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Only resistance 'R' in the rod.

friction neglected.

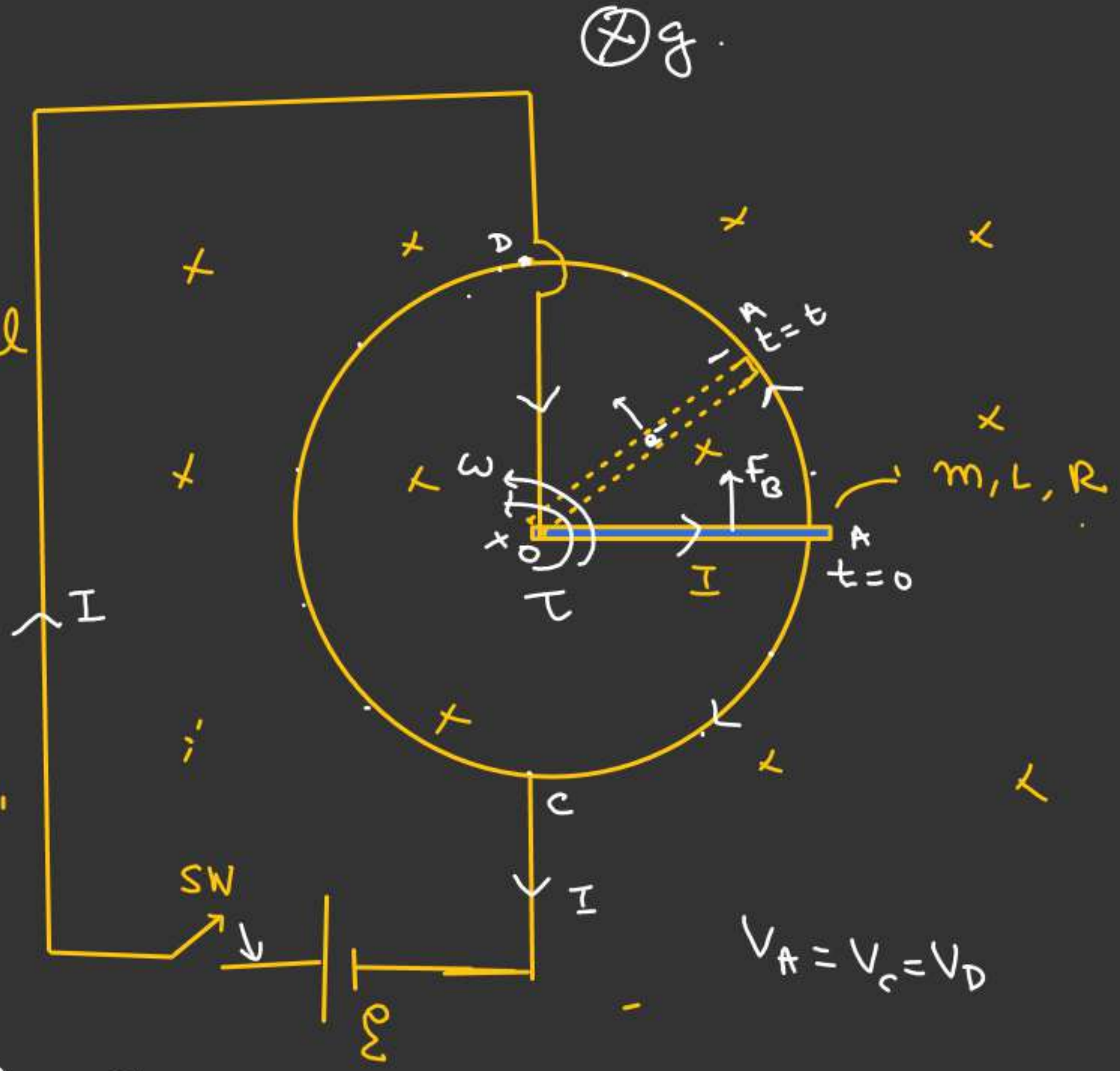
B is uniform.

The whole system is kept on horizontal surface.

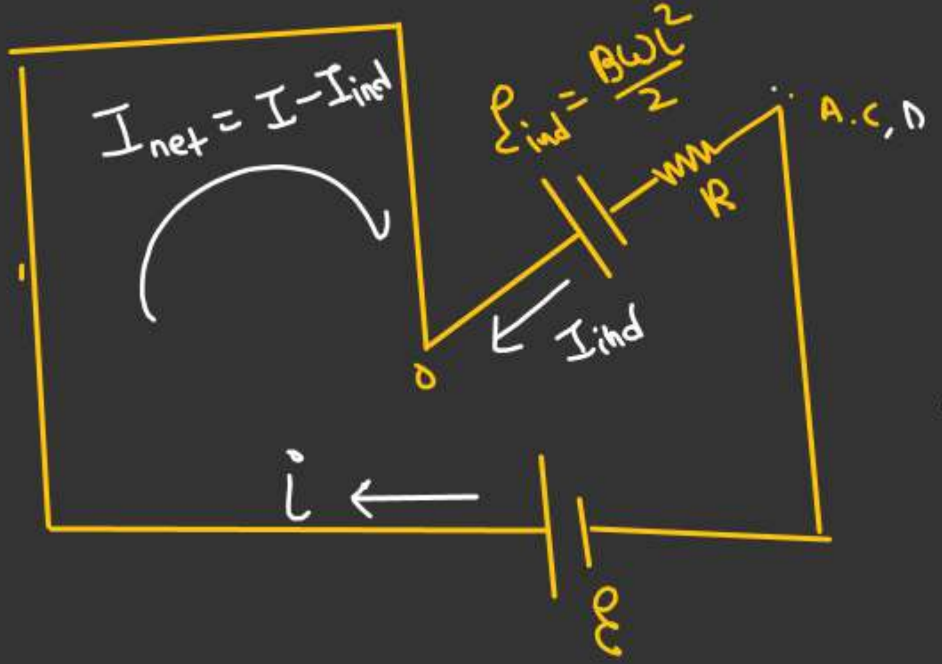
1) $\omega \to f(t)$

At $t=0$, SW is closed.

let, $t=t$, angular velocity of Rod be ω.



