



Magnetic field at the center of a Sprial: $\rightarrow B = \frac{\mu_0 I}{4\pi R} (\phi) \quad \underline{\phi = 2\pi}$

Total no of turns = N.

No of turns per unit width = $\left(\frac{N}{b-a} \right)$

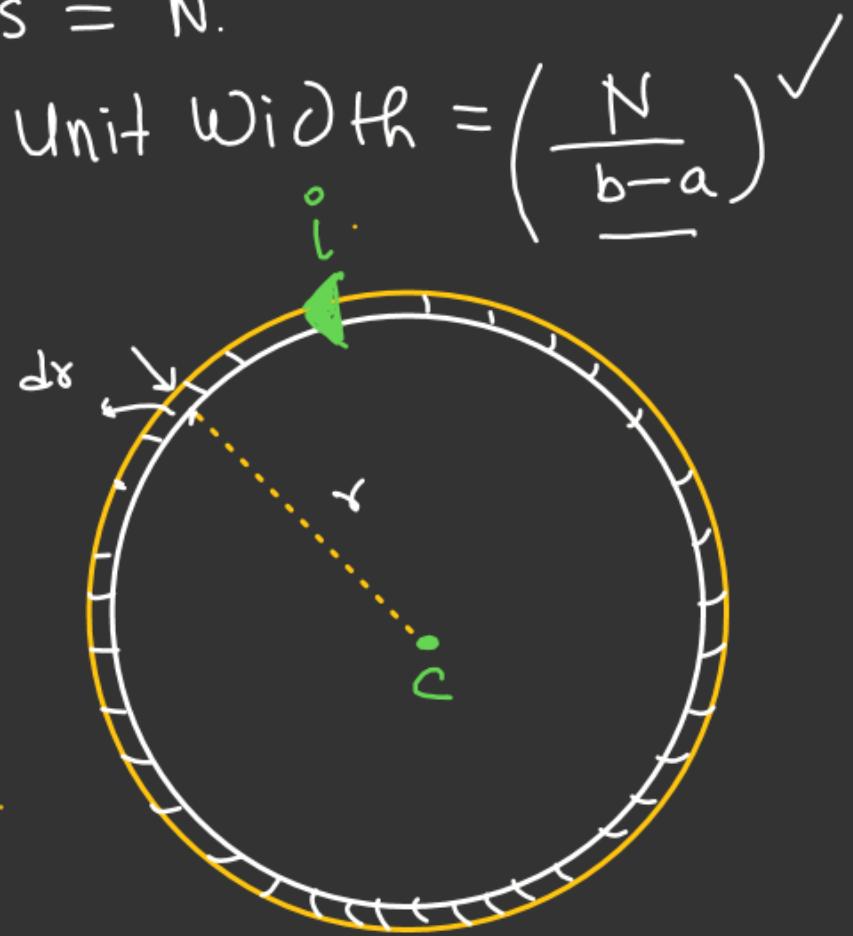
$$dB = \left(\frac{\mu_0 i}{2r} \right)$$

