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Advance pattern

Test Syllabus

- → Electrostatic
- → Capacitor
- → Current Electricity

} 60%

- → Magnetic field] 40%

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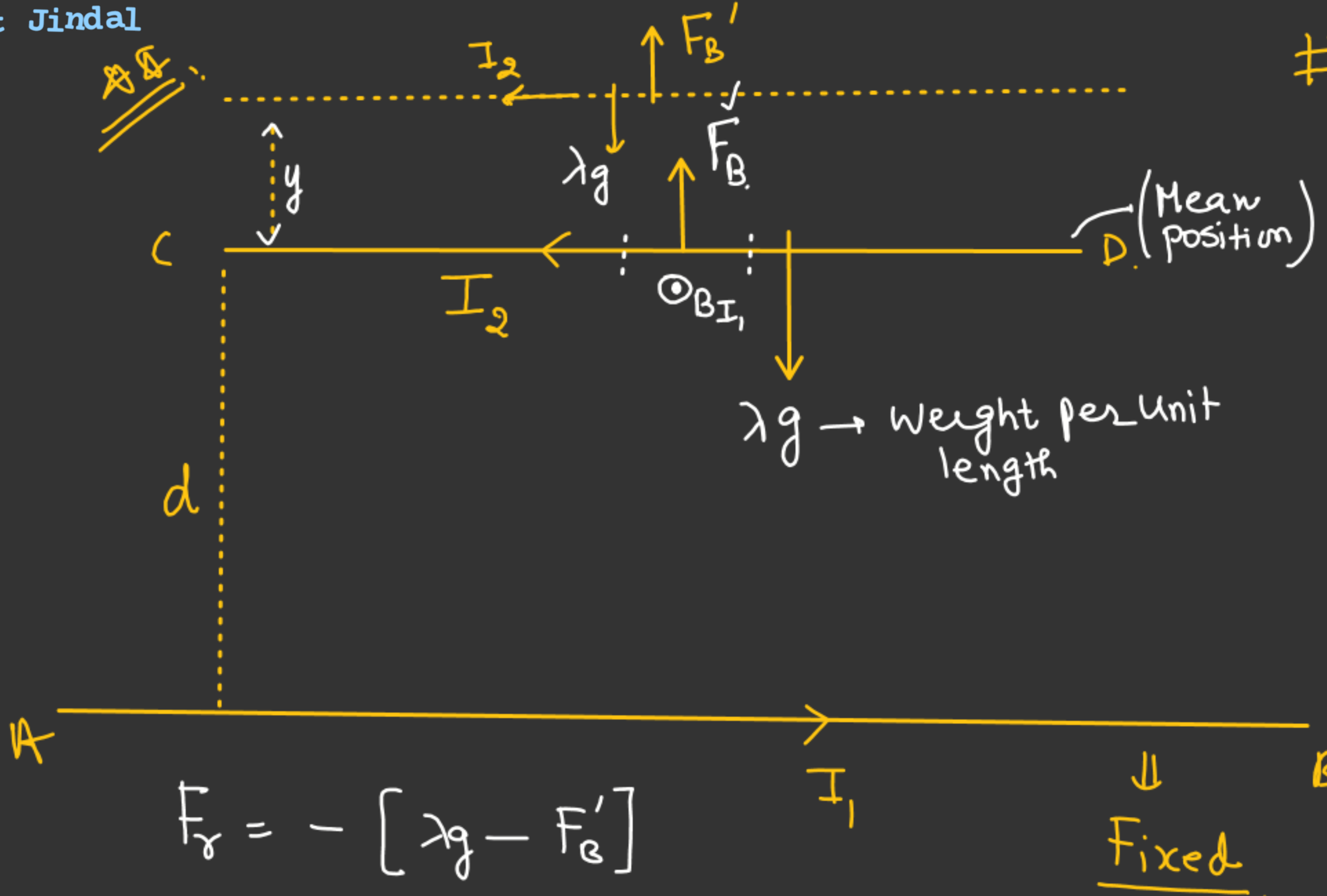

Wire CD is parallel to AB and is in equilibrium at a vertical separation d.

$\lambda \rightarrow$ linear mass density

Both the wires are infinite.

If wire CD is displaced slightly, prove that it will perform S.H.M & find the time period.

