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BIOT–SAVART LAW

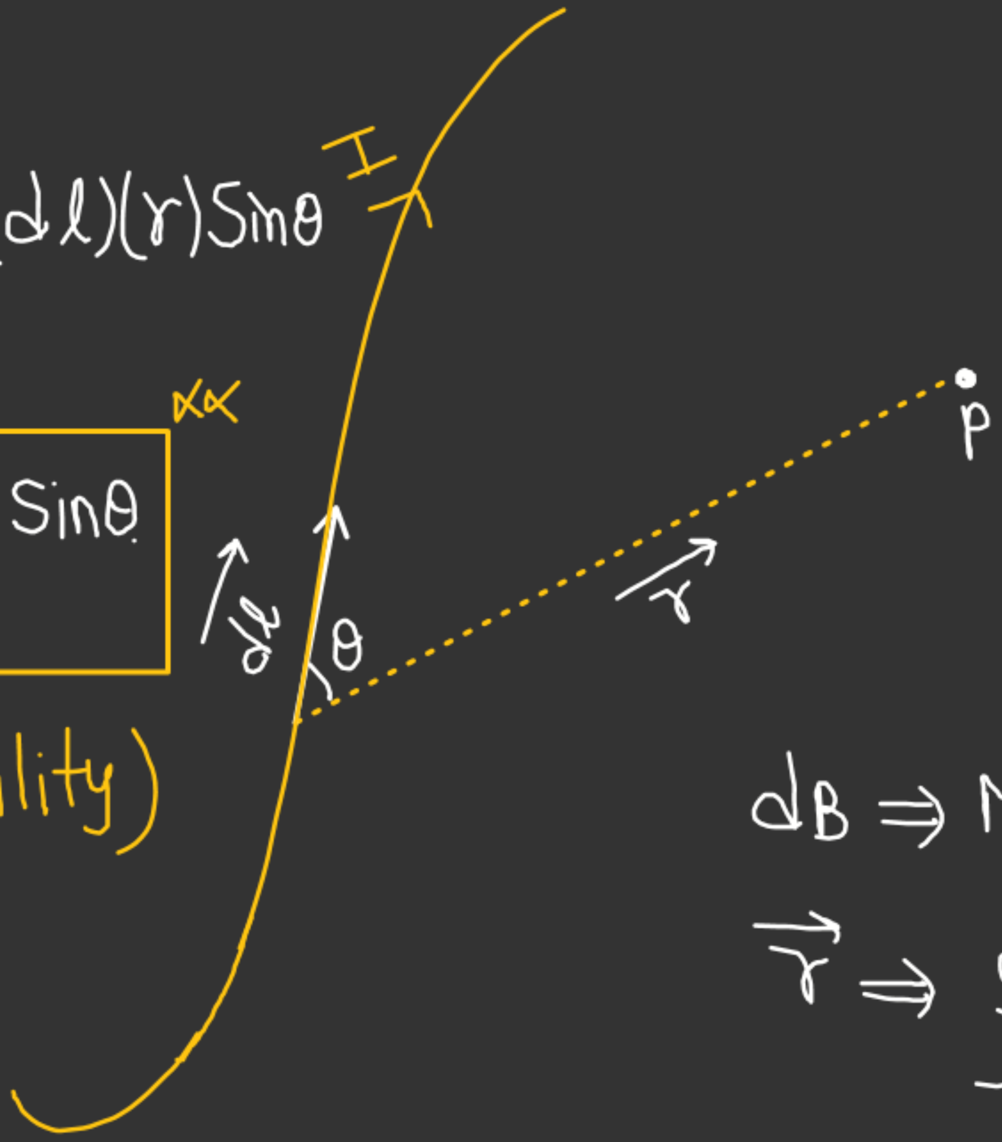
$$\vec{dB} = \frac{\mu_0 I}{4\pi r^2}\left(\vec{dl} \times \hat{r}\right)$$

$$\left|\vec{dB}\right| = \frac{\mu_0 I}{4\pi r^3}(dl)(r)\sin\theta$$

$$\vec{dB} = \frac{\mu_0 I}{4\pi r^2}\left(\vec{dl} \times \frac{\vec{r}}{|\vec{r}|}\right)$$

$$\boxed{dB = \frac{\mu_0 I}{4\pi r^2}\, dl \sin\theta}$$

$\propto\propto$



$$\boxed{\vec{dB} = \frac{\mu_0 I}{4\pi r^3}\left(\vec{dl} \times \vec{r}\right)}$$

$\mu_0 =$ (Permeability)
⇓
(air)

$$\left[\frac{\mu_0}{4\pi} = 10^{-7}\right]$$

$dB \Rightarrow$ Magnetic field at P due to current carrying element dl.

$\vec{r} \Rightarrow$ It is the position from dl to the point where we have to calculate the magnetic field.