No of turns in dr thickness

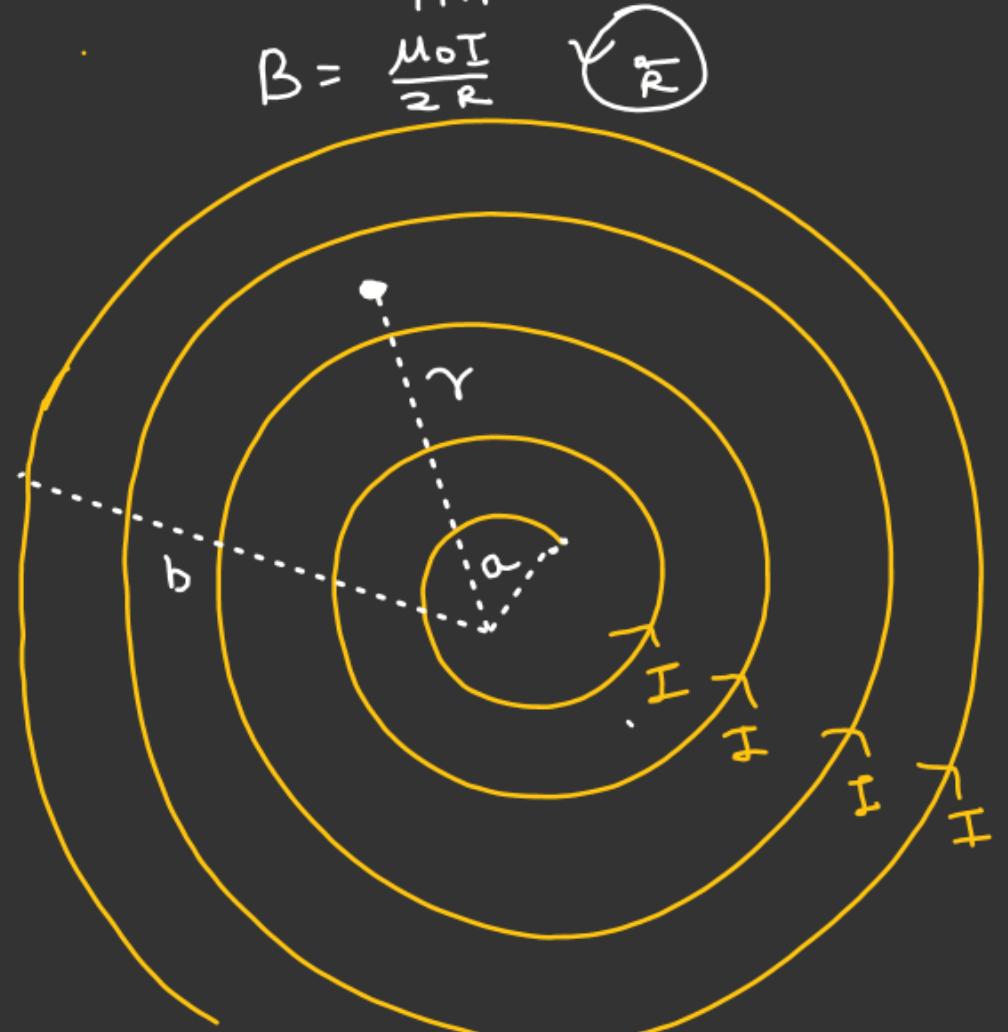
$$\left(\frac{N}{b-a} \right) dr$$

$$i = \left(\frac{N}{b-a} \right) dr \cdot I$$

(current in dr thickness) $\left[\begin{array}{l} \downarrow \\ \text{No of turns in dr thickness} \end{array} \right]$ (current in each turn)



$$B = \frac{\mu_0 I}{2R} \quad \circlearrowleft \frac{r}{R}$$



$$\int_a^b dB = \frac{\mu_0}{2\pi} \left(\frac{NI}{b-a} \right) dr$$

$$B = \frac{\mu_0 NI}{2(b-a)} \int_a^b \frac{dr}{r}$$

$$B = \frac{\mu_0 NI}{2(b-a)} \ln\left(\frac{b}{a}\right) \text{ Ans.}$$

Magnetic Moment of the Sprial:

dM = Magnetic moment of ring
of radius ' r ' having current
 i

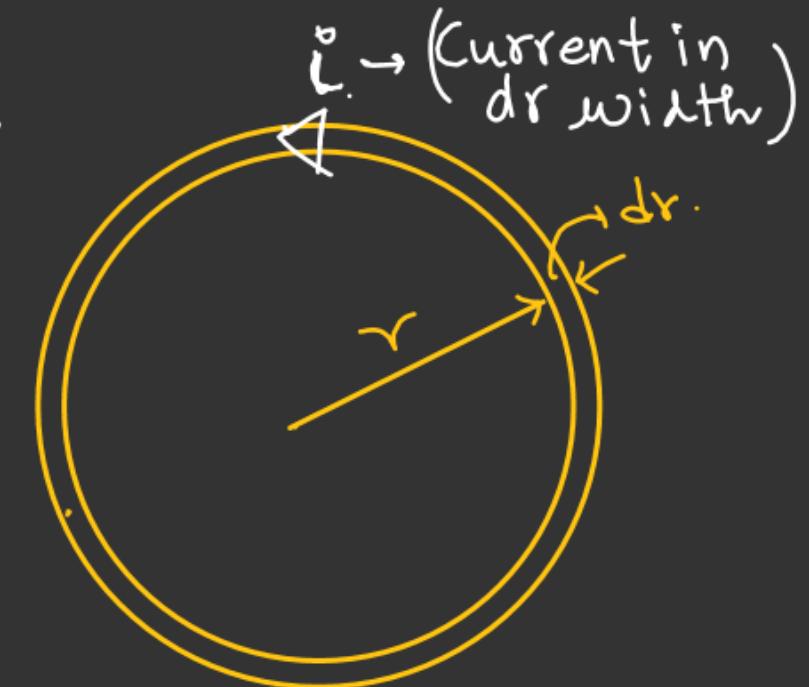
$\left(\frac{N}{b-a}\right)$ = Current per
Unit width.

