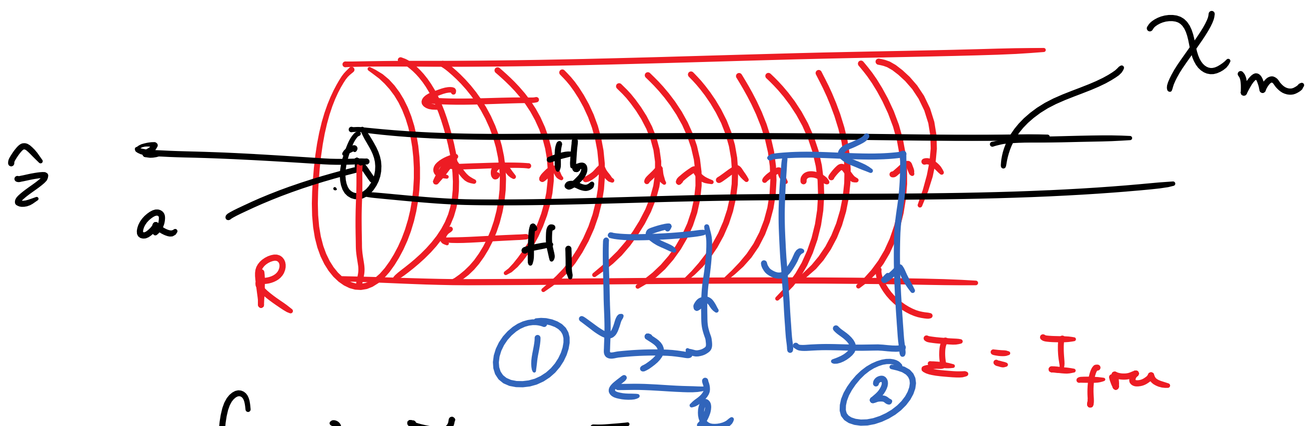
The more I want to get something done, the less I call it work.

ARISTOTLE
(384–322 BC)

Q4




$$\oint \vec{H} \cdot d\vec{l} = I_{fenc}$$

$\vec{B} = \mu \vec{H}$

$$H_1 l = n I l \Rightarrow \vec{H}_1 = n I \hat{z}$$

$$H_2 l = n I l \Rightarrow \vec{H}_2 = n I \hat{z}$$

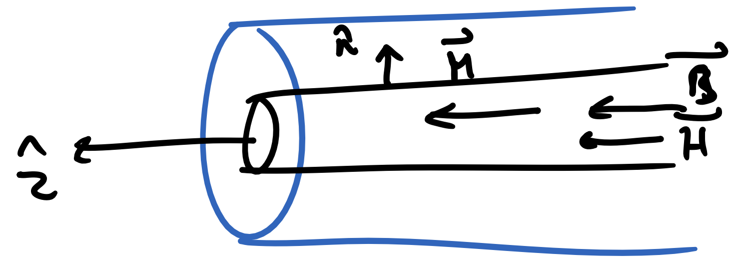
$$\vec{B}_1 = \mu_0 \vec{H}_1 = \mu_0 n I \hat{z}$$

$$\vec{B}_2 = \mu \vec{H}_2 = \mu n I \hat{z} = \mu_0 (1 + \chi_m) I \hat{z}$$

$$\vec{M} = \chi_m \vec{H}$$

Within the medium

$$\boxed{\vec{M} = \chi_m n I \hat{z}}$$




$$\vec{J}_b = \nabla \times \vec{M} = 0$$

$$\vec{K}_b = \vec{M} \times \hat{n} = \chi_m n I (\hat{z} \times \hat{r}) = \chi_m n I \hat{\phi}$$

$(r, \phi, z)$

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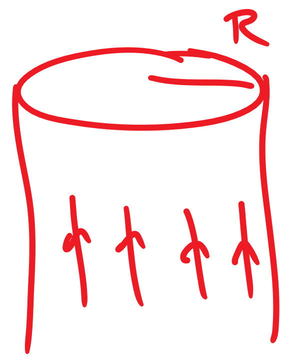
Q2

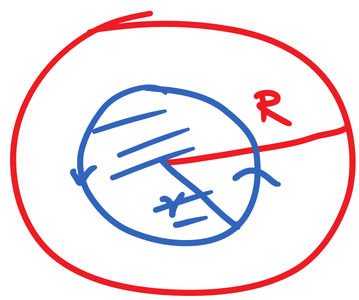
$I$

$$J = \frac{I}{\pi R^2}$$




$$\oint \vec{H} \cdot d\vec{l} = I_{fenc}$$

$$\vec{H} \rightarrow \hat{\phi}$$




$$2\pi r \cdot H = \pi r^2 J = \pi r^2 \frac{I}{\pi R^2}$$

$$\boxed{\vec{H} = \frac{I r}{2\pi R^2} \hat{\phi}} \qquad r < R$$

$$\boxed{\vec{H} = \frac{I}{2\pi r} \hat{\phi}} \qquad r > R$$

$$\vec{B} = \mu \vec{H} = \frac{\mu I r}{2\pi R^2} \hat{\phi} \qquad r < R$$

$$= \mu_0 \vec{H} = \frac{\mu_0 I}{2\pi r}\hat{\phi} \qquad r > R$$

$$\boxed{\vec{M} = \chi_m \vec{H} = \frac{\chi_m I}{2\pi R^2} r\hat{\phi}}$$

$$\vec{J}_b = \nabla \times \vec{M} = \frac{1}{r}\frac{\partial}{\partial r}(r M_\phi)\hat{z}$$