At Mean position

$F_B = \lambda g$

$\lambda \rightarrow$ Mass per Unit length

$$\frac{\mu_0 I_1 I_2}{2\pi d} = \lambda g \quad \text{— (1)}$$

$$F_r = -\left[\lambda g - F_B'\right]$$

$$F_r = -\left[\lambda g - \frac{\mu_0 I_1 I_2}{2\pi(d+y)}\right]$$

$$a = \frac{F_r}{\lambda} = -\left[g - \frac{\mu_0 I_1 I_2}{2\pi\lambda d(1+y/d)}\right]$$

$$a = -\left[g - \frac{\mu_0 I_1 I_2}{2\pi\lambda d}\left(1+\frac{y}{d}\right)^{-1}\right]$$

$y \ll d$

$$a = -\left[g - \frac{\mu_0 I_1 I_2}{2\pi\lambda d}\left(1-\frac{y}{d}\right)\right] \Rightarrow$$

$$a = -\left[\underbrace{g - \frac{\mu_0 I_1 I_2}{2\pi\lambda d}}_{0} + \frac{\mu_0 I_1 I_2}{2\pi\lambda d^2}\, y\right]$$

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$$a = -\omega^2 x$$

$$a = -\left(\frac{\mu_0 I_1 I_2}{2\pi\lambda d^2}\right) y$$

From (1)

$$\frac{\mu_0 I_1 I_2}{2\pi d} = \lambda g$$

$$a = -\left(\frac{\mu_0 I_1 I_2}{2\pi\lambda d}\right) \cdot \frac{y}{d}$$

$$\frac{\mu_0 I_1 I_2}{2\pi\lambda d} = g$$

$$\Downarrow$$

$$\boxed{a = -\frac{g}{d} y}$$

$$\Downarrow$$

Compare with

$$a = -\omega^2 y$$

$$\omega = \sqrt{\frac{g}{d}}$$

$$\boxed{T = 2\pi\sqrt{\frac{d}{g}}}$$ ★★

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Capacitor is fully charged. d = Seperation at $t=0$. Strings are insulated.

At $t=0$, Switch is closed.

$R \to$ Total resistance of the Ckt.

↳ seperation assumed to be constant

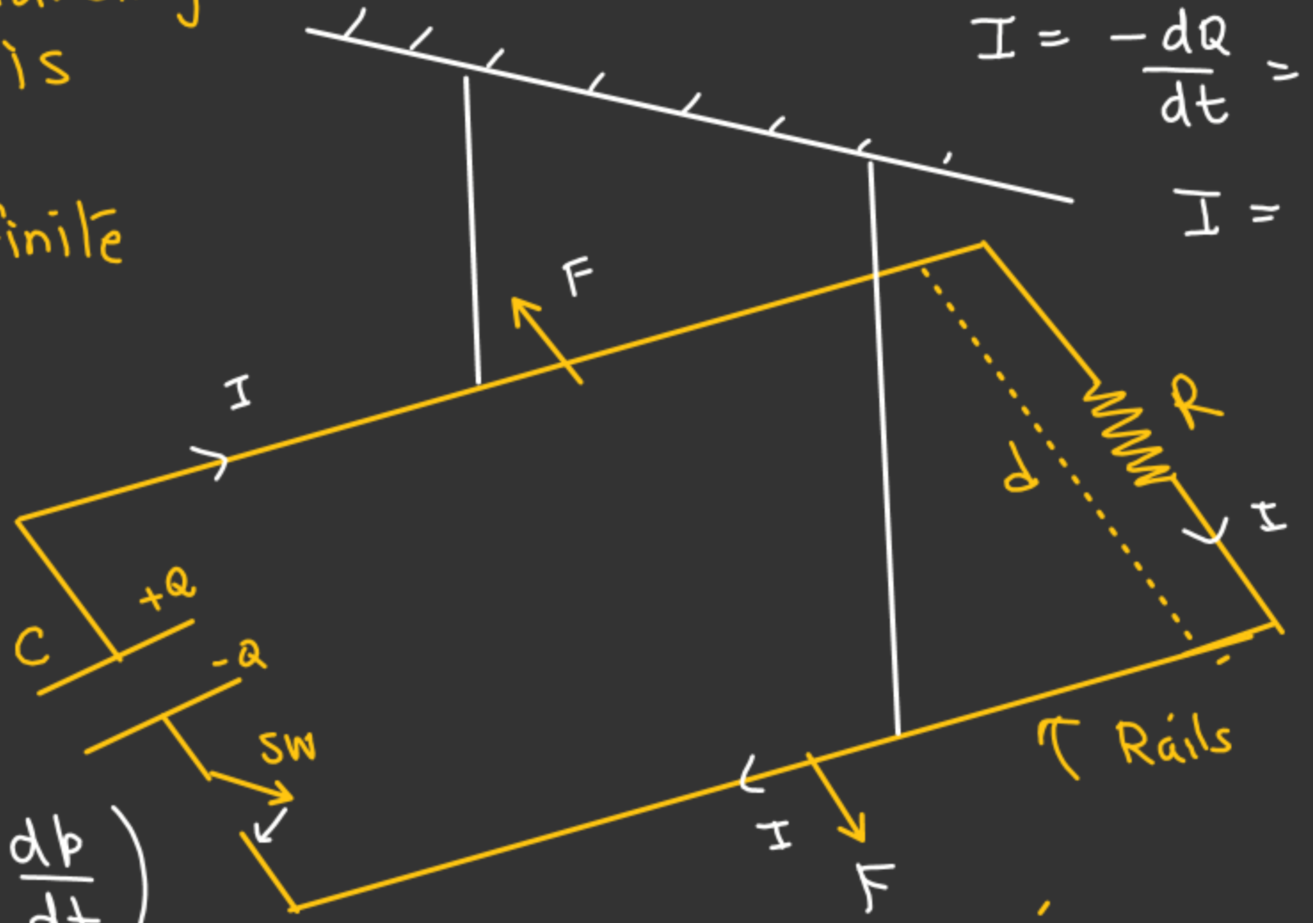
Find the velocity of the two conducting parallel rails when capacitor is fully discharge.