$V_A = V_C = V_D$



$$\mathcal{E} - \mathcal{E}_{ind} - I_{net} \cdot R$$

$$I_{net} = \frac{\mathcal{E} - \mathcal{E}_{ind}}{R} = \left(\frac{\mathcal{E}}{R} - \frac{B\omega L^2}{2R}\right) \checkmark$$

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$\otimes g.$

$$d\tau = dF_B\, x.$$

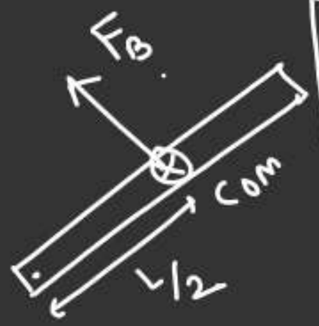
$$\int_0^{\tau} d\tau = B I_{net} \int_0^{L} x\,dx$$

dF_B of dx length.

$$dF_B = (B\,dx\,I_{net})$$

$$\tau = \frac{B I_{net} \cdot L^2}{2} \leftarrow \text{At } t = t$$

$$\tau = (B I_{net} L)\left(\frac{L}{2}\right)$$



When B is uniform

$$\tau = \left(F_B \cdot \frac{L}{2}\right)$$

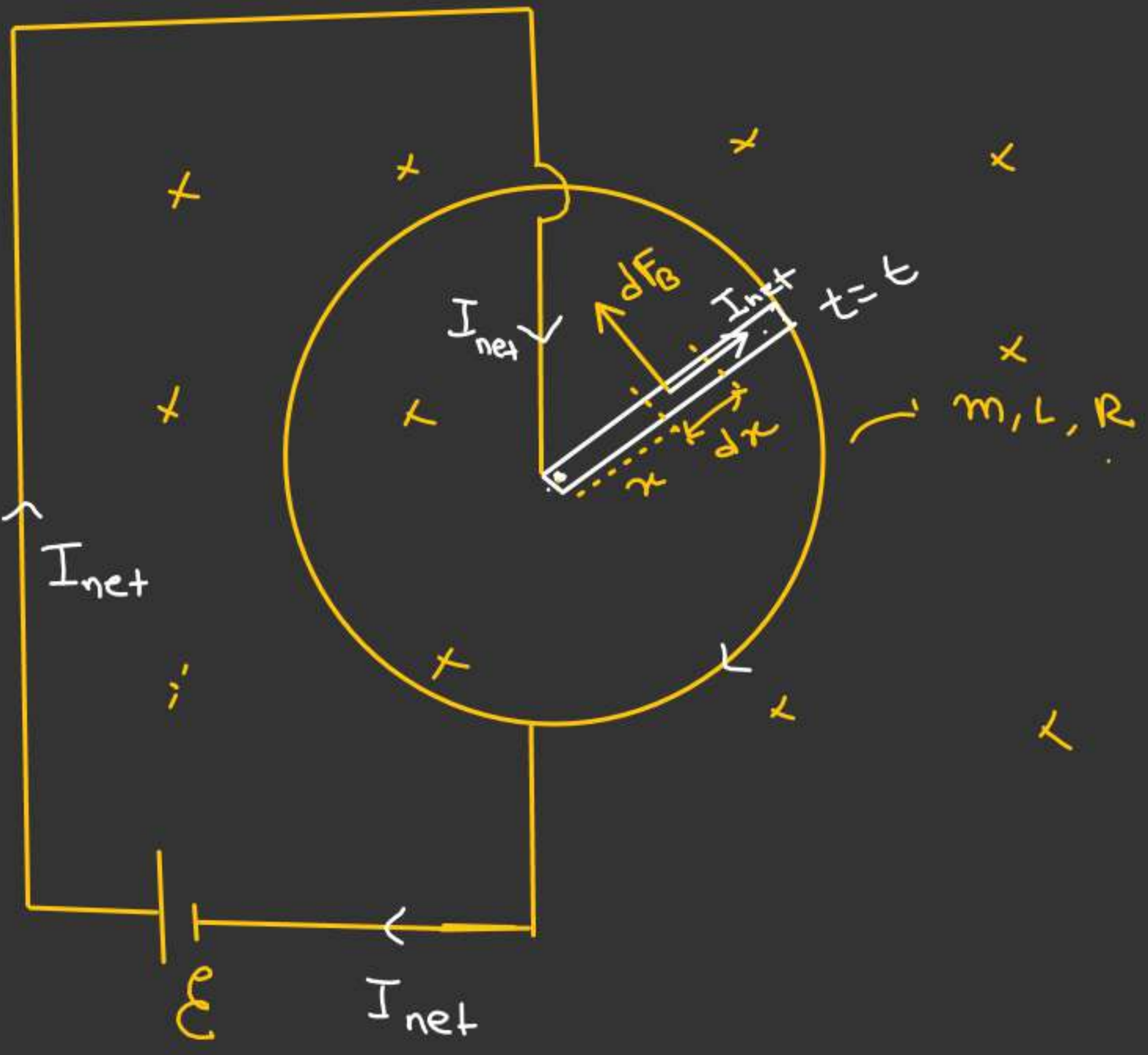
$$I\alpha = \frac{B L^2}{2} I_{net}$$

M.I of the Rod.

