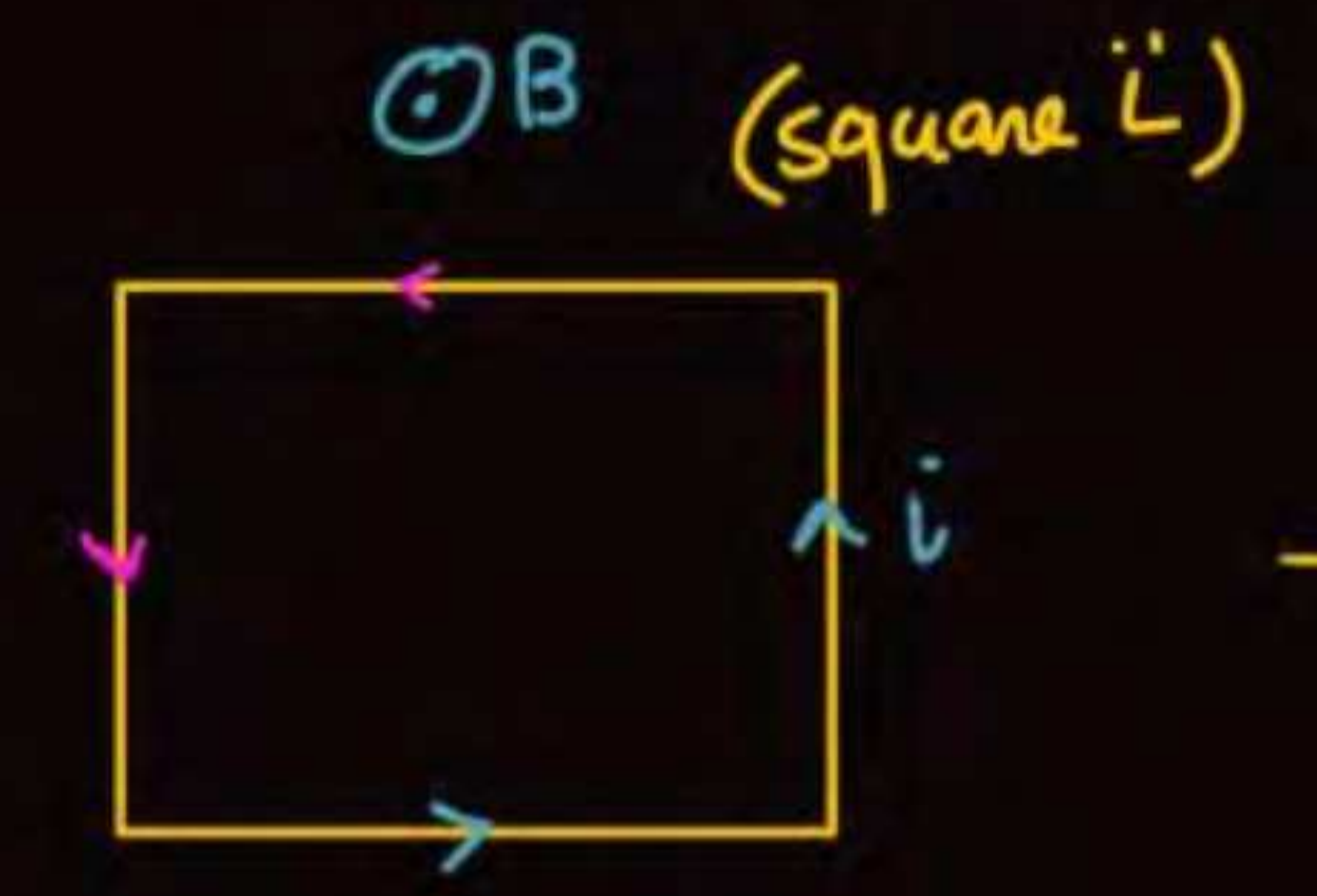
$$T = 2\pi \sqrt{\frac{I}{mB}}$$

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