$$i = \left[\left(\frac{N}{b-a} \right) I dr \right]$$

$$dM = i \pi r^2$$

$$\int_0^M dM = \left(\frac{\pi NI}{b-a} \right) \int_a^b r^2 dr = \frac{\pi NI}{b-a} \left[\frac{r^3}{3} \right]_a^b$$

$$M = \frac{\pi NI}{3(b-a)} \left[b^3 - a^3 \right]$$





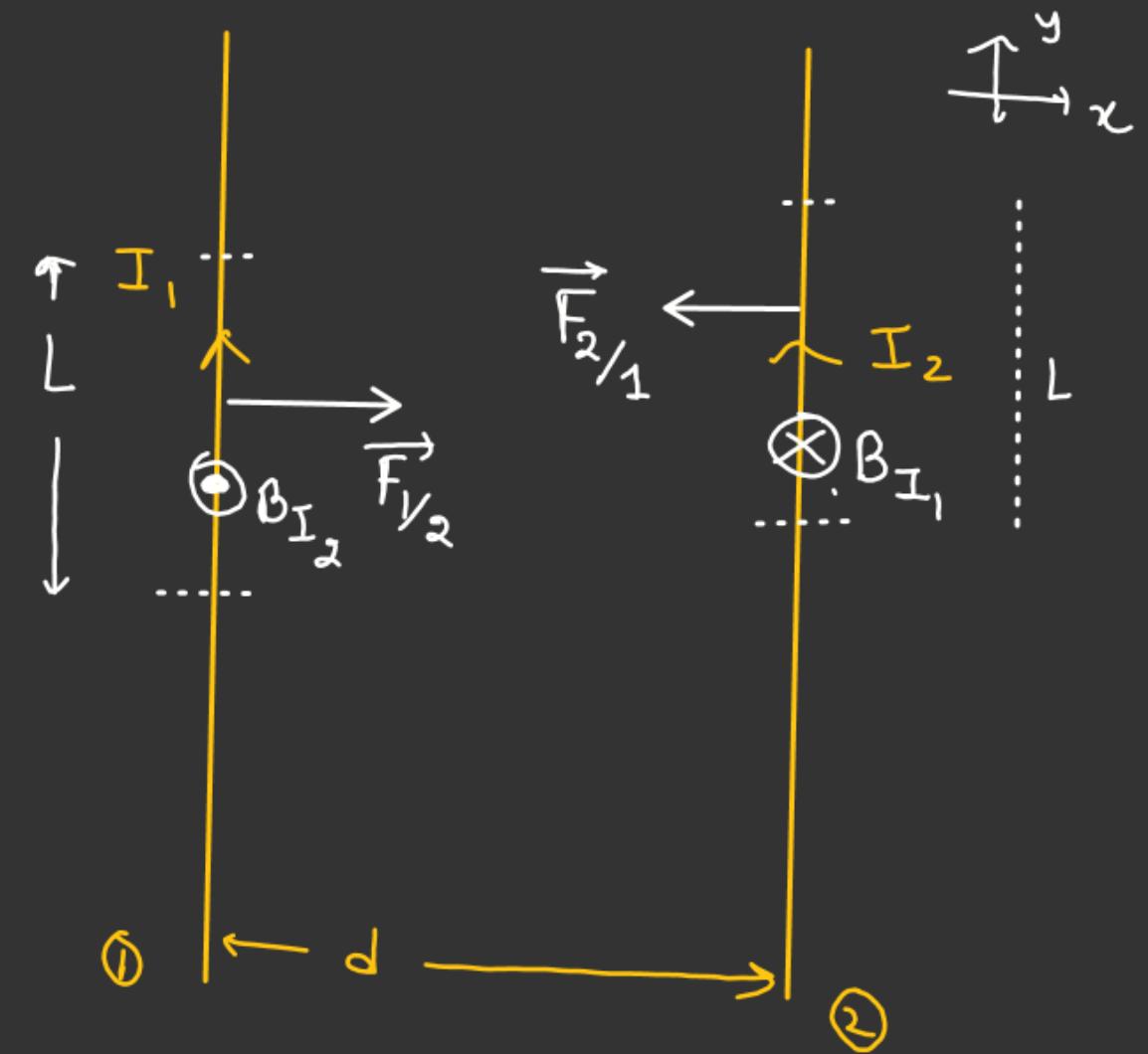
Force b/w two infinitely long parallel Current Carrying wire