$$\alpha = \frac{3 B L^2}{2 M L^2} I_{net}$$

$$\alpha = \frac{3B}{2M}(I_{net}) = \frac{3B}{2M}\left[\frac{\varepsilon}{R} - \frac{B L^2}{2R}\omega\right]$$

$$\alpha = \left(\frac{3 B \varepsilon}{2MR} - \frac{3 B^2 L^2}{4MR}\omega\right)$$



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$$\alpha = \left(\underbrace{\frac{3B\varepsilon}{2MR}}_{P} - \underbrace{\frac{3B^2L^2}{4MR}}_{q}\,\omega\right)$$

$$\Downarrow$$

$$\frac{d\omega}{dt} = P - q\omega$$

$$\int_0^{\omega} \frac{d\omega}{P-q\omega} = \int_0^{t} dt$$

$$\frac{\ln\left[P-q\omega\right]_0^{\omega}}{-q} = t$$

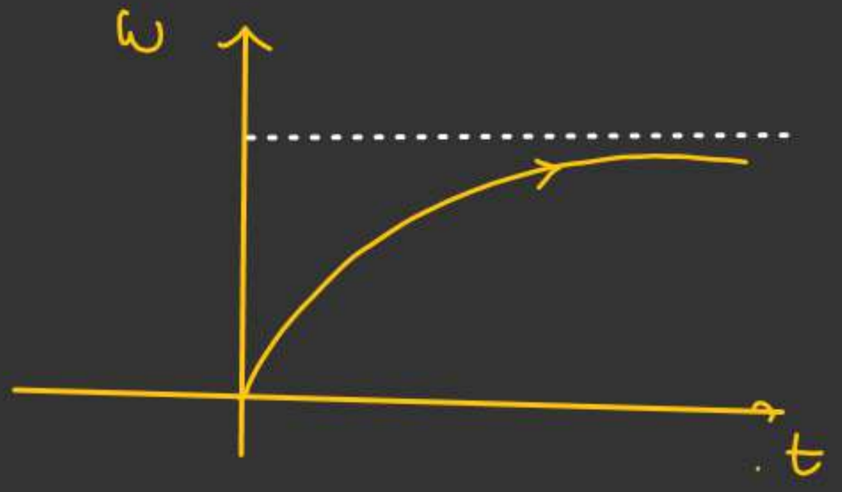
$$\ln\left[\frac{P-q\omega}{P}\right] = -qt$$

$$P - q\omega = P e^{-qt}$$

$$\omega = \frac{P}{q}\left(1-e^{-qt}\right)$$

$$\omega = \frac{\cancel{3}B\varepsilon}{2\cancel{mR}} \times \frac{4\cancel{mR}}{\cancel{3}B^2L^2}\left(1 - e^{-\frac{3B^2L^2}{4mR}t}\right)$$

$$\omega = \frac{2\varepsilon}{BL^2}\left(1 - e^{-\frac{3B^2L^2}{4mR}t}\right)$$



$$\omega_{max} = \left(\frac{2\varepsilon}{BL^2}\right)$$

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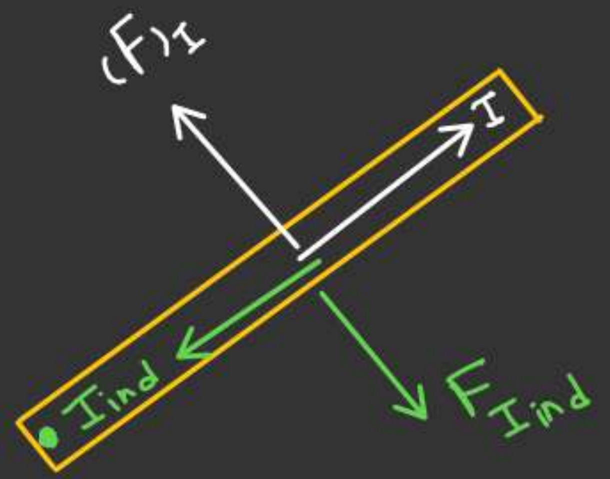