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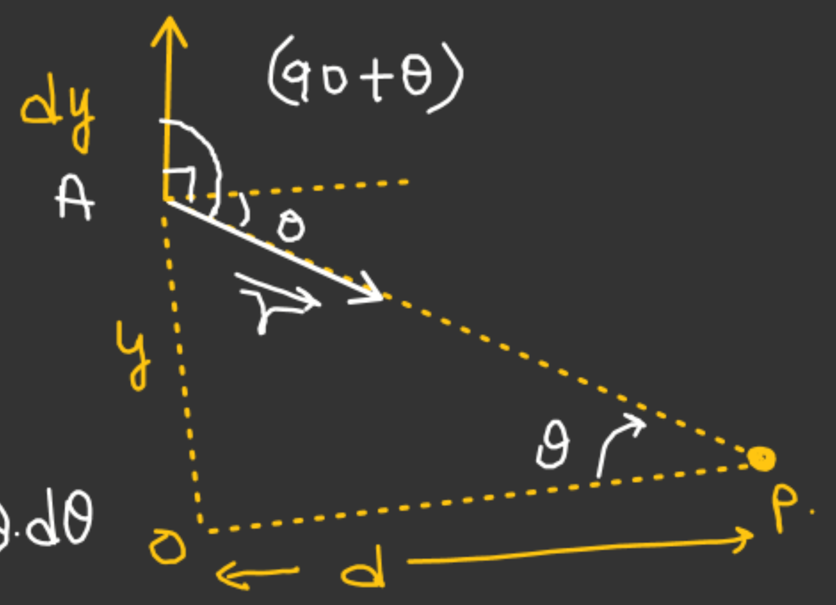
Magnetic field due to finite current carrying wire at any point 'P' in its plane :→

$$dB = \frac{\mu_0 I (dy) \sin(90+\theta)}{4\pi r^2}$$



$$dB = \frac{\mu_0 I}{4\pi r^2} (dy) \cos\theta$$

$$dB = \frac{\mu_0 I}{4\pi (d^2 \cancel{\sec^2\theta})} (d \cancel{\sec^2\theta}) \cos\theta \, d\theta$$

$$\int_0^B dB = \frac{\mu_0 I}{4\pi d} \int_{-\beta}^{+\alpha} \cos\theta \, d\theta$$

