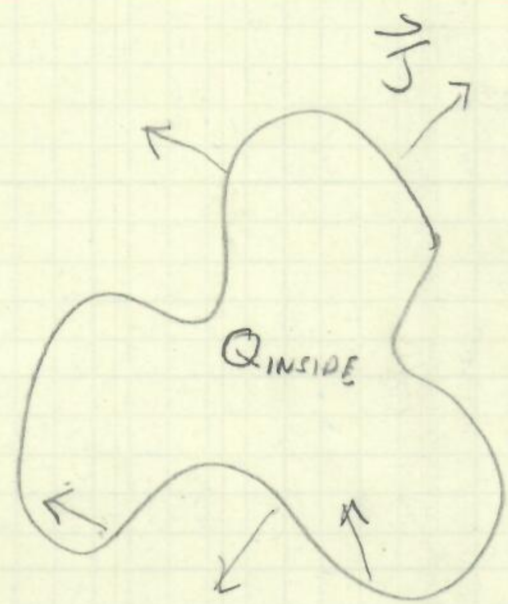


$I = -\frac{dQ}{dt}$

$\int \vec{J}\cdot da = -\frac{dQ}{dt}$

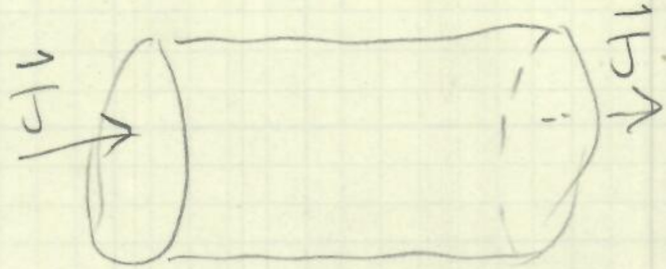
Eqn 5.29 p. 222

Self Evident

$$\oint \vec{J}\cdot d\vec{a} = \int_V \nabla\cdot\vec{J}\,d\tau = -\frac{d}{dt}\int_V \rho\,d\tau$$

For arb V

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



Wire $\oint \vec{J}\cdot d\vec{a} = 0$

In equilibrium

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

$\nabla\times\vec{E} = -\frac{\partial\vec{B}}{\partial t}$ $\qquad \nabla\times\vec{B} = \mu J$ w/o Maxwell term

$\nabla\cdot\nabla\times\vec{A} = 0$ for <u>any</u> vector fn $\vec{A}$

So

$\underbrace{\nabla\cdot\nabla\times\vec{E}}_{0\text{, identically}} = -\frac{\partial}{\partial t}\underbrace{\nabla\cdot\vec{B}}_{0}$ $\qquad \underbrace{\nabla\cdot\nabla\times\vec{B}}_{0} = \mu\underbrace{\nabla\cdot\vec{J} = -\mu\frac{\partial\rho}{\partial t}}_{\text{Not }0}$

But $\mu \frac{\partial}{\partial t} \nabla\cdot\vec{E} = \mu\frac{\partial}{\partial t}\rho/\epsilon$ By Gauss

So $\mu\epsilon\nabla\cdot\frac{\partial\vec{E}}{\partial t} = \mu\frac{\partial\rho}{\partial t}$

So change Ampere:

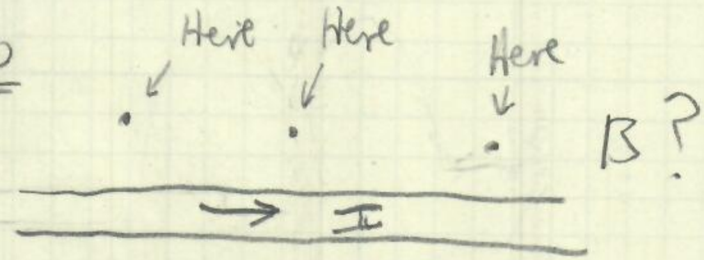
$$\nabla\times\vec{B}=\mu\vec{J} \to \nabla\times\vec{B} = \mu\vec{J}+\mu\epsilon\frac{\partial\vec{E}}{\partial t}$$

Now $\nabla\cdot\nabla\times B=0$

$$\nabla\cdot\left(\mu J+\mu\epsilon\frac{\partial\vec{E}}{\partial t}\right)$$

$$= -\mu\frac{\partial\rho}{\partial t}+\mu\epsilon\frac{\partial}{\partial t}\frac{\rho}{\epsilon}=0$$