$\lambda \to$ Mass per unit length of the infinite length parallel rails

$$Q = Q_0 e^{-t/\tau}$$

$$I = -\frac{dQ}{dt} = \frac{Q_0}{\tau} e^{-t/\tau}$$

$$I = \left(\frac{Q_0}{RC} e^{-t/\tau}\right)$$



Sol^n After SW closed.

$$I = \frac{Q_0}{RC} e^{-t/RC}$$

$$F = \frac{\mu_0 I^2}{2\pi d}$$

$$F = \frac{\mu_0}{2\pi d}\left(\frac{Q_0}{RC} e^{-t/RC}\right)^2$$

$$\left(F = \frac{dp}{dt}\right)$$

$$\int_0^p dp = \int_0^\infty F \cdot dt$$

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$$\int_0^{p} dp = \int_0^{\infty} \underline{F} \cdot dt$$

$$p = \frac{\mu_0}{2\pi d}\left(\frac{Q_0}{RC}\right)^2 \int_0^{\infty} e^{-\frac{2t}{RC}} \cdot dt$$

$$\Downarrow$$

$$\underset{\Downarrow}{\lambda v} = \left(\frac{\mu_0 Q_0^2}{2\pi d \underline{R^2 C^2}}\right) \frac{\left[e^{-2t/RC}\right]_0^{\infty}}{\left(-2/\underline{RC}\right)}$$

{ Momentum per unit length

$$\lambda v = -\frac{\mu_0 Q_0^2}{4\pi d RC}\left[0 - e^0\right]$$

$$\underline{v} = \frac{\mu_0 Q_0^2}{4\pi \lambda d RC}$$

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Q8 Find closest distance of approach of the charged particle