$$\vec{\tau}_{F_I} = -\vec{\tau}_{F_{I_{ind}}}$$

$$\tau_{net} = 0$$

$$I_{net} = 0$$

$$\Downarrow$$

$$\omega \Rightarrow \omega_c$$

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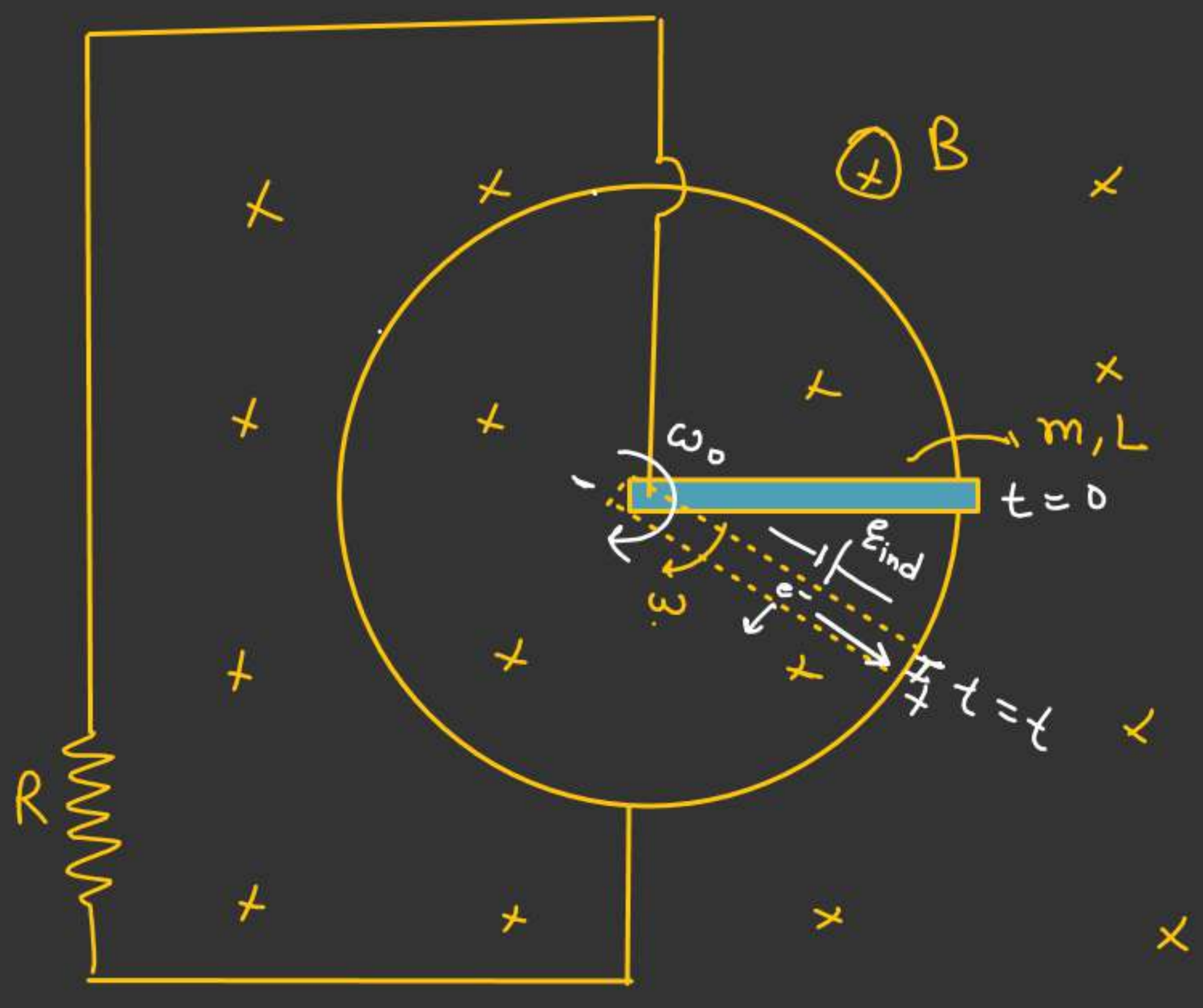
- No resistance of hoop & rod. friction neglected.

Whole system on a smooth horizontal table.

At $t=0$, rod rotated by ω_0

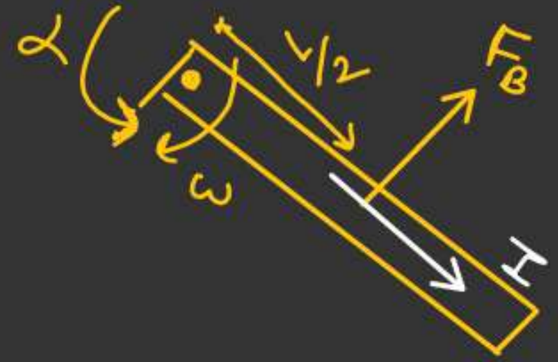
Find

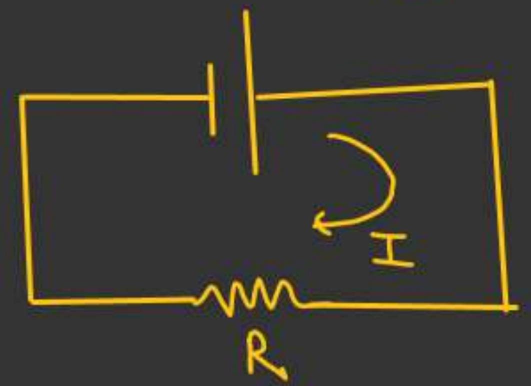
1. $\omega = f(t)$
2. $I = f(t)$
3. Net charge flow in the ckt.
4. Net heat dissipiated in the ckt



$$I = \left(\frac{B\omega L^2}{2R}\right)$$

$$\mathcal{E}_{ind} = \frac{B\omega L^2}{2}$$





$\tau = I\alpha$

I = M.I of Rod

α = Angular acceleration

$$\tau = F_B \cdot \frac{L}{2}$$

$$= (ILB)\frac{L}{2}$$

$$= \frac{BL^2}{2}\cdot(I)$$

$$= \frac{BL^2}{2}\cdot\left(\frac{B\omega L^2}{2R}\right)$$

$$\tau = \frac{B^2L^4}{4R}\,\omega$$

$$I = \frac{B\omega L^2}{2}$$

$$\alpha = \frac{\tau}{(I)_{Rod}} = \frac{3B^2\cancel{L^4}}{4M\cancel{L^2}R}\,\omega$$