In ΔAOP

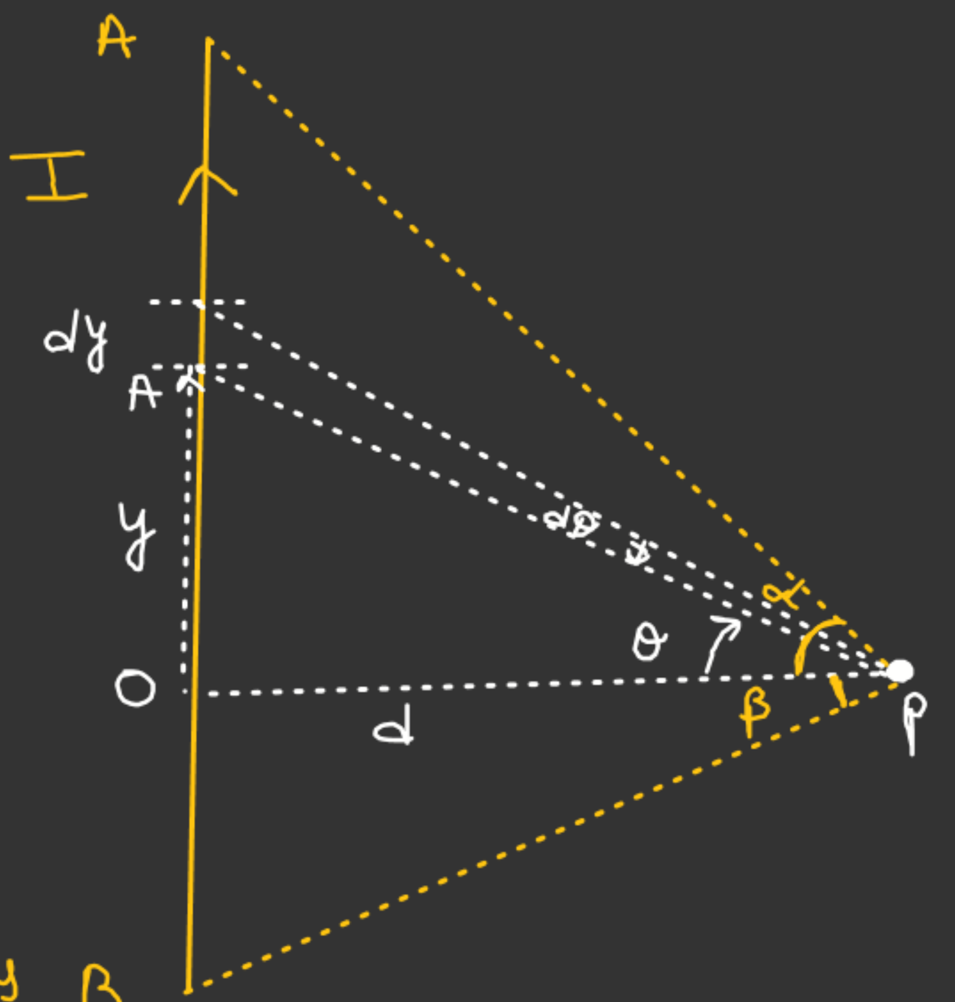
$\cos\theta = \frac{d}{r}$

$r = d \sec\theta$

$\tan\theta = \frac{y}{d}$

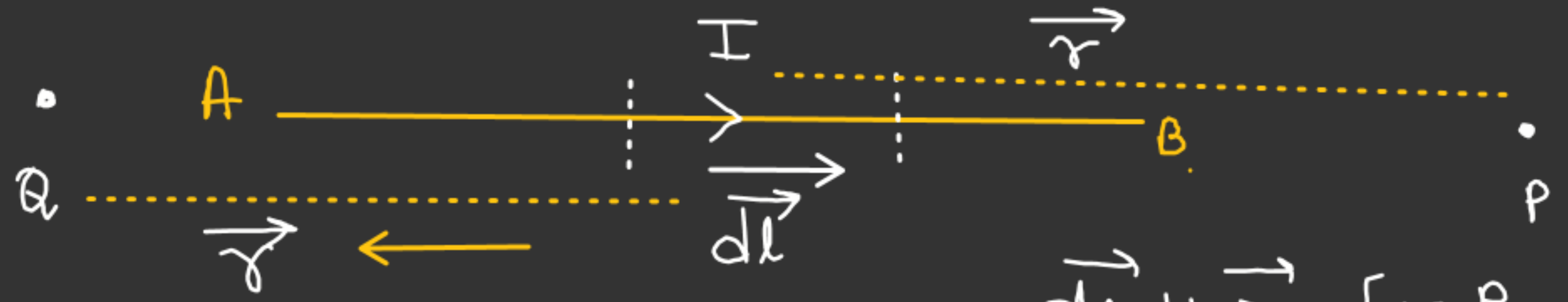
$y = d\tan\theta$

$\frac{dy}{d\theta} = d\sec^2\theta \Rightarrow dy = d\sec^2\theta \, d\theta$



$$(\vec{dl} \times \vec{r}) \Rightarrow (\text{direction})$$

$\vec{dl}$ = [Always taken along the direction of current flow.]



$\vec{dl} \parallel \vec{r}$ for P. $[\theta = 0]$

$dB = 0$

For Q

$\vec{dl} \uparrow \downarrow \vec{r}$ $(\theta = \pi)$

$dB = 0$

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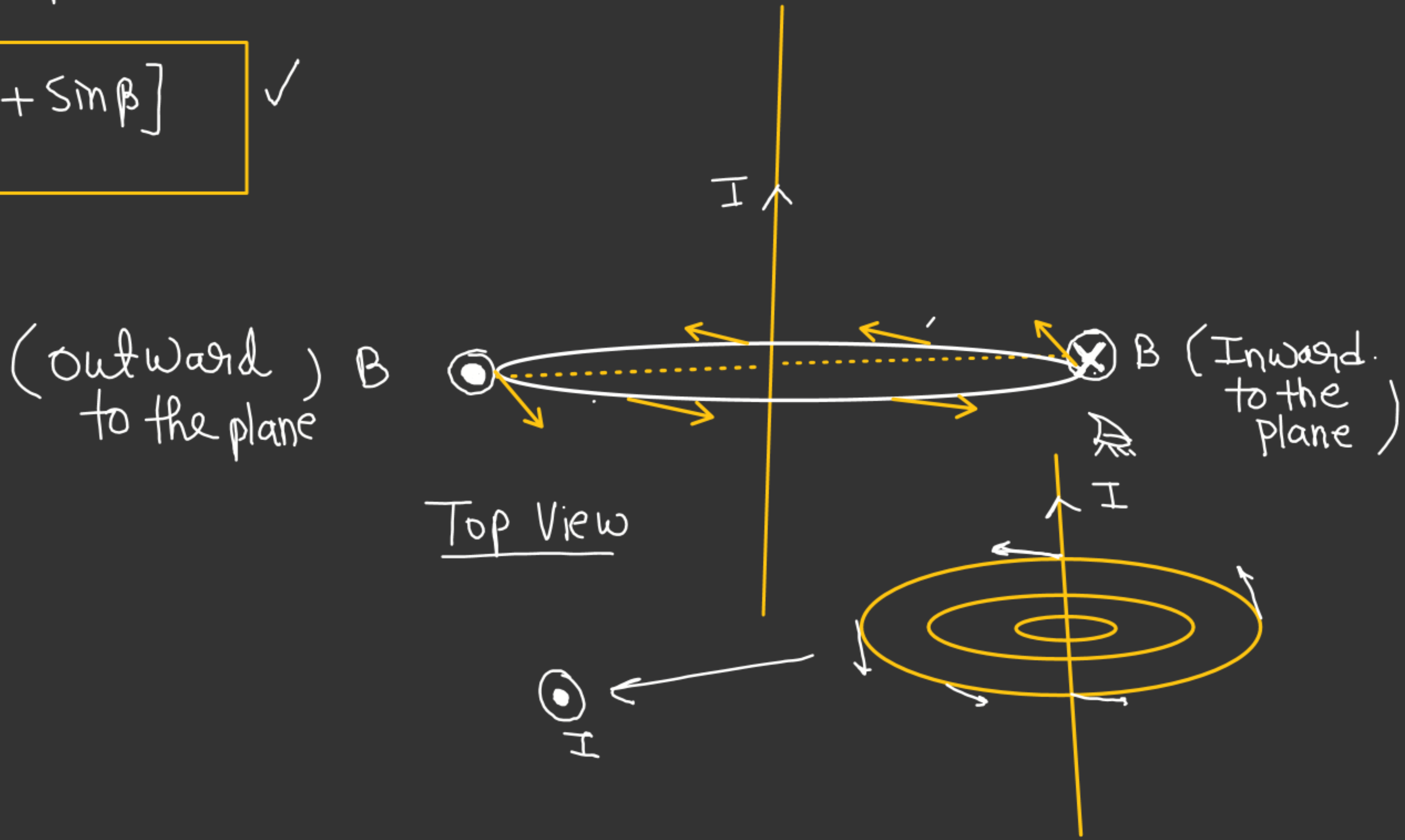
$$B = \frac{\mu_0 I}{4\pi d}\left[\sin\theta\right]_{-\beta}^{\alpha}$$