$$\vec{F}_{2/1} = I_2 (\vec{l} \times \vec{B}_{I_1})$$

$$\begin{aligned}\vec{F}_{2/1} &= I_2 L B_{I_1} (\hat{j} \times -\hat{k}) \\ &= I_2 L B_{I_1} (-\hat{i})\end{aligned}$$

$$\left(\frac{F_{2/1}}{L} \right) = I_2 \frac{\mu_0 I_1}{2\pi d} = \left(\frac{\mu_0 I_1 I_2}{2\pi d} \right)$$

$$\left(\frac{F_{1/2}}{L} \right) = I_1 L B_{I_2} = \left(\frac{\mu_0 I_1 I_2}{2\pi d} \right)$$

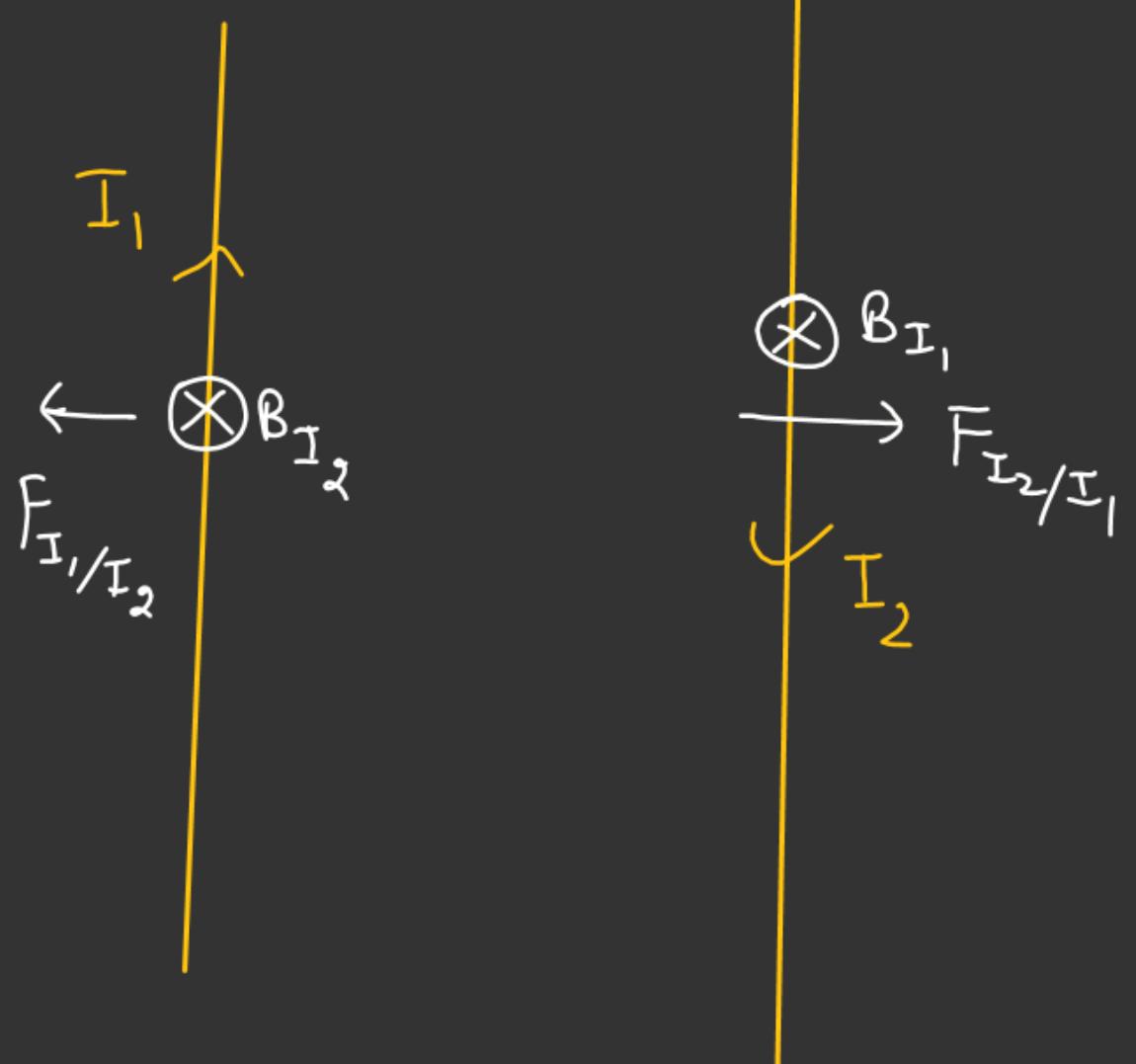


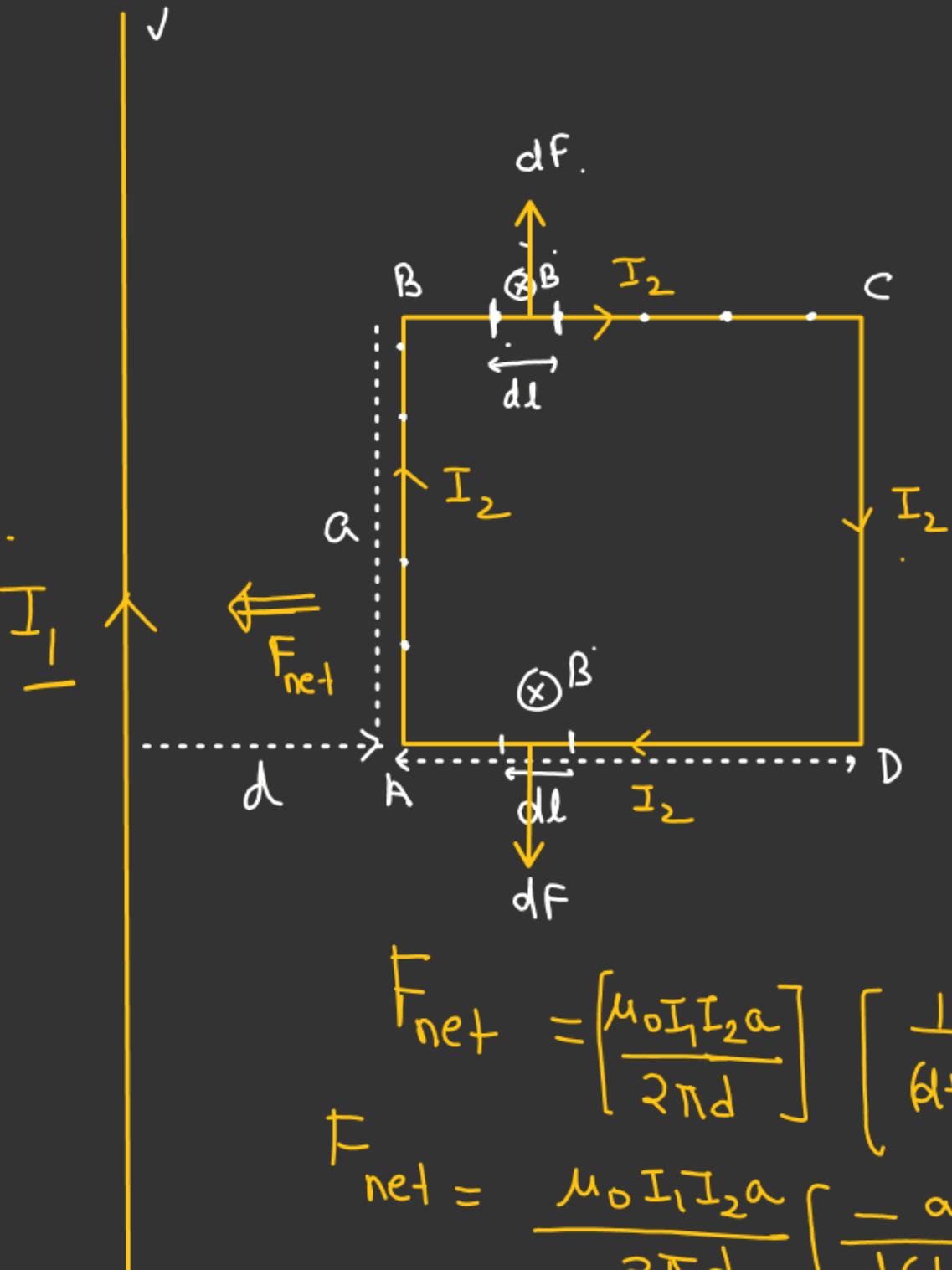
$$\text{Magnetic Force per Unit length} = \left(\frac{\mu_0 I_1 I_2}{2\pi d} \right)$$