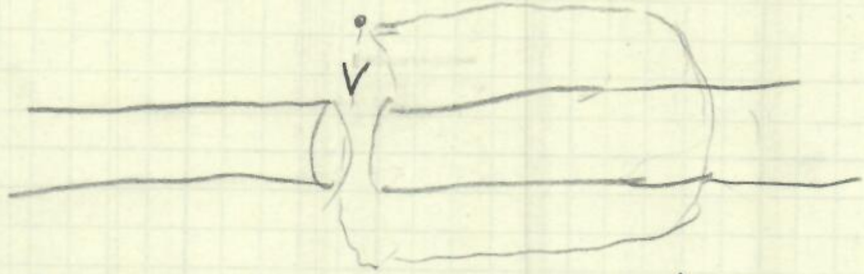
<u>Also</u>



It might be less. We broke symmetry

But still does not depend on theta & should be only a fn of r

Amperian Bag



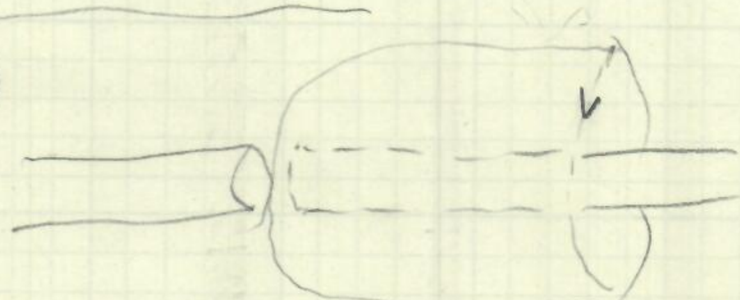
Same current is enclosed

$$\int \vec{B}\cdot d\vec{l} = \mu_0 I$$

$$2\pi r B = \mu_0 I$$

$$B = \frac{\mu_0 I}{2\pi r}$$ ... No Difference

ALSO



The Bag can go in the gap, but there is no current in the gap!

$$E = \frac{\sigma}{\epsilon_0} \qquad \sigma = \frac{Q}{A} \qquad \frac{dQ}{dt} = I = A\frac{d\sigma}{dt}$$

$$A\frac{d\sigma}{dt} = A\epsilon_0\frac{\partial E}{\partial t}$$

$$\int \vec{B}\cdot d\vec{l} = \mu_0 I + \mu_0\epsilon_0 \underbrace{\frac{\partial \Phi_E}{\partial t}}_{I_D}$$

What's the Maxwell Displacement current?

$\mu_0 J$?

$\mu_0 \epsilon_0 E$

$\mu_0 \epsilon_0 \frac{\partial E}{\partial t}$

$\epsilon_0 \frac{\partial \Phi_E}{\partial t}$

None of these

$\vec{A}$

$\vec{A} = \frac{\mu}{4\pi} \int \frac{\vec{J}}{r} d\tau$

Skip this

Students - This is from 7.2.4 of new book (5th ed)
same as 7.2.4 of 4th ed

B-field energy -- Next Time? $u = \frac{B^2}{2\mu}$ $u = \frac{1}{2}\epsilon E^2$

$W = qV \rightarrow \frac{dW}{dt} = \frac{dq}{dt} V = IV = \text{Power}$

$\text{Power} = \frac{dW}{dt} = -\mathcal{E} I = L \frac{dI}{dt} I \leftarrow \Phi \equiv LI$

$\mathcal{E} = \frac{-d\Phi}{dt} = -L\frac{dI}{dt}$

$\int \frac{dW}{dt} dt = W \quad \int LI \frac{dI}{dt} dt = \int \frac{d}{dt} \frac{1}{2} LI^2 dt$

$= \frac{1}{2} LI^2$

Analogous to $\frac{1}{2} CV^2$

Write $\frac{1}{2} LI^2$ in terms of B in general

$\Phi = \int \vec{B} \cdot da = \int \nabla \times \vec{A} \cdot d\vec{a} = \oint \vec{A} \cdot d\vec{l}$ Stokes $= LI$

So $\frac{1}{2} LI^2 = \frac{1}{2} I \, LI = \frac{1}{2} I \oint \vec{A} \cdot d\vec{l}$

But $I = \vec{J} \cdot d\vec{a}$

$\frac{1}{2} LI^2 = \frac{1}{2} \oint \vec{A} \cdot d\vec{l} \, \vec{J} \cdot d\vec{a} = \frac{1}{2} \int_V \vec{A} \cdot \vec{J} \, d\tau$

$$\frac{1}{2}LI^2 = \frac{1}{2}\int_V \vec{A}\cdot\vec{J}\,d\tau \quad \text{Gives } \nabla\times B = \mu_0 J$$

$$= \frac{1}{2\mu_0}\int_V \vec{A}\cdot(\nabla\times\vec{B})\,d\tau$$

$$\nabla\cdot(A\times B) = \vec{B}\cdot(\nabla\times\vec{A}) - \vec{A}\cdot(\nabla\times\vec{B}) \quad \text{Product Rule}$$

$$\vec{A}\cdot\nabla\times\vec{B} = \vec{B}\cdot(\nabla\times\vec{A}) - \nabla\cdot(\vec{A}\times\vec{B})$$

$$= \vec{B}\cdot\vec{B} - \nabla\cdot(A\times B)$$

$$W = \frac{1}{2\mu_0}\left[\int_V B^2\,d\tau - \int \nabla\cdot(A\times B)\,d\tau\right]$$

$$= \frac{1}{2\mu_0}\int_V B^2\,d\tau - \oint_S (\vec{A}\times\vec{B})\cdot d\vec{a}$$

Take Surface to ∞ $A, B \to 0$ Because far from currents