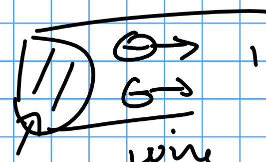
$$\vec{B}(x,y,z) = \frac{\mu_0}{4\pi}\int \frac{\vec{J}(x',y',z')\times\hat{r}}{r^2}\,d\tau'$$

$\vec{J} = \rho\vec{v}$ $\frac{\text{Amps}}{m^2}$



$J = \frac{1\ \text{Amp}}{.1\ m^2} = 10$

$.1\ m^2$

vector function $\vec{A}$

$\vec{A}$ is known if $\vec{\nabla}\cdot\vec{A}$ & $\vec{\nabla}\times\vec{A}$

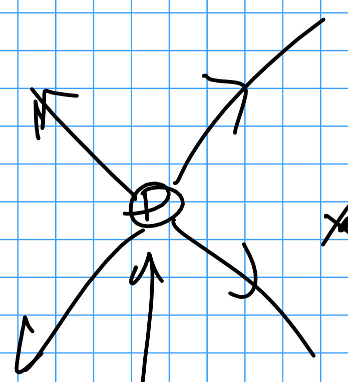
$\vec{J}(x',y',z')$

$$\vec{\nabla}\cdot\vec{B} = \vec{\nabla}\cdot\frac{\mu_0}{4\pi}\int\frac{\vec{J}\times\hat{r}}{r^2}\,d\tau' = \phi$$

$\frac{\partial}{\partial x}$ $dx'dy'dz'$

$$\vec{\nabla}\times\vec{B} = \vec{\nabla}\times\frac{\mu_0}{4\pi}\int\frac{\vec{J}\times\hat{r}}{r^2}\,d\tau' = \mu_0\vec{J}$$

$\vec{\nabla}\cdot\vec{E} = \rho/\epsilon_0$

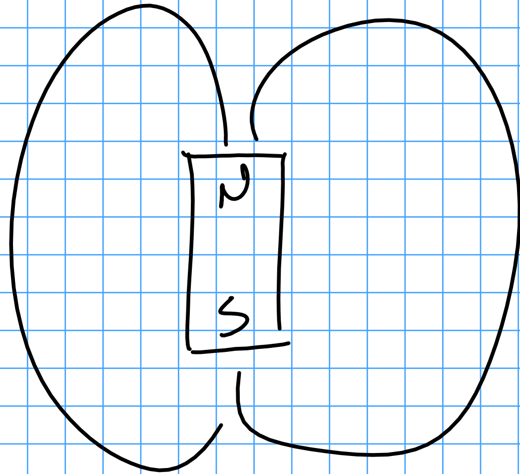


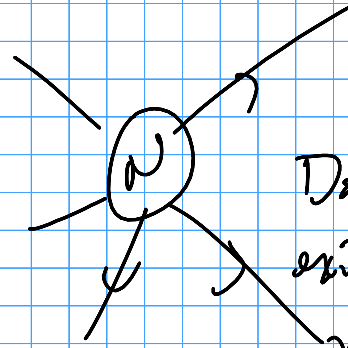
Source of E is ρ

$\vec{\nabla}\cdot\vec{E} = \phi$

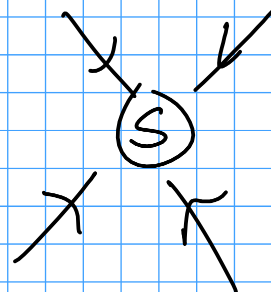
$\vec{\nabla}\cdot\vec{E} \neq 0$

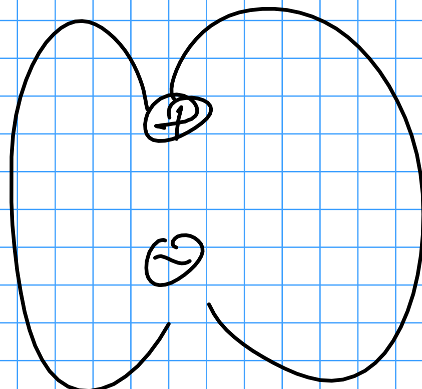
$\vec{\nabla}\cdot\vec{B} = 0$ Source of B current but it is not a point source