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If current flow in same direction
then attractive in nature
and if current flow in opposite
direction then repulsive in
nature





$$F_{\text{net}} = \left[\frac{\mu_0 I_1 I_2 a}{2\pi d} \right] \left[\frac{1}{d+a} - \frac{1}{d} \right]$$

$$F_{\text{net}} = \frac{\mu_0 I_1 I_2 a}{2\pi d} \left[\frac{-a}{d(d+a)} \right] = \left(- \frac{\mu_0 I_1 I_2 a^2}{2\pi d^2 (d+a)} \right)$$

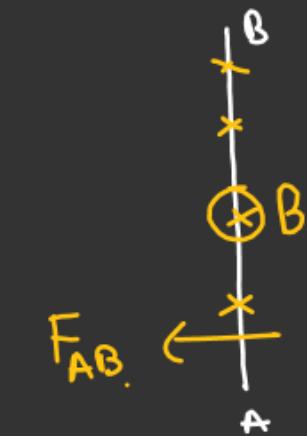
① Find Magnetic force of interaction b/w infinitely long wire and Square frame.

Solⁿ For AB .

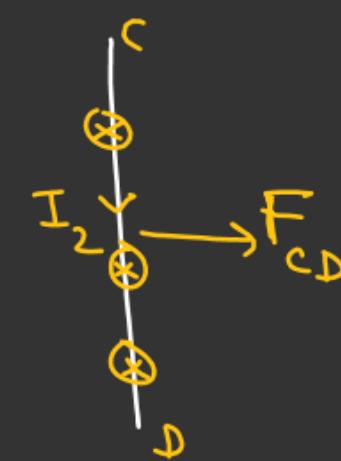
$$B = \frac{\mu_0 I_1}{2\pi d}$$

[due to infinitely long wire]