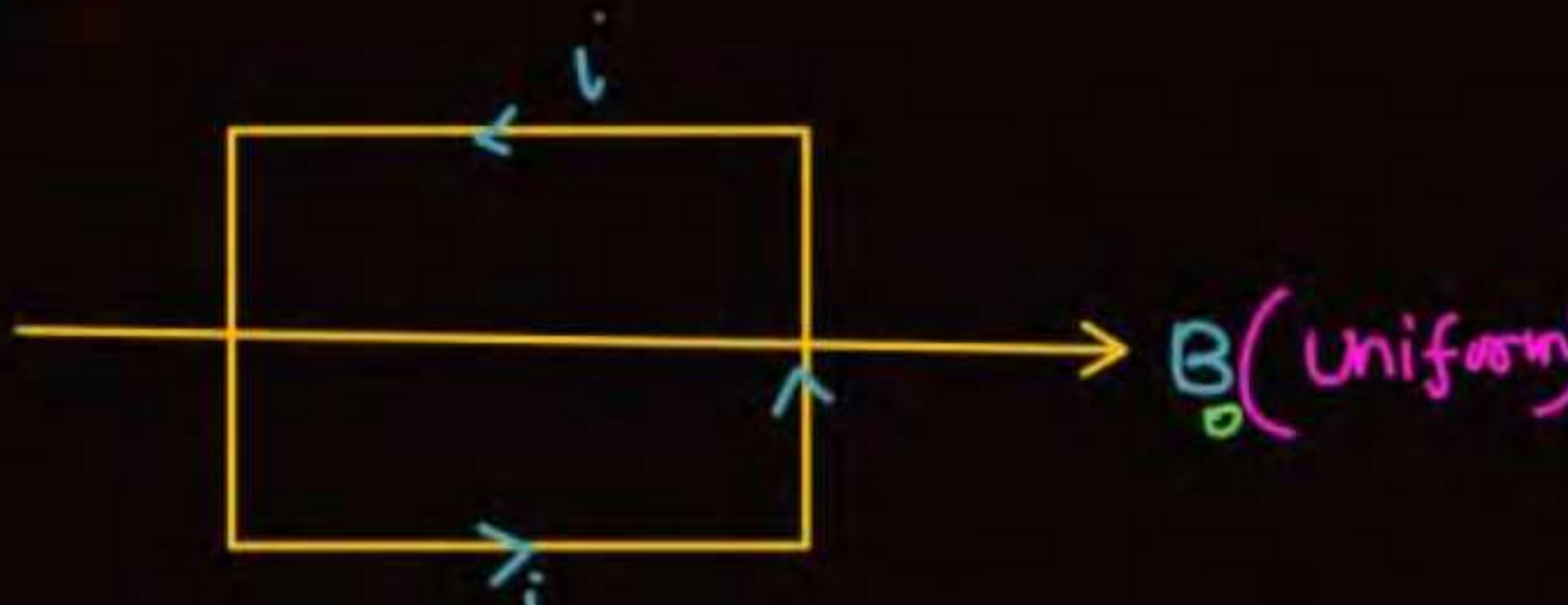


$F = 0$
 $\tau = 0$
 $\theta = 0$
 $\tau = 0$
 (Stable)