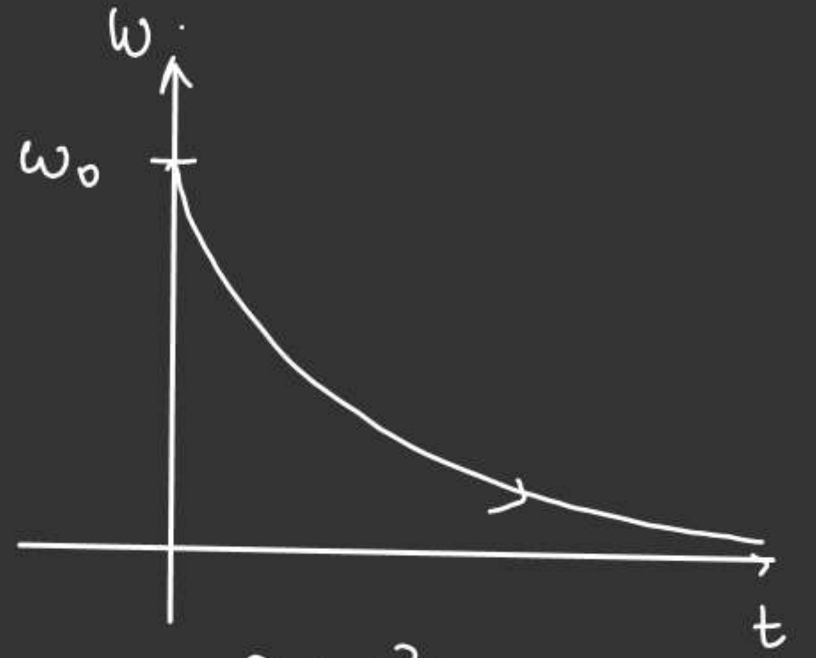
$$\alpha = \frac{3B^2L^2}{4MR}\,\omega$$

$$-\frac{d\omega}{dt} = \frac{3B^2L^2}{4MR}\,\omega$$

$$\int_{\omega_0}^{\omega}\frac{d\omega}{\omega} = -\frac{3B^2L^2}{4MR}\int_0^t dt$$

$$\ln\left(\frac{\omega}{\omega_0}\right) = \left(-\frac{3B^2L^2}{4mR}\right)t$$

$$\omega = \omega_0\, e^{-\frac{3B^2L^2}{4mR}t}$$



$$I = \frac{B\omega L^2}{2R}$$

$$I = \frac{BL^2}{2R}\cdot\omega_0\, e^{-\frac{3B^2L^2}{4mR}t}$$

$$I = \frac{B\omega_0L^2}{2R}\, e^{-\frac{3B^2L^2}{4mR}t}$$

$$\Downarrow$$

$$\frac{dq}{dt} = \frac{B\omega_0L^2}{2R}\, e^{-\frac{3B^2L^2}{4mR}t}$$

$$\int_0^Q dq = \frac{B\omega_0L^2}{2R}\int_0^\infty e^{-\frac{3B^2L^2}{4mR}}\cdot dt$$

$Q =$ ✓.

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M-1.

$$P = i^2 R$$

$$\Downarrow$$

$$\frac{dH}{dt} = i^2 R$$

$$\int_0^H dH = \int_0^\infty i^2 R \, dt$$

M-2.

Initial Rotational K.E of Rod = Heat dissipiated.

$$\left(\frac{1}{2}\frac{ML^2}{3}\cdot\omega_0 = \text{Heat dissipiated.}\right)$$

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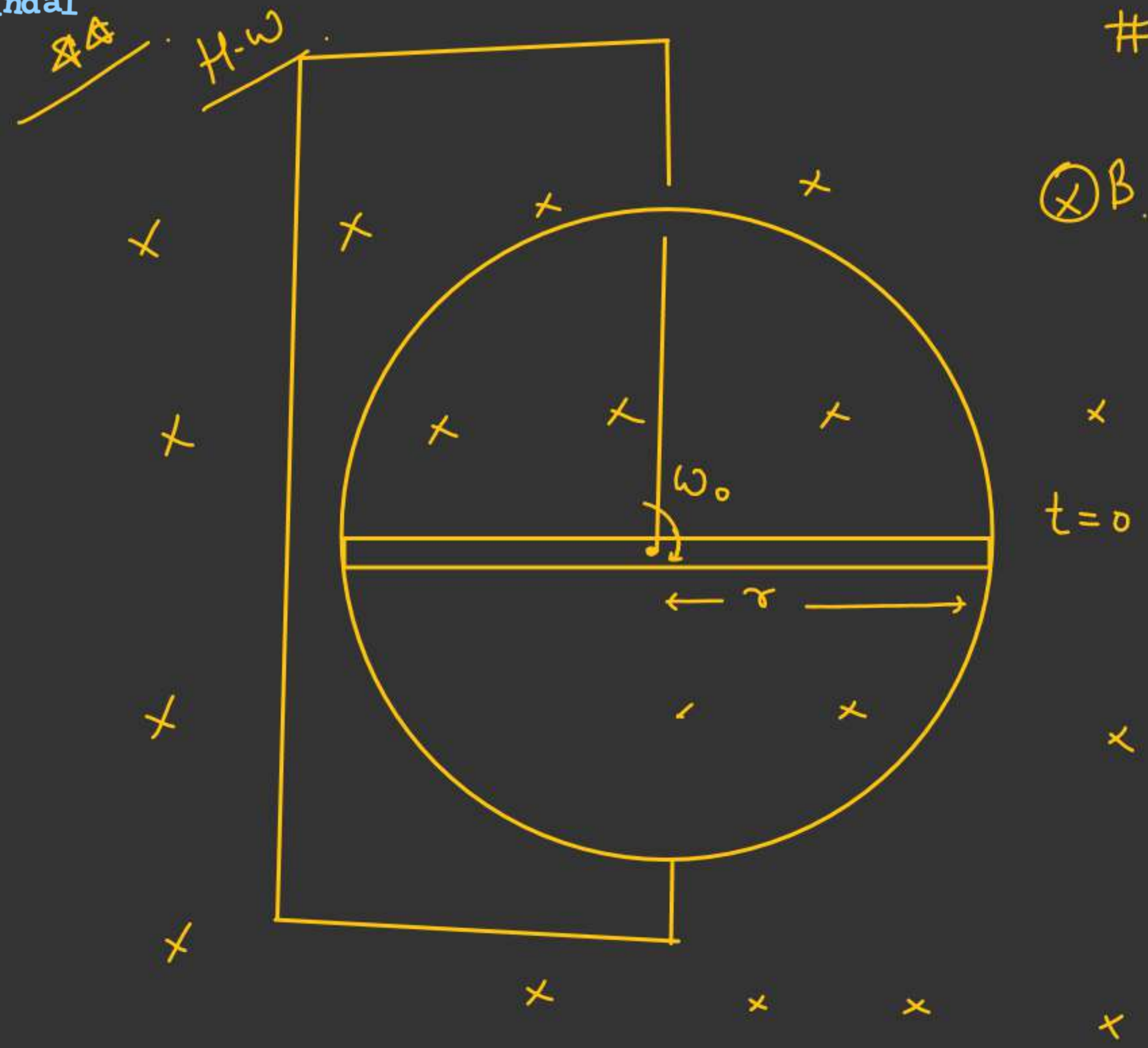
H.W.