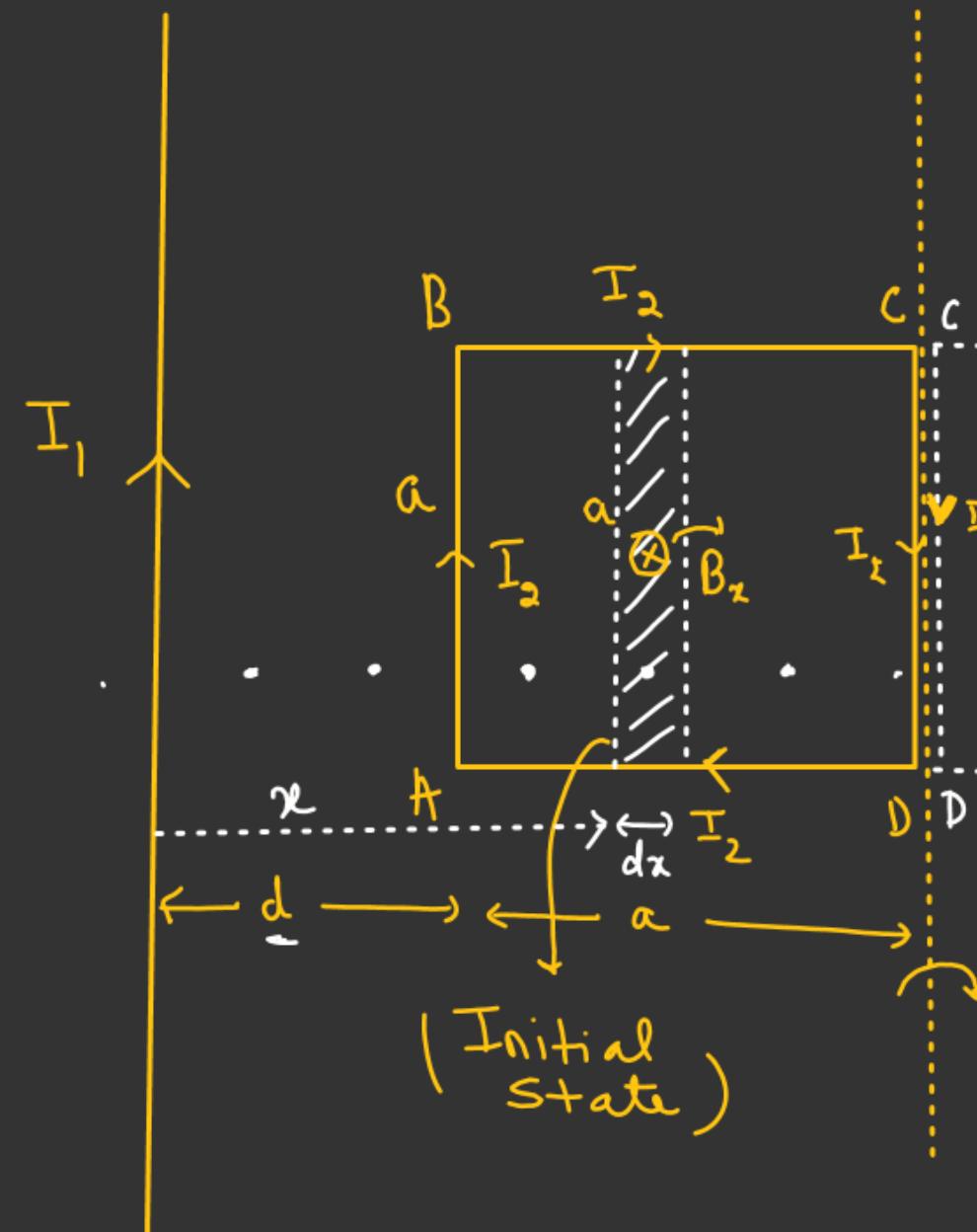
$$\vec{F}_{AB} = \left(\frac{\mu_0 I_1 I_2}{2\pi d} \right) a (-\hat{i})$$



For CD :-



$$\vec{F}_{BD} = \left(\frac{\mu_0 I_1 I_2}{2\pi(d+a)} \right) a (\hat{i})$$

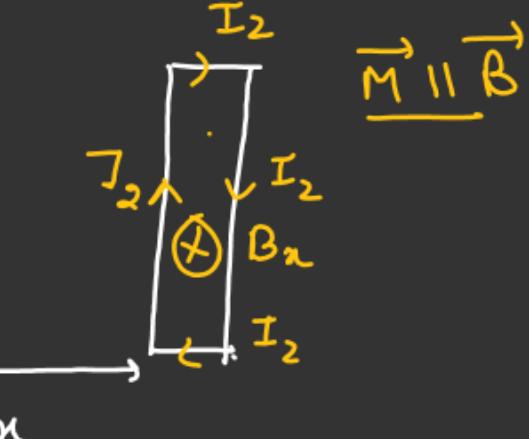


[A Square loop is in the plane of an infinitely long Current Carrying wire. Find the work done in rotating the Square loop along Side CD to 180]