$$\boxed{B = \frac{\mu_0 I}{4\pi d}\left[\sin\alpha + \sin\beta\right]}$$ ✓



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Special Cases :→

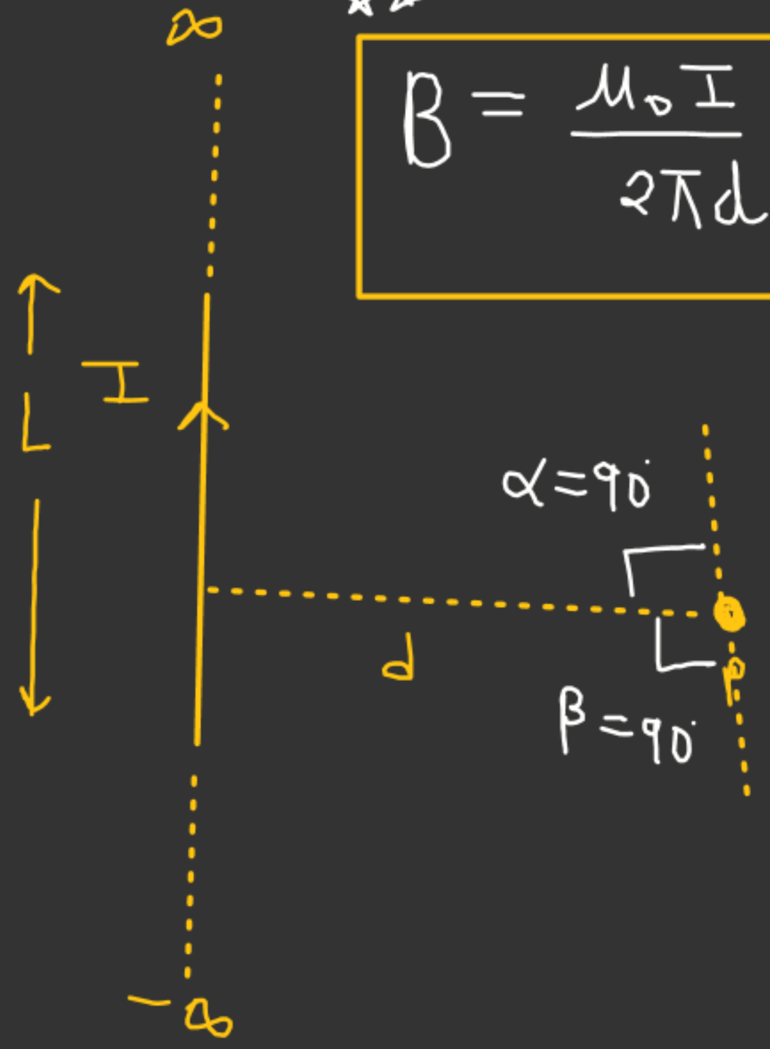
$$B = \frac{\mu_0 I}{4\pi d}[\sin\alpha + \sin\beta]$$