Resistance 'R' only for the rod. Kept on smooth horizontal surface. (r = radius of hoop)

Q B.

$\omega = f(t)$

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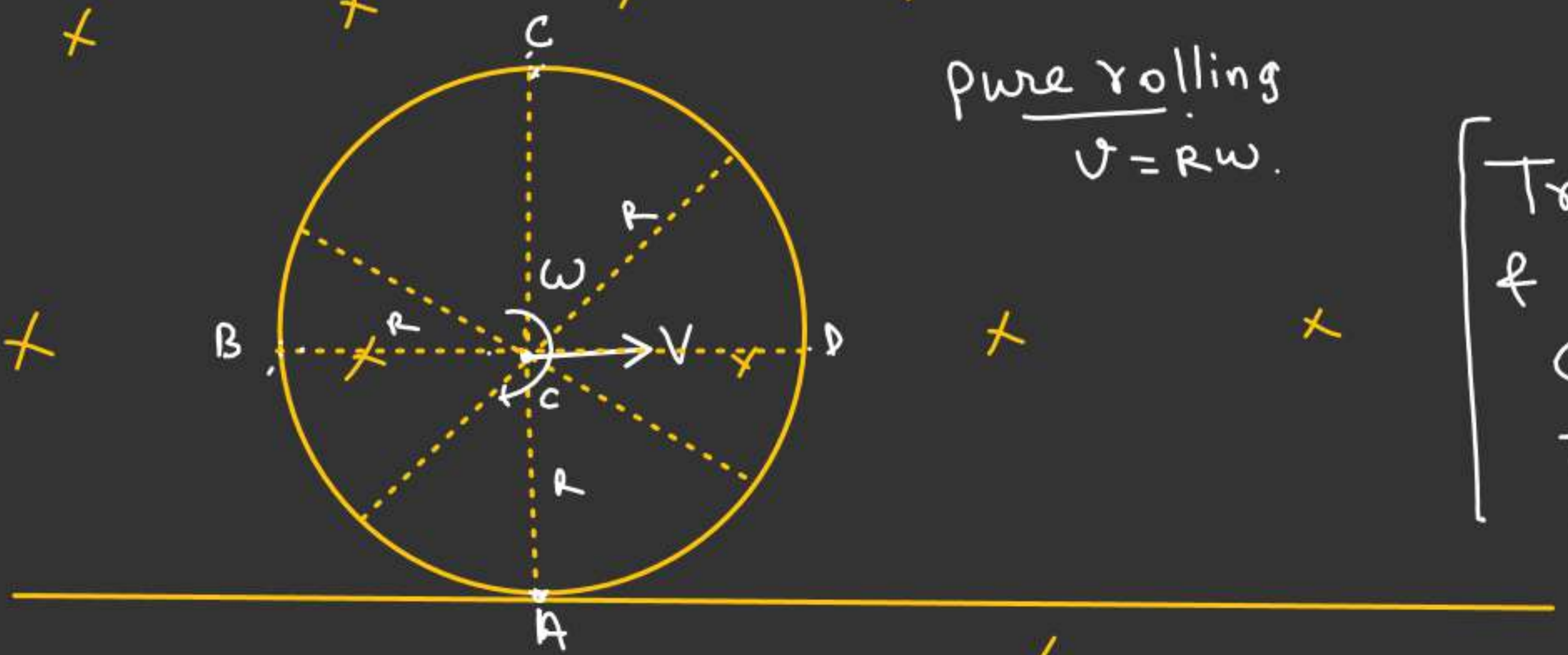
$\mathcal{E}_{ind}$ due to (translational + Rotational) motion

V & ω Constant.