$$\vec{V} = v_x\hat{i} - V_y\hat{j}$$

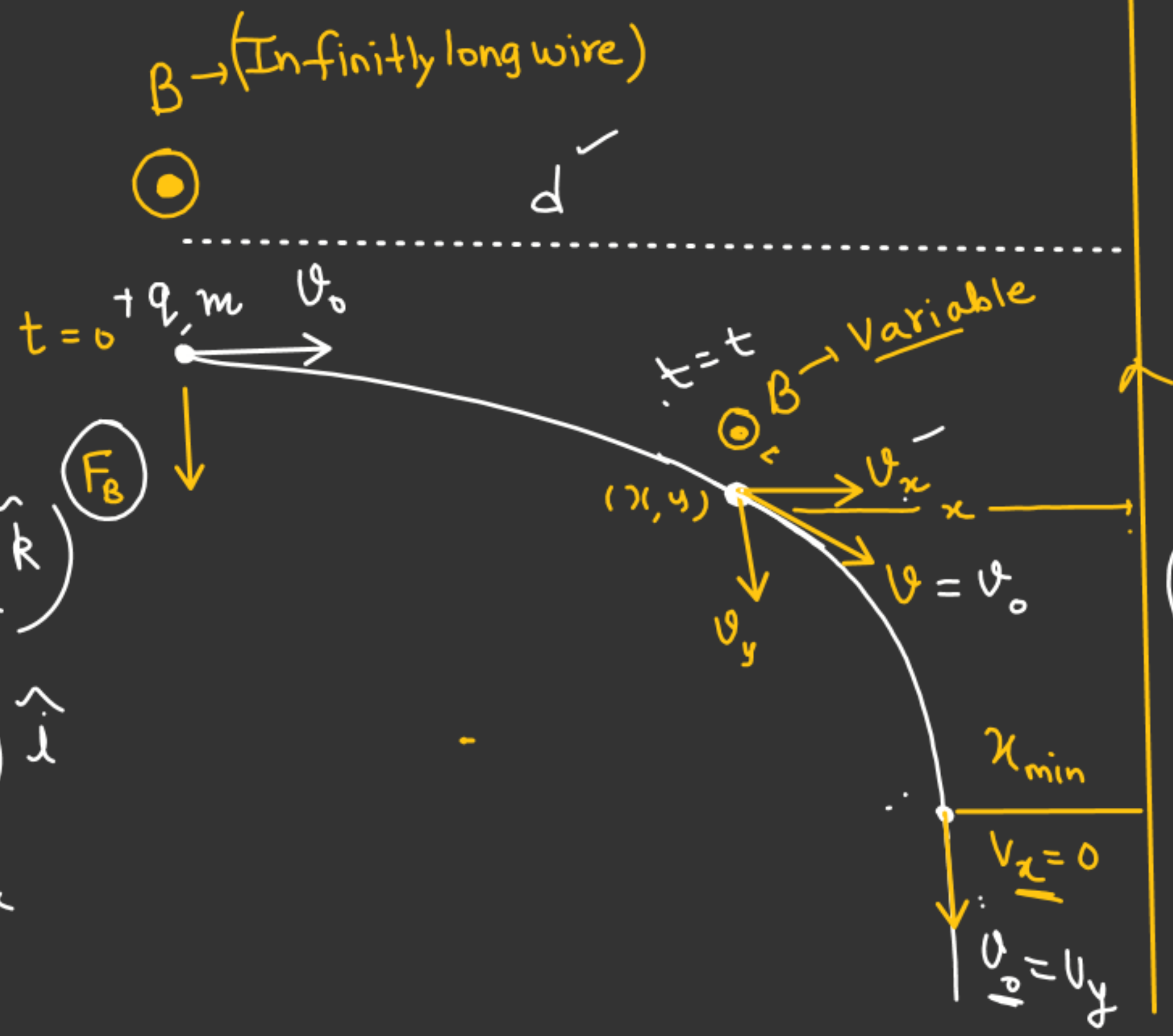
$$\vec{B} = \left(\frac{\mu_0 I}{2\pi x}\right)(+\hat{k})$$

$$\vec{F} = q\left(\vec{v}\times\vec{B}\right)$$

$$\vec{F} = q\left(V_x\hat{i} - V_y\hat{j}\right)\times\left(\frac{\mu_0 I}{2\pi x}\hat{k}\right) \quad F_B$$

$$\vec{F} = \left(\frac{q\mu_0 I}{2\pi x}v_x\right)(-\hat{j}) - \left(\frac{\mu_0 I\, v_y}{2\pi x}\right)\hat{i}$$

$\Downarrow F_y$ $\qquad\qquad \Downarrow F_x$



→ Infinitly long wire

$$F_y = -\frac{q\mu_0 I}{2\pi x}v_x$$

$$\Downarrow$$

$$a_y = -\frac{q\mu_0 I}{2\pi m x}v_x$$

$$\Downarrow$$

$$\frac{dv_y}{\cancel{dt}} = -\frac{q\mu_0 I}{2\pi m x}\left(\frac{dx}{\cancel{dt}}\right)$$

$$\int_0^{V_0} dv_y = -\frac{q\mu_0 I}{2\pi m}\int_d^{x_{min}}\frac{dx}{x}$$

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$$\int_0^{v_0} dv_y = -\frac{q\mu_0 I}{2\pi m}\int_d^{x_{min}} \frac{dx}{x}$$

$$v_0 = -\frac{q\mu_0 I}{2\pi m}\ln\left(\frac{x_{min}}{d}\right)$$

$$\ln\left(\frac{x_{min}}{d}\right) = -\frac{2\pi m v_0}{q\mu_0 I}$$

$$\underline{x_{min} = d\, e^{-\frac{2\pi m v_0}{q\mu_0 I}}}$$

$$\Downarrow$$

(Closest distance of approach)

