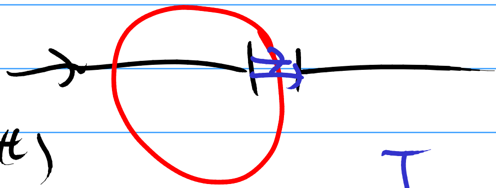
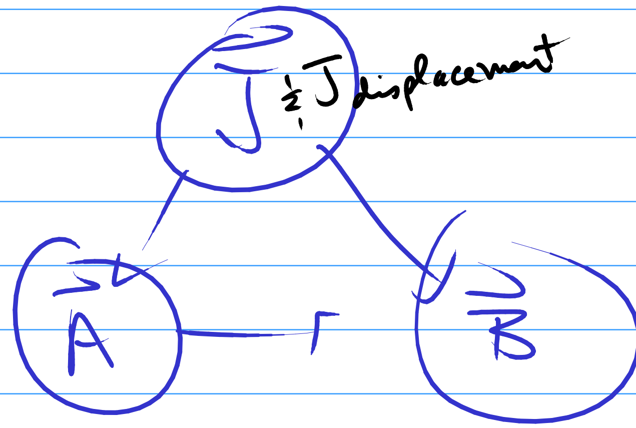


$I(t)$

$J_{displacement} \xRightarrow{\text{generates a}}$ magnetic field

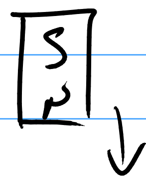


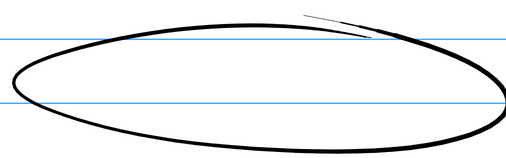
Does $J_{displacement}$ go into our expression for conservation of charge? NO

$$\vec{\nabla}\cdot\vec{J} = -\frac{\partial \rho}{\partial t}$$

Hmwk problem on last set

See soln on wiki

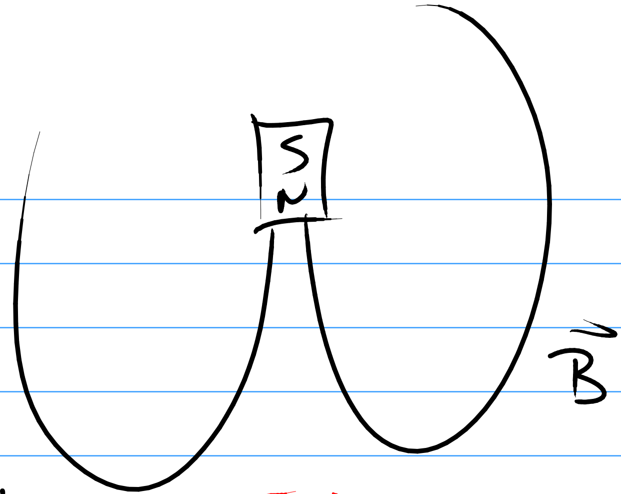




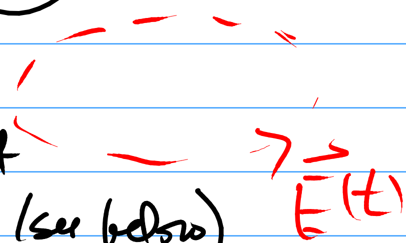
$$\mathcal{E}mf = -\frac{d\Phi_B^{tot}}{dt} \qquad \Phi_B^{tot} = \int \vec{B}\cdot d\vec{a}$$

$$\vec{B}_{wire} + \vec{B}_{magnet}$$

$$\Phi_{wire} = \int B_{wire}\cdot da \equiv L I$$



Should also include B due to J displacement but it is small (see below)



no metal

Causes $\vec{J}_{displacement} = \epsilon_0 \frac{\partial \vec{E}}{\partial t} \Rightarrow B$

Maxwell's Eqns

$$\vec{\nabla} \times \vec{B} = \mu_0 \vec{J} + \mu_0 \epsilon_0 \frac{\partial \vec{E}}{\partial t}$$