Case of infinite wire :→

$L >> d$

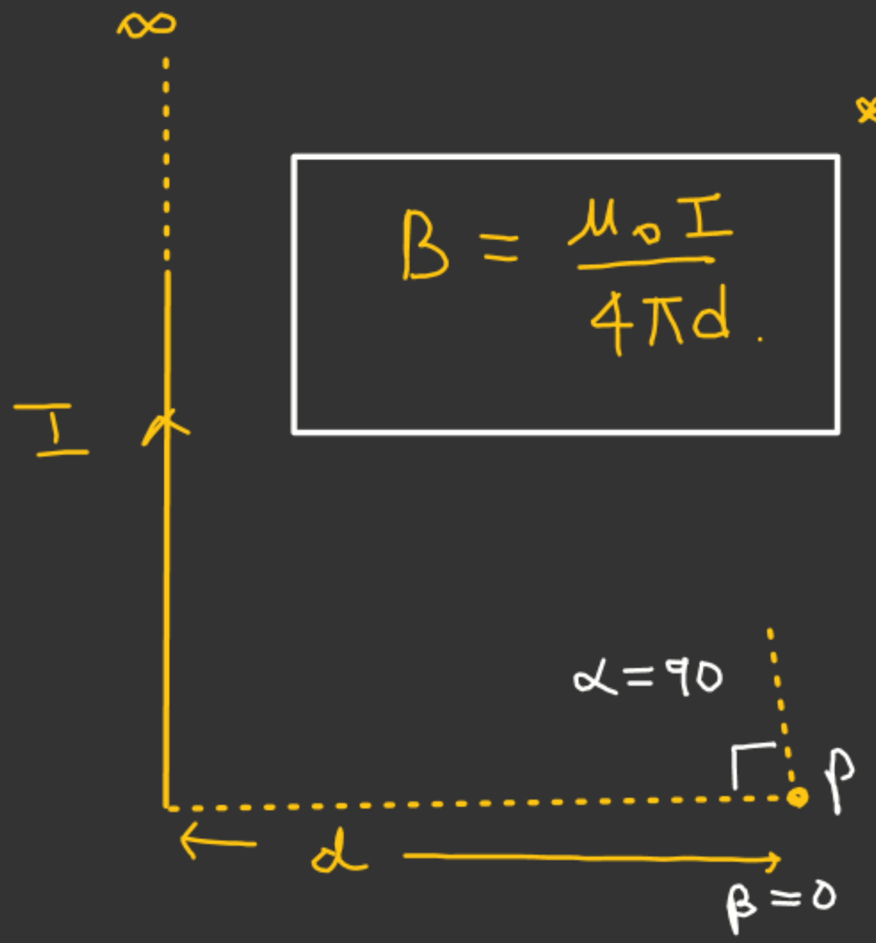
⇓

Infinite wire



$$\boxed{B = \frac{\mu_0 I}{2\pi d}}$$

Semi infinite wire



$$\boxed{B = \frac{\mu_0 I}{4\pi d}}$$

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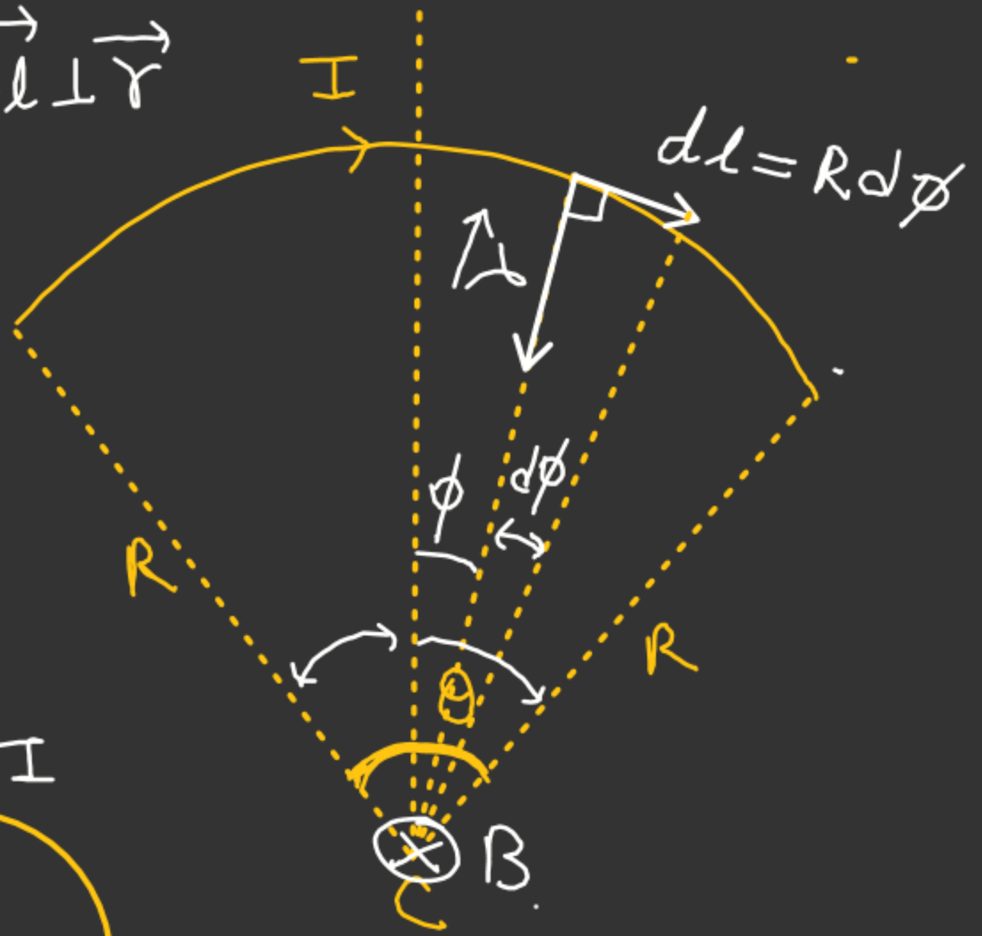
Magnetic field at the Center of a Current Carrying arc :→

$|\vec{r}| = R \qquad \vec{dl} \perp \vec{r}$

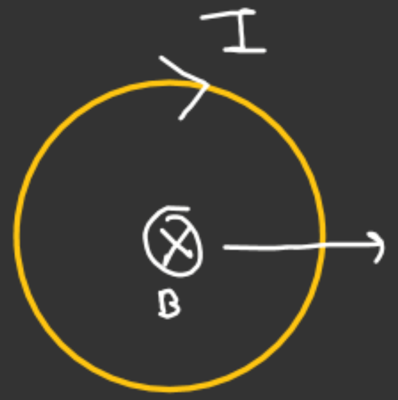


$$dB = \frac{\mu_0 I}{4\pi R^2}\, dl\left(\sin \pi/2\right)$$

$$dB = \frac{\mu_0 I}{4\pi R^2}\left(R\, d\phi\right)$$

$$\int_0^B dB = \frac{\mu_0 I}{4\pi R}\int_{-\theta/2}^{+\theta/2} d\phi$$

$$\boxed{B = \frac{\mu_0 I}{4\pi R}(\theta)}$$



B → ⊥ to plane and inward.