$$= \frac{1}{r}\frac{\partial}{\partial r}\left(\frac{\chi_m I r^2}{2\pi R^2}\right)\hat{z} = \frac{\chi_m I}{\pi R^2}\hat{z}$$

$$\vec{K}_b = \vec{M} \times \hat{n}\Big|_{r=R} = \frac{\chi_m I}{2\pi R^2} R(\hat{\phi} \times \hat{r}) = -\frac{\chi_m I}{2\pi R}\hat{z}$$

Total bound volume current $= \frac{\chi_m I}{\pi R^2} \cdot \pi R^2 = \chi_m I$

Total bound surface current $= -\frac{\chi_m I}{2\pi R} \cdot 2\pi R = -\chi_m I$

Total bound current $= \chi_m I - \chi_m I = 0$

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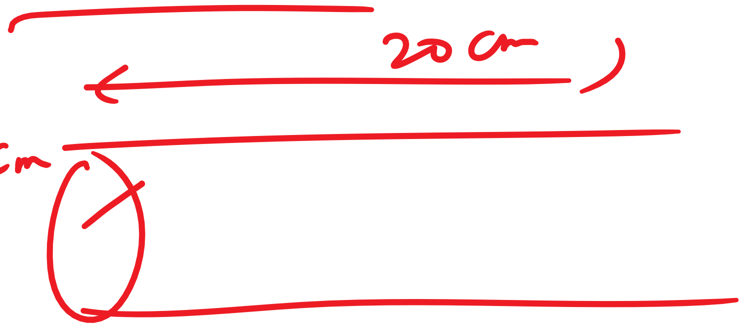
Q
check $\vec{F} = \frac{x\hat{y} - y\hat{x}}{\sqrt{x^2+y^2}}$ Can represent a magnetic field?

$\nabla \cdot \vec{F} = 0$ ?

$$\vec{B} = \nabla \times \vec{A}$$

$$\Phi_m = \int \vec{B} \cdot d\vec{a} = \int (\nabla \times \vec{A}) \cdot d\vec{a} = \oint \vec{A} \cdot \vec{dl}$$

Q7 $R = 2\,cm$




$N = 100$ turn

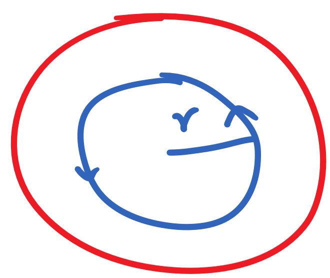
$$I = I_0 \sin 2\pi f t = 5 \sin 2\pi \times 10^4 t$$

$\vec{E} \to$ azimuthal $\hat{\phi}$

$$\nabla \cdot \vec{B} = 0 \qquad \nabla \cdot \vec{E} = 0$$

$$\nabla \times \vec{B} = \mu_0 \vec{J} \qquad \nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$

$$\oint \vec{E} \cdot \vec{dl} = -\frac{d\Phi_m}{dt}$$

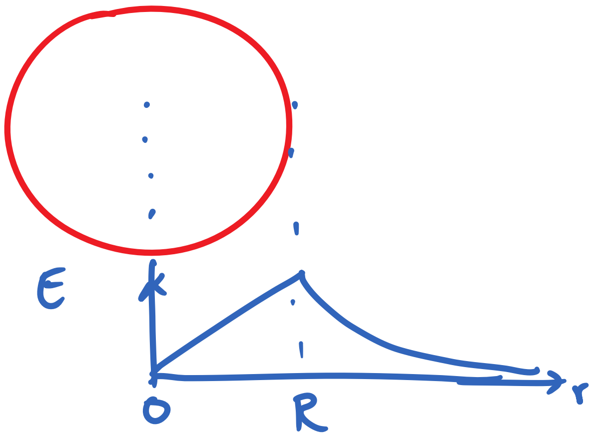



$$2\pi r E = -\frac{d}{dt}\Big(\underbrace{\mu_0 n I}_{B} \cdot \underbrace{\pi r^2}_{\text{area}}\Big)$$

$$= -\mu_0 n \pi r^2 \frac{dI}{dt}$$

$$\boxed{\vec{E} = -\frac{\mu_0 n r}{2} \frac{dI}{dt} \hat{\phi}}$$

$$= -\frac{\mu_0 n r}{2} \underbrace{I_0 2\pi f \cos 2\pi f t}_{dI/dt} \hat{\phi}$$




Q

$$\vec{A} = -K \ln\left(\frac{x^2+y^2}{r_0^2}\right)\hat{z}$$

$\vec{B} = ?$