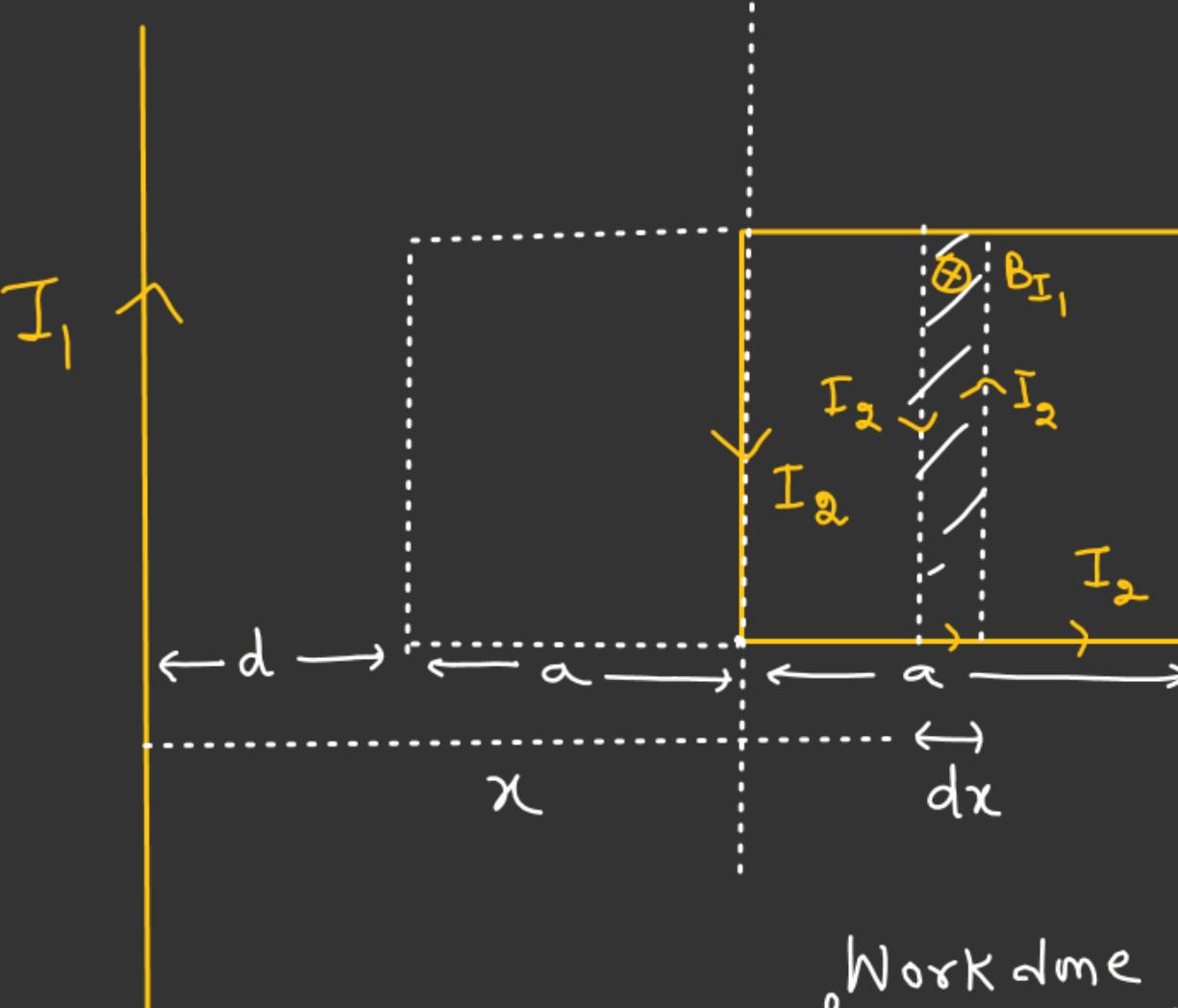
$$U = -[\vec{M} \cdot \vec{B}]$$

dU = P.E of rectangular loop having thickness dx and length a .

$$\begin{aligned} dU &= -dM \cdot B_x \\ U_i &= -I_2(a dx) \frac{\mu_0 I_1}{2\pi x} T_1 \\ (\text{Final State}) \quad \int_0^x dU &= -\frac{\mu_0 I_1 I_2 a}{2\pi} \int_0^x \frac{dx}{x} \end{aligned}$$



$$U_f = -\frac{\mu_0 I_1 I_2 a}{2\pi} \ln \left[\frac{d+a}{a} \right]$$



$$dU_f = -dm(B_{I_1})_x \cos \pi$$

$$\begin{aligned} dU_f &= +\frac{\mu_0 I_1}{2\pi x} (a dx) I_2 \\ \int dU_f &= \frac{\mu_0 I_1 I_2 a}{2\pi} \int_{(d+a)}^{d+2a} \frac{dx}{x} \end{aligned}$$

$$U_f = \frac{\mu_0 I_1 I_2 a}{2\pi} \ln \left[\frac{d+2a}{d+a} \right]$$

$$\begin{aligned} \text{Work done by ext agent} &= \Delta U = \\ &= U_f - U_i = \frac{\mu_0 I_1 I_2 a}{2\pi} \left[\ln \left(\frac{d+2a}{d+a} \right) + \ln \left(\frac{d+a}{a} \right) \right] \\ &= \underbrace{\frac{\mu_0 I_1 I_2 a}{2\pi} \ln \left[\frac{d+2a}{a} \right]}_{\checkmark} \end{aligned}$$