2 sources of B

$\vec{J}$ & $\epsilon_0 \frac{\partial E}{\partial t}$

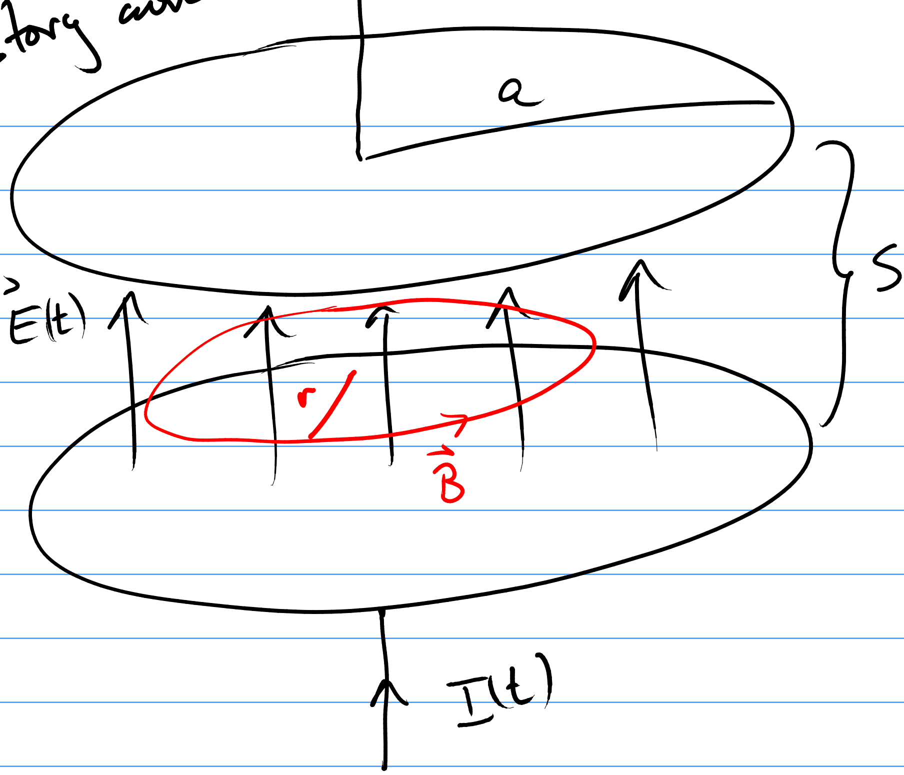
$$\vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t} \qquad \vec{\nabla} \cdot \vec{E} = \rho / \epsilon_0$$

2 sources of E

charge & $\frac{\partial \vec{B}}{\partial t}$

Conservative & non- E

charging a capacitor with oscillatory current



$$A = \pi a^2$$

$$\vec{J}_{displacement} = \epsilon_0 \frac{\partial \vec{E}}{\partial t}$$

$$E = \frac{\sigma}{\epsilon_0} = \frac{1}{\epsilon_0}\frac{Q}{A}$$

$$\vec{J}_{displacement} = \frac{I}{A}\hat{z}$$

$$\frac{\partial E}{\partial t} = \frac{1}{\epsilon_0}\frac{I}{A}$$

$$\oint \vec{B}\cdot d\vec{\ell} = \mu_0 \int \vec{J}_d \cdot d\vec{a} = \mu_0 \frac{I}{\pi a^2}\pi r^2$$