$\vec{\tau} = \vec{m} \times \vec{B}$

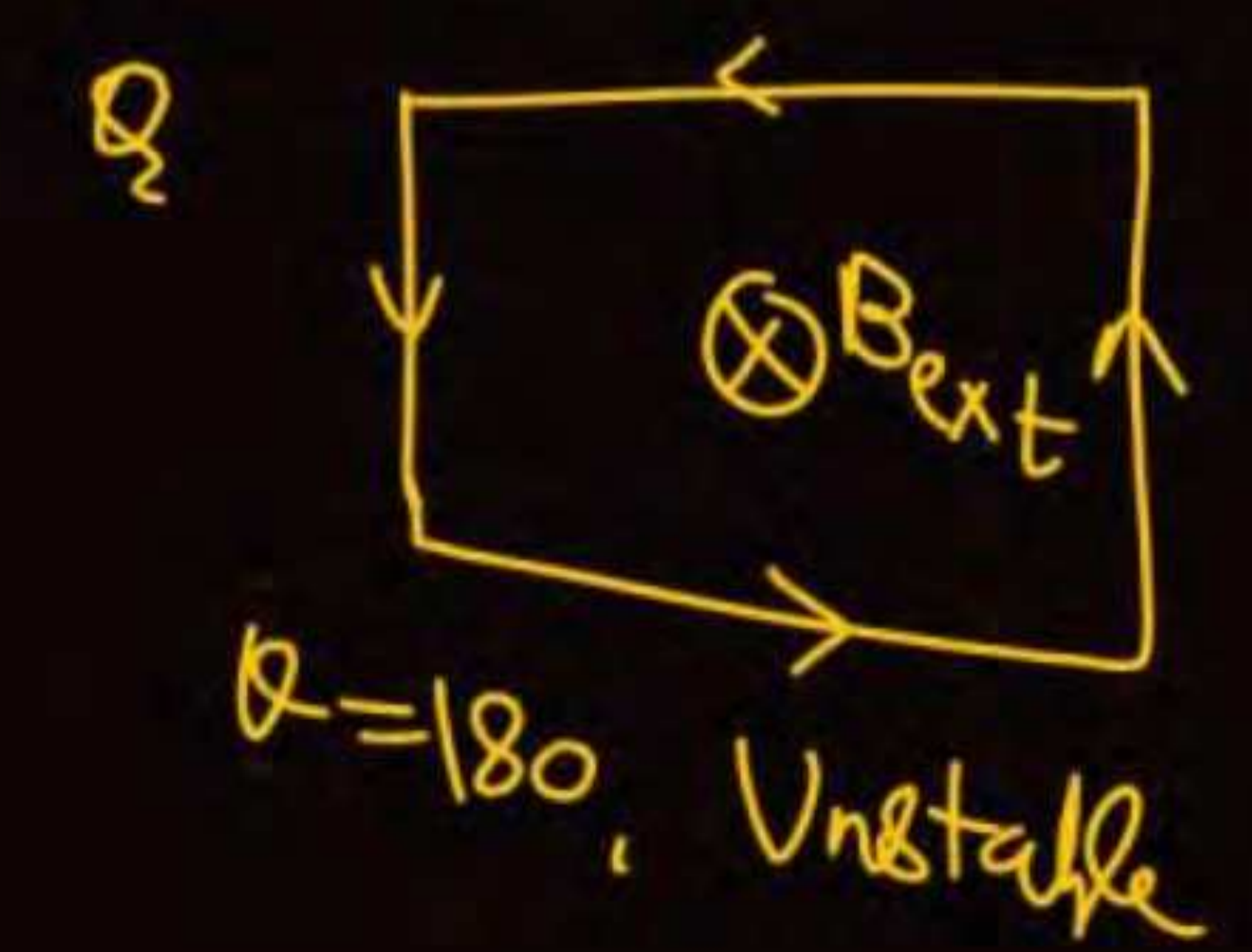


$F = 0$
 $\theta = 0, \tau = 0$, stable



$F = 0$
 $\tau \neq 0$
 $\theta = 90^\circ$
 $\vec{\tau} = \vec{m} \times \vec{B} \neq 0$