$\theta \to$ Radian

⊥ to plane and outward

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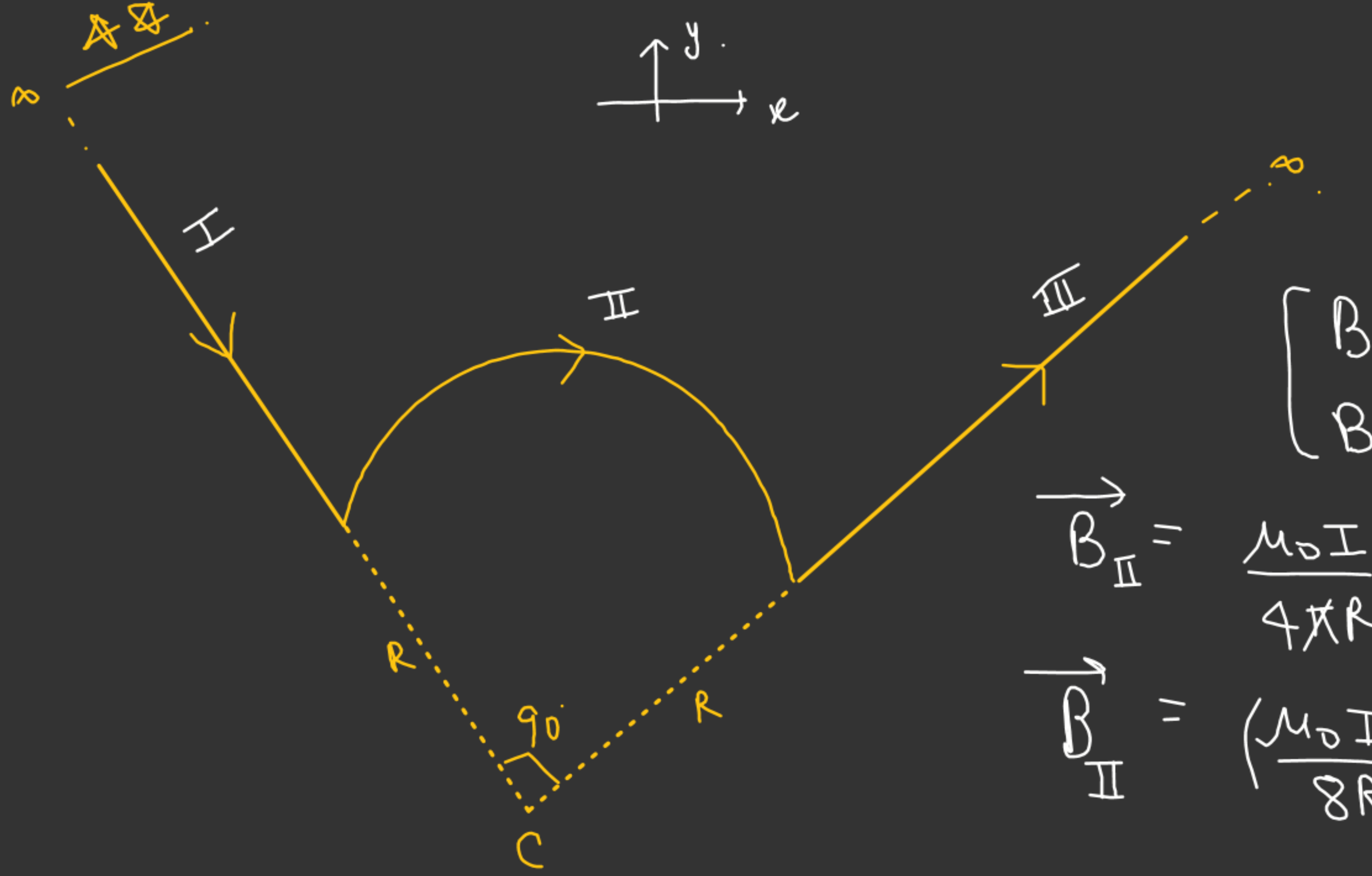

$$\begin{bmatrix} B_{I} = 0 \\ B_{III} = 0 \end{bmatrix} \quad \begin{matrix} \vec{dl} \uparrow \vec{r} \\ \vec{dl} \uparrow\downarrow \vec{r} \end{matrix}$$

$$\vec{B}_{II} = \frac{\mu_0 I}{4\cancel{\pi} R} \times \left(\frac{\cancel{\pi}}{2}\right)(-\hat{k})$$