$\mathcal{E}_A - \mathcal{E}_C = ??$

$\mathcal{E}_A - \mathcal{E}_B = ??$



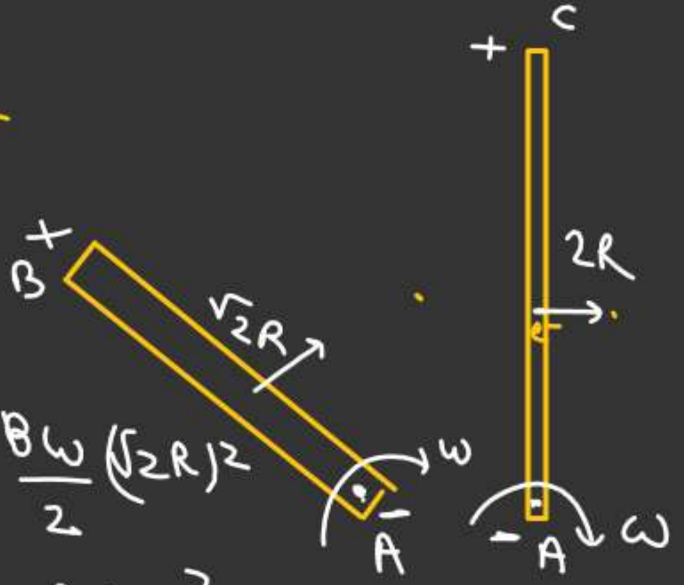
pure rolling

$v = R\omega$.

COM frame → pure Rotational Motion.

Translational & Rotational can be Considered as pure rotation about (IAOR)

For pure rolling motion IAOR is our Contact point



$$\mathcal{E}_B - \mathcal{E}_A = \frac{B\omega}{2}(\sqrt{2}R)^2$$
$$= \underline{B\omega R^2}$$

$$\mathcal{E}_C - \mathcal{E}_A = \frac{B\omega}{2}(2R)^2$$
$$= 2B\omega R^2$$

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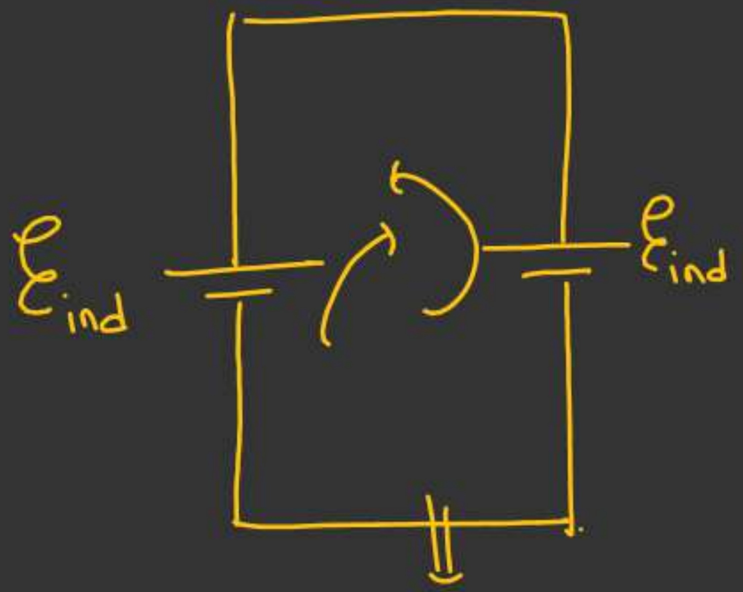
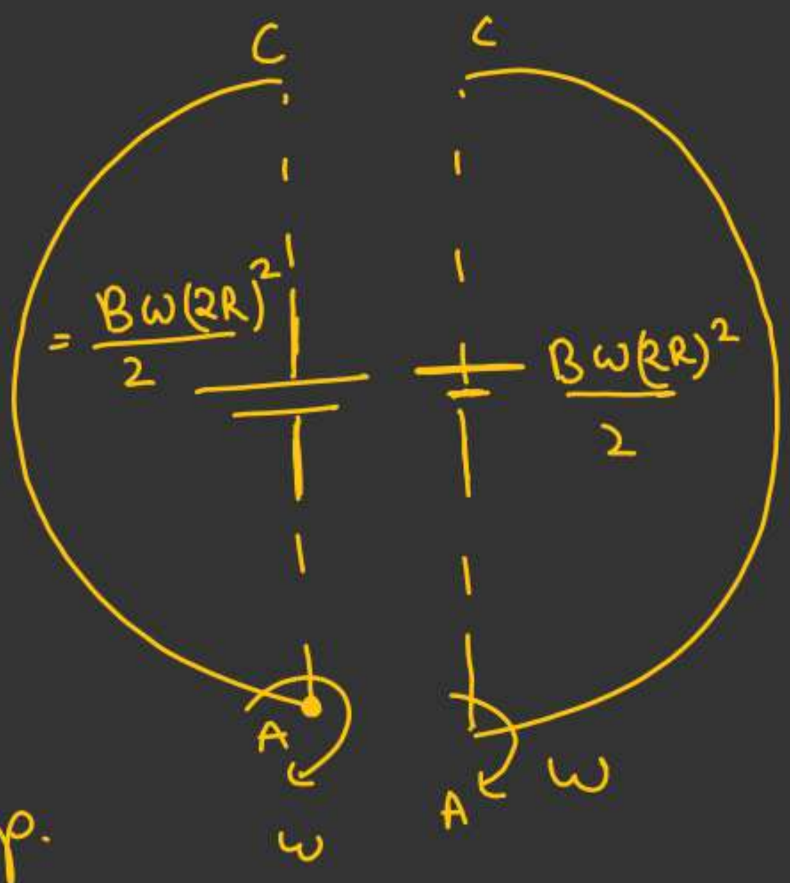
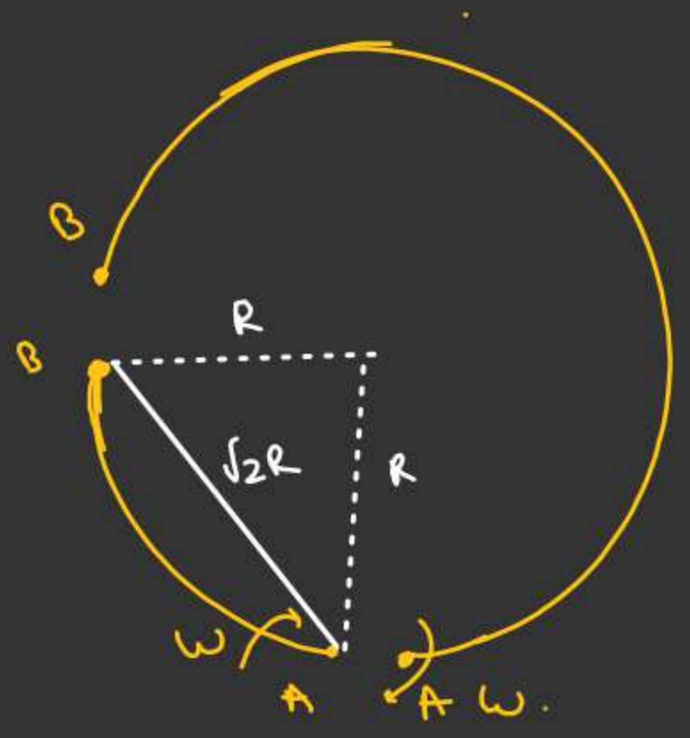