$|\vec{m}| = L^2 \hat{k}$
 $\vec{B} = B_0 \hat{i}$



$$\vec{\tau} = \vec{p} \times \vec{E}$$



$$\theta = 0$$

$$\tau = 0$$



$$\tau = PE \sin \theta$$

for small displacement
 $\sin \theta \approx \theta$

$$\vec{\tau} = -PE \theta$$

$$\vec{\tau} = -(K) \theta$$

Angular SHM
 ✓

$$T = 2\pi \sqrt{\frac{I}{PE}}$$

$$\vec{F} = -k\vec{x}$$

$$T = 2\pi \sqrt{\frac{m}{k}}$$

$\vec{p} \uparrow \vec{E}$ Stable
 $\theta = 0$



$\vec{m} \uparrow \vec{B}$ (stable)
 $\theta = 0$, parallel

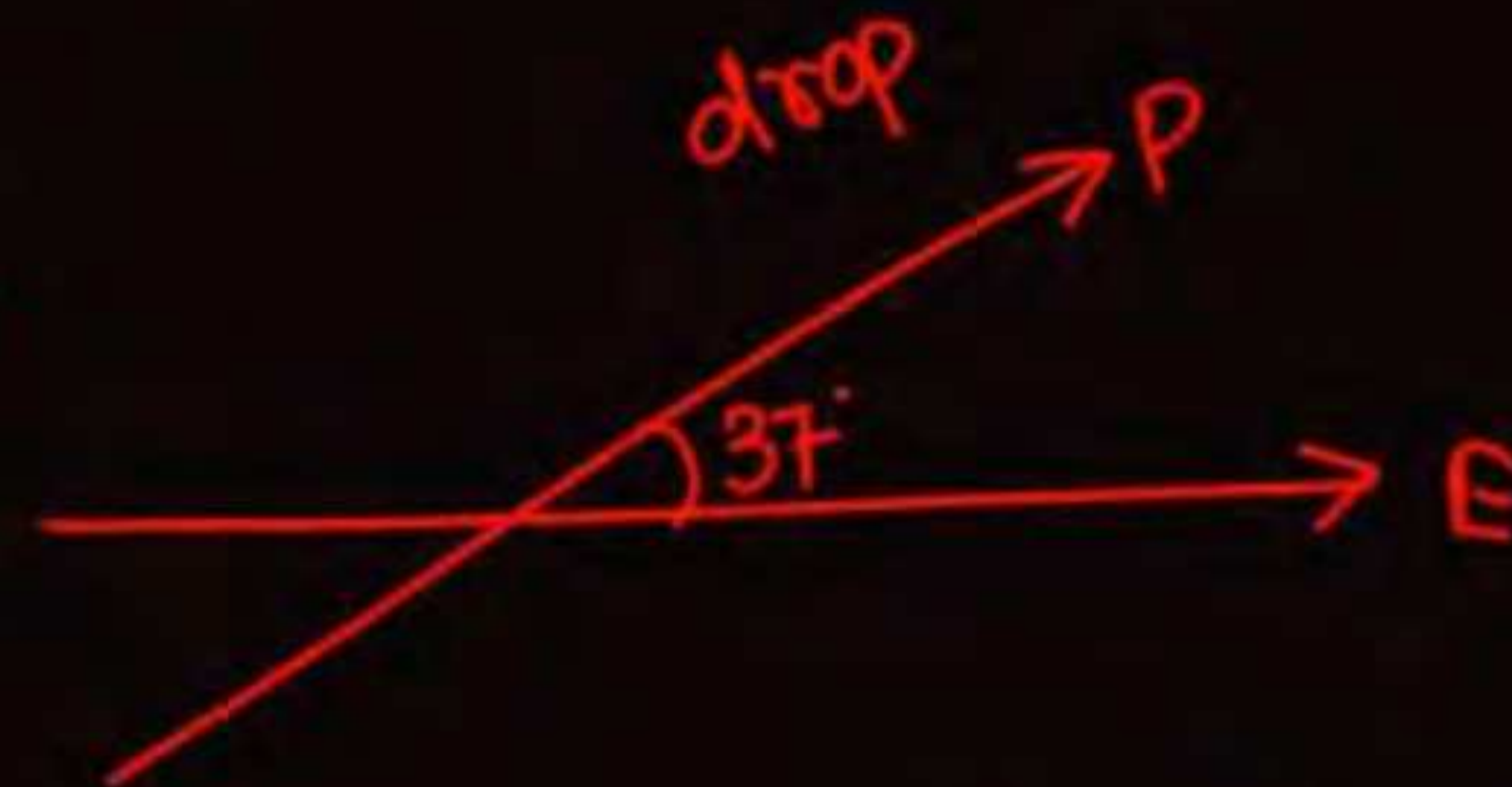
$\vec{p} \downarrow \vec{E}$ Unstable
 $\theta = 180$



$\vec{m} \downarrow \vec{B}$ (Antiparallel)
 $\theta = 180$, (Unstable)

पुरानी कौत

Q



$$PE = U = -\vec{P} \cdot \vec{E} = -PE \cos \theta$$



$$K_i + U_i = K_f + U_f$$

$$0 + (-PE \cos 37^\circ) = \frac{1}{2} I \omega^2 + (-PE \cos 0)$$

$$\omega = \sqrt{\quad}$$

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Home Work

— Revise all the qns of today class

— HCV page (251)

(24-55)

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page 231 \Rightarrow (10-20) must do.

(21, 22, 23, 24, 25, 26, 27) = मनकरे तो कर लियो 😊



THANK

YOU

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