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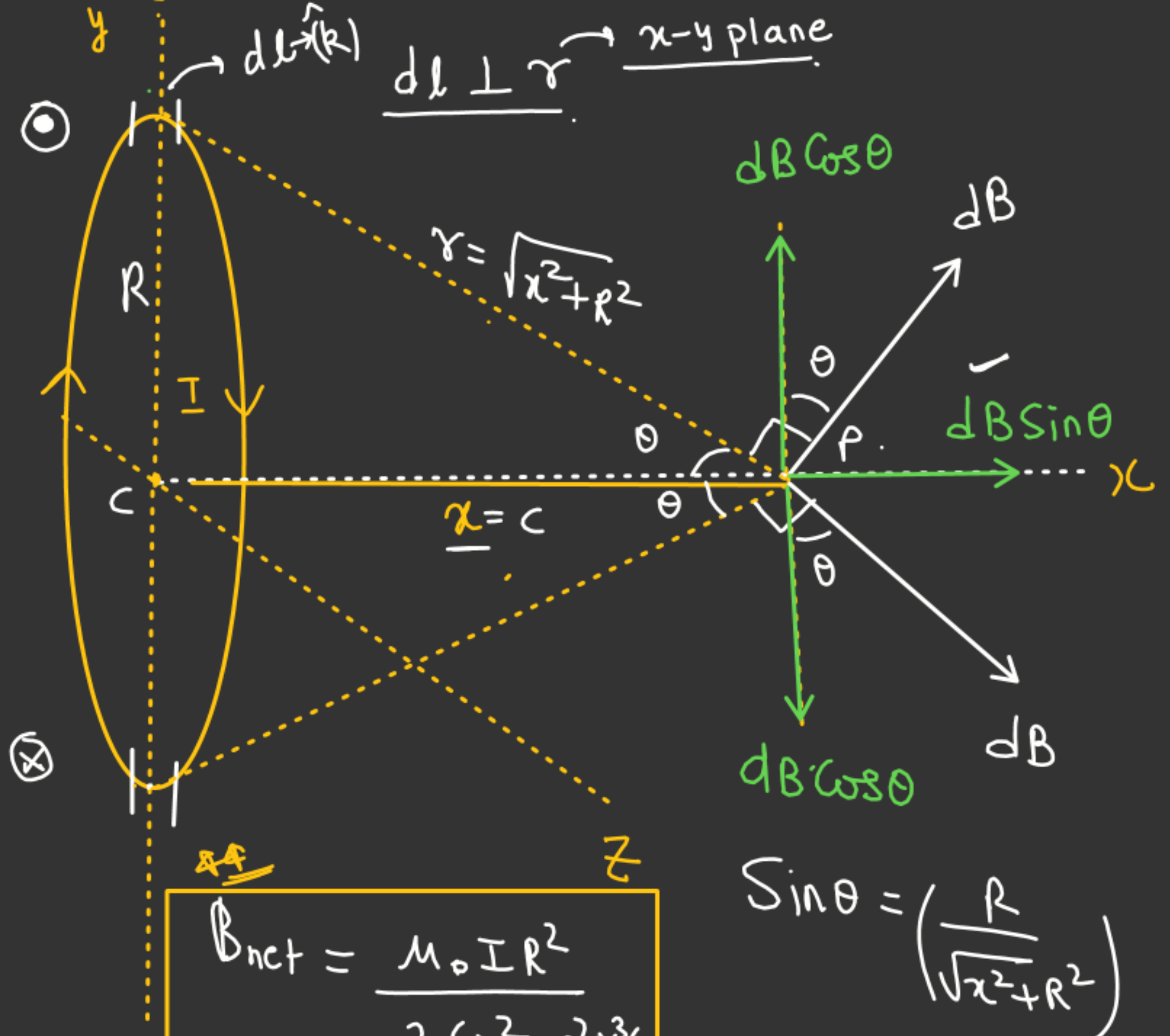
Magnetic field on the axis of a Current Carrying ring:→



$dl \perp r \rightarrow$ x-y plane

$$dB = \left(\frac{\mu_0 I\, dl \sin\theta}{4\pi r^2}\right) \quad \sin\theta \to 1 \quad \vec{dl} \perp \vec{r}$$

$$dB = \frac{\mu_0 I\, dl}{4\pi (x^2+R^2)}$$

$$\sin\theta = \left(\frac{R}{\sqrt{x^2+R^2}}\right)$$

$$B_{net} = \int dB \sin\theta$$

$$B_{net} = \int \underbrace{\frac{\mu_0 I}{4\pi(x^2+R^2)} \times \frac{R}{\sqrt{x^2+R^2}}}_{\text{Constant}}\, dl$$

$$B_{net} = \frac{\mu_0 I R}{4\pi (x^2+R^2)^{3/2}} \left(\int dl\right) = \frac{\mu_0 I R}{4\pi (x^2+R^2)^{3/2}} \cdot 2\pi R$$

$$\boxed{B_{net} = \frac{\mu_0 I R^2}{2(x^2+R^2)^{3/2}}}$$

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