Does not exist in nature

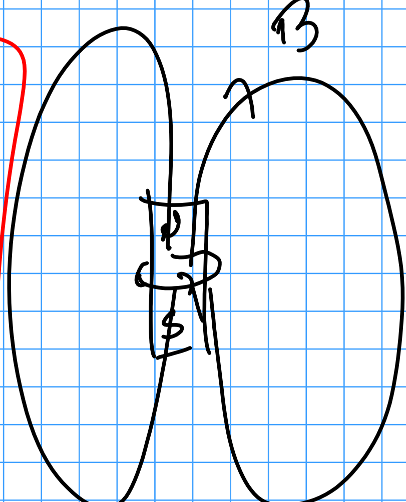




$$\vec{\nabla} \times \vec{E} = 0$$

$$\vec{\nabla} \cdot \vec{E} = \frac{\rho}{\epsilon_0}$$

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



field lines for B form a loop

$$\vec{\nabla} \cdot \vec{B} \neq 0$$

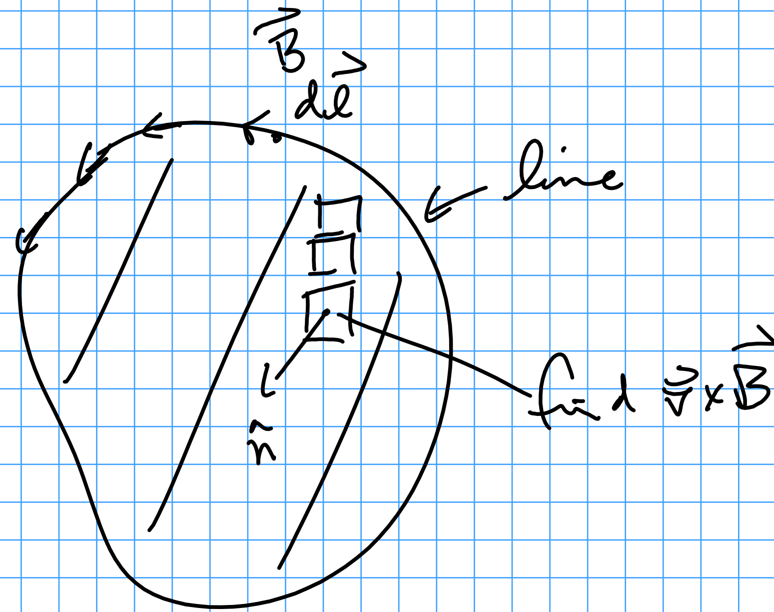
$$\vec{\nabla} \times \vec{B} = \mu_0 \vec{J}$$

diff form of Ampere's law

integral form of Ampere's law: use Stokes Thm

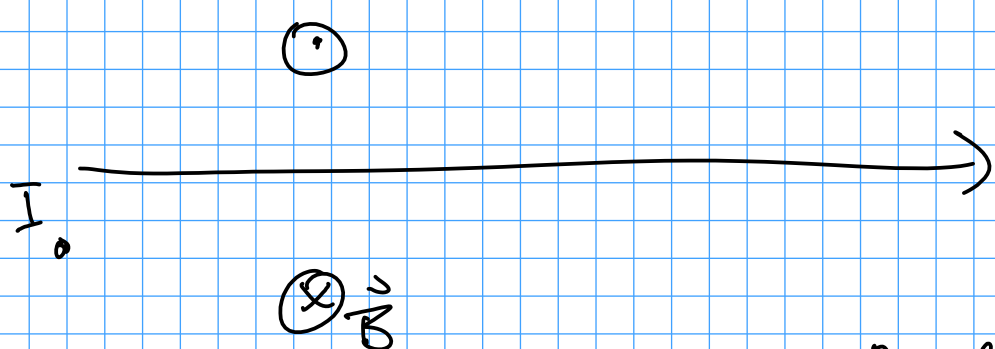
$$\int \vec{\nabla}\times\vec{B}\cdot d\vec{a} = \oint \vec{B}\cdot d\vec{l}$$ Ampere's law

$d\vec{a} = \hat{n}\, da$



Learning objective: understand how to apply Amps law for a symmetric current distribution to find B given current

Ex:

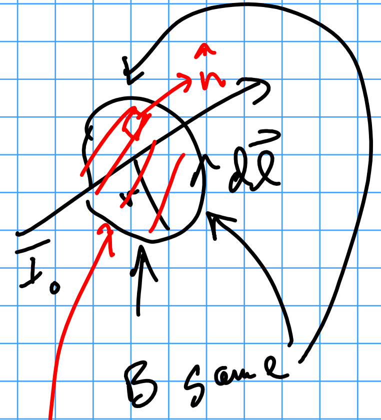


$$\int \vec{\nabla}\times\vec{B}\cdot d\vec{a} = \oint \vec{B}\cdot d\vec{l}$$

$$\parallel$$

$$\int \mu_0\vec{J}\cdot d\vec{a} = \oint \vec{B}\cdot d\vec{l}$$

Path chosen so that $\vec{B}$ & $d\vec{l}$ are parallel & $\vec{B}\cdot d\vec{l} = B\,dl$