$$\vec{B}_{II} = \left(\frac{\mu_0 I}{8R}\right)(-\hat{k})$$

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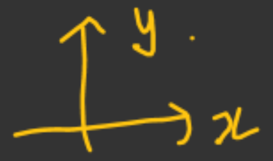
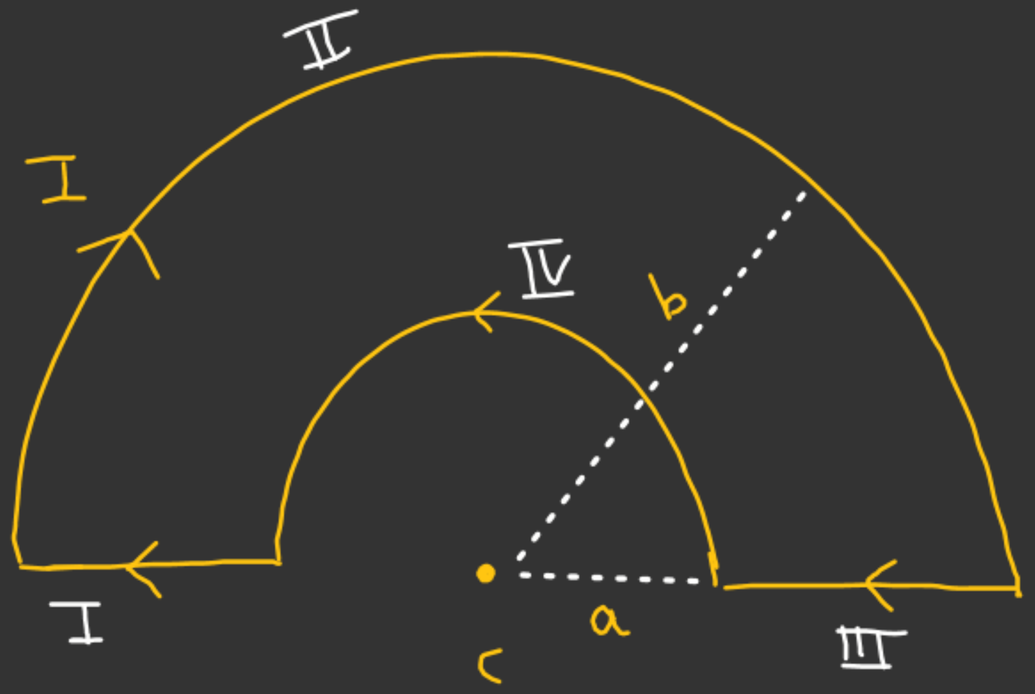


Find B at c

#



$$B_I = B_{III} = 0.$$

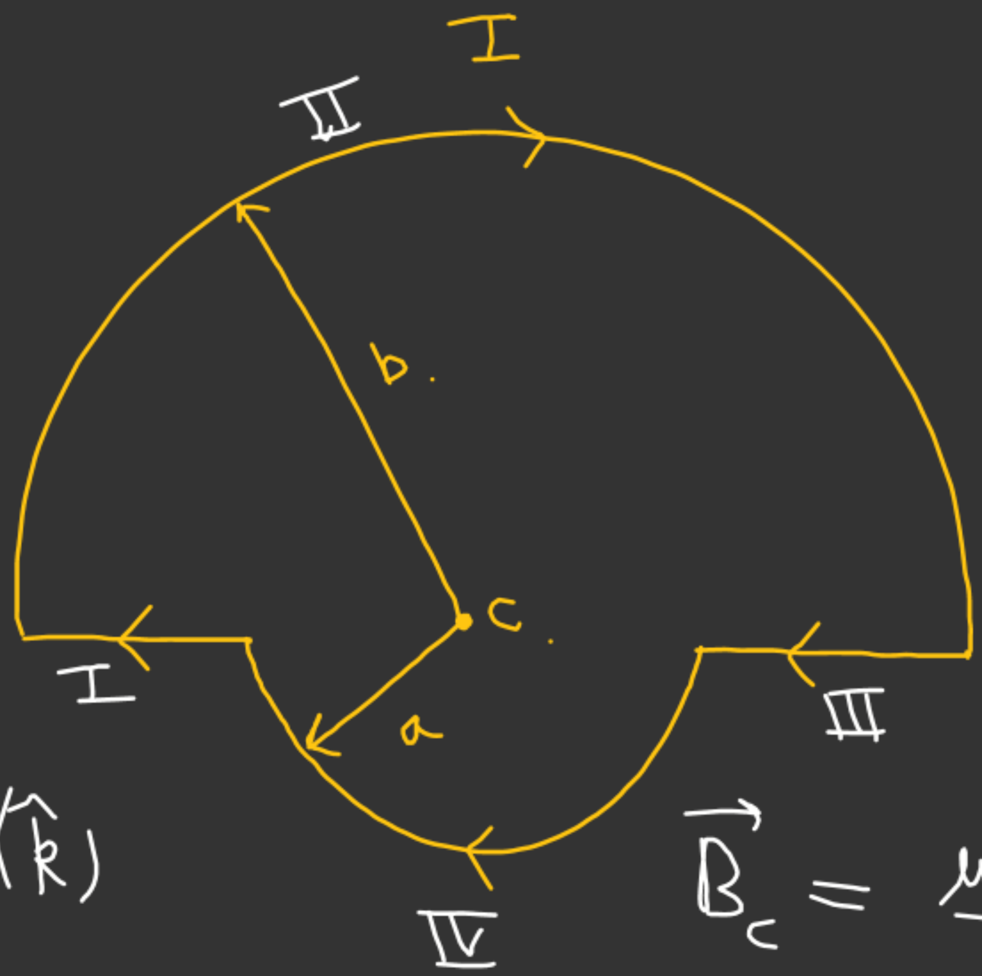
$$\vec{B}_{II} = \frac{\mu_0 I}{4\pi b}(\pi)(-\hat{k})$$