Net for loop.

$\underline{\mathcal{E}_{ind} = 0}$





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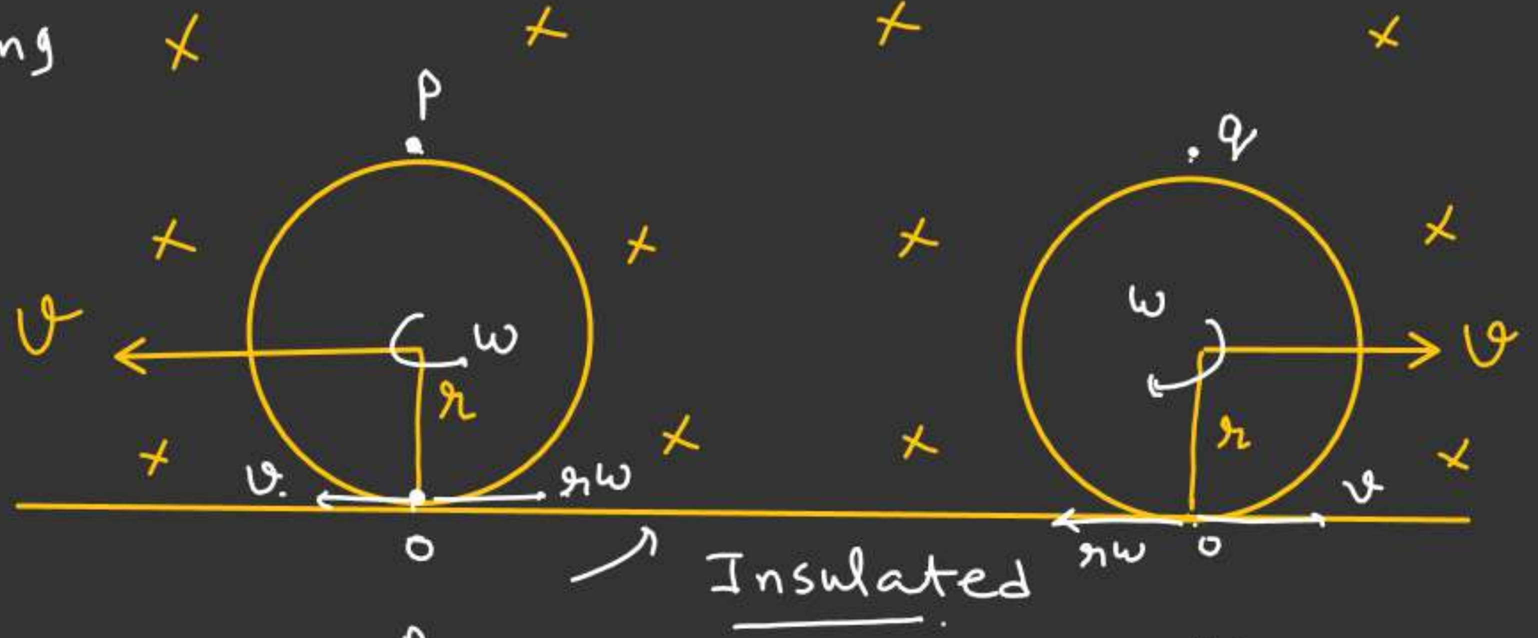
Pure Rolling



$|\mathcal{E}_P - \mathcal{E}_Q| = ??$

$$\mathcal{E}_O - \mathcal{E}_P = \frac{B\omega}{2}(2r)^2$$

$$= 2B\omega r^2 \quad -(1)$$

$$\mathcal{E}_Q - \mathcal{E}_O = 2B\omega r^2 \quad -(2)$$

(1) + (2)

$$|\mathcal{E}_Q - \mathcal{E}_P| = \underline{4B\omega r^2}$$

Self Induction
Mutual Induction
L-R Ckt

⇓

Remaining topic in E-M-I