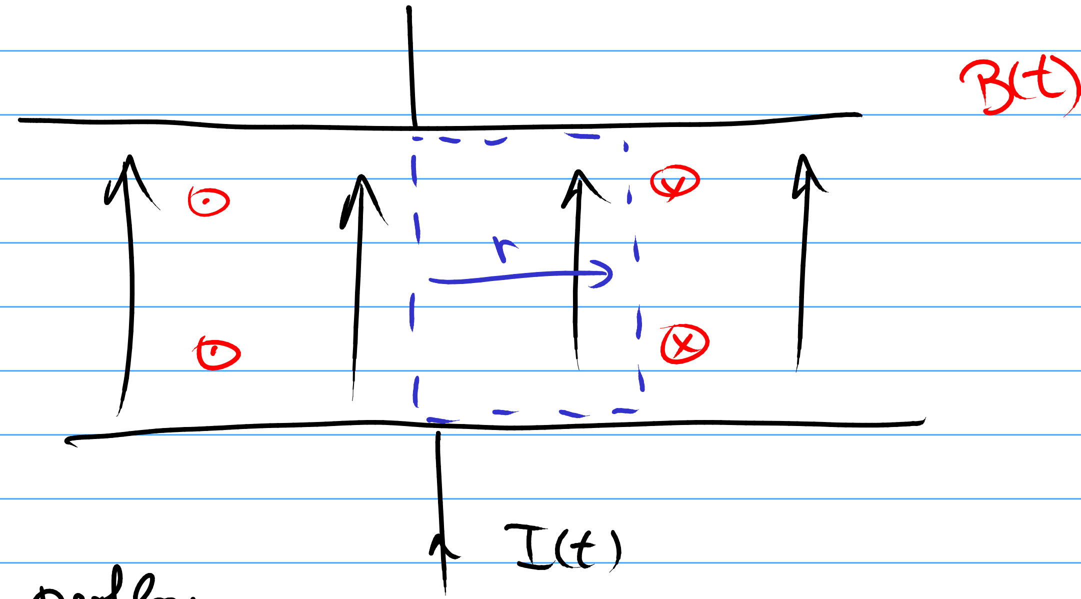
$$\parallel$$

$$B\, 2\pi r = \mu_0 I \frac{r^2}{a^2} \Rightarrow \vec{B} = \frac{\mu_0 I}{2\pi}\frac{r}{a^2}\hat{\phi}$$

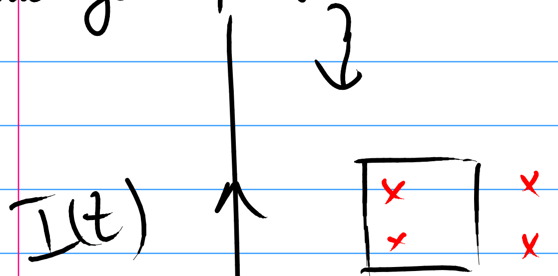
If $Q = I_0 t$ then $I = I_0$ is constant and B is constant. No need to include any effects of a changing B generating another E (Faraday's law).

If $I(t)$ then $B(t)$.

side view



Analogous problem



$$\mathcal{E}_{mf} = -\frac{d\Phi_B}{dt}$$

$$\oint \vec{E}\cdot d\vec{l} = -\int \frac{d}{dt}(\vec{B})\cdot d\vec{a}$$

1st term in perturbation

not uniform

$$E = E_1 + E_2 + \dots$$

uniform (constant)

Assume harmonic oscillation

$$\boxed{E_1 e^{i\omega t}}$$

σ_0

t_0

$$\oint \vec{E}\cdot d\vec{l} = \underbrace{\oint \vec{E}_1\cdot d\vec{l}} + \oint \vec{E}_2\cdot d\vec{l}$$

Symmetry $\quad E_2(r=0) = 0$

$$\oint \vec{E}\cdot d\vec{l} = E_2\, l = E_2\, s$$ = Left hand side

$$B = B_1 + B_2 + \cdots$$

From above,

caused by the 1st approx to J_{disp}

$$\vec{B} = \frac{\mu_0 I}{2\pi}\frac{r}{a^2}\hat{\phi} = B_1 \qquad I_{disp_1} = \epsilon_0 A \frac{\partial (E_1 e^{i\omega t})}{\partial t}$$

$$I_{disp_1} = \epsilon_0 A i\omega E_1 e^{i\omega t}$$

$$B_1 = \frac{\mu_0}{2\pi}\frac{r}{a^2}\overbrace{\epsilon_0 A i \omega E_1 e^{i\omega t}}$$ where $A = \pi a^2$

$$B_1 = \frac{i\omega}{2}\mu_0 \epsilon_0 r E_1 e^{i\omega t}$$

$$c = \frac{1}{\sqrt{\mu_0 \epsilon_0}} \qquad \mu_0 \epsilon_0 = \frac{1}{c^2}$$

$$B_1 = i\frac{\omega}{2}\frac{1}{c^2} r E_1 e^{i\omega t}$$

Faraday's law is now

$$-E_2 s = -\frac{\partial}{\partial t}\int B_1 s\, dr$$

$$E_2 \cancel{s} = \frac{\partial}{\partial t}\int \frac{i\omega}{2c^2} E_1 e^{i\omega t} r \cancel{s}\, dr$$

$$E_2 = -\frac{\omega^2 r^2}{4c^2} E_1 e^{i\omega t}$$

$$E = E_1 + E_2 = E_1 e^{i\omega t}\left(1 - \frac{1}{4}\frac{\omega^2 r^2}{c^2} + \cdots\right)$$