$$= \frac{\mu_0 I}{4b}(-\hat{k})$$

$$\vec{B}_{IV} = \frac{\mu_0 I}{4a}(\hat{k})$$

$$\vec{B} = \frac{\mu_0 I}{4}\left[\frac{1}{a} - \frac{1}{b}\right]\hat{k}$$

#



$$\vec{B}_c = \frac{\mu_0 I}{4}\left[\frac{1}{a} + \frac{1}{b}\right](-\hat{k})$$

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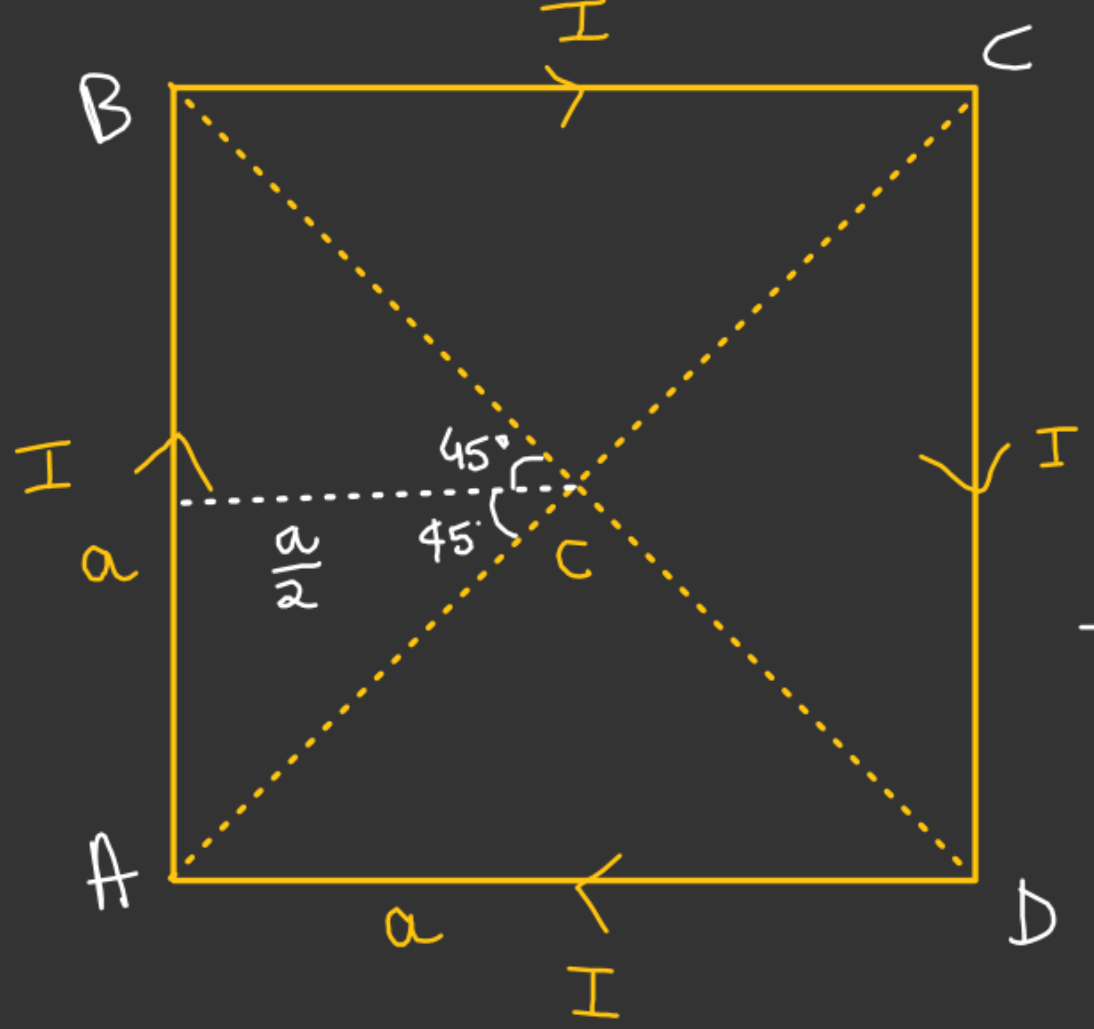
$\vec{B}$ at C



$$\vec{B}_{AB} = \frac{\mu_0 I}{4\pi\left(\frac{a}{2}\right)}\left(2\sin 45^\circ\right)\left(-\hat{k}\right)$$

$$\vec{B}_{AB} = \frac{\mu_0 I}{\sqrt{2}\pi a}\left(-\hat{k}\right)$$

$$\vec{B}_C = 4\,\vec{B}_{AB}$$

$$= \frac{4\mu_0 I}{\sqrt{2}\pi a}\left(-\hat{k}\right)$$

$$= 2\sqrt{2}\,\frac{\mu_0 I}{\pi a}\left(-\hat{k}\right)$$

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