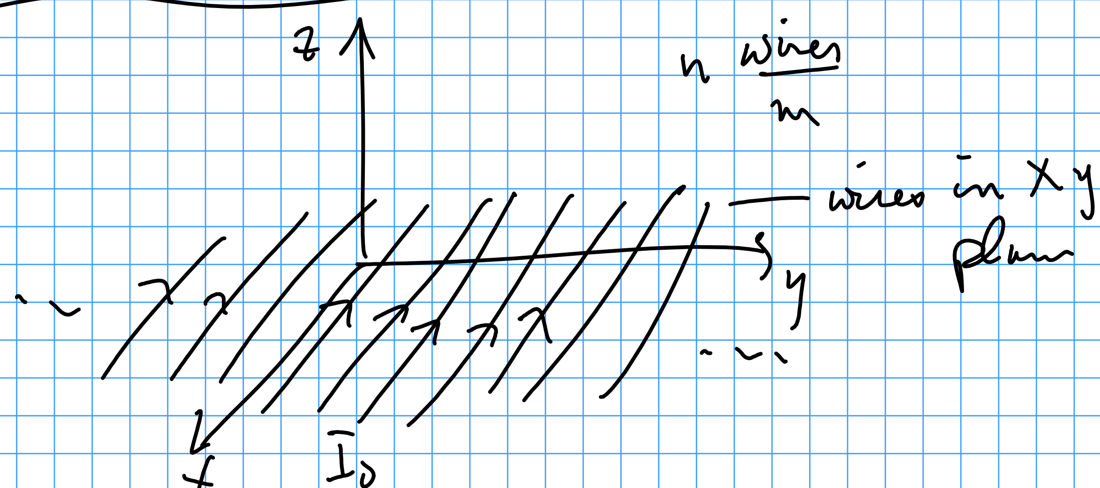
$$\oint \vec{B}\cdot d\vec{l} = \oint B\,dl = B\oint dl$$

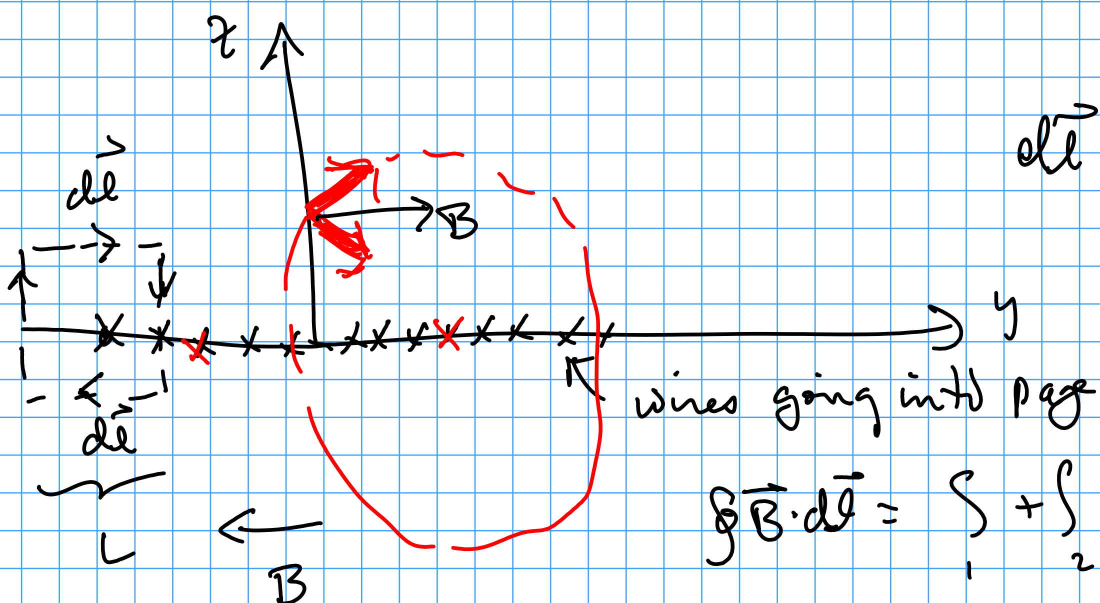
$$= B\,2\pi r$$

$$\int \mu_0 \vec{J}\cdot d\vec{a} \qquad \vec{J} \parallel d\vec{a} \qquad \mu_0\int J\,da = \mu_0 I_0$$

$$\mu_0 I_0 = B\,2\pi r \Rightarrow B = \frac{\mu_0 I_0}{2\pi r}$$

Ex:





$d\vec{l}$ is either $\parallel$ or $\perp$ to B

$$\oint \vec{B}\cdot d\vec{l} = \int_1 + \int_2 + \int_3 + \int_4$$

$$\int_{\text{up \& down}} \vec{B}\cdot d\vec{l} = 0 \qquad \int_{\text{horizontal}} \vec{B}\cdot d\vec{l} = \int B\,dl\underbrace{\cos\phi}_{1} = B\underbrace{\int dl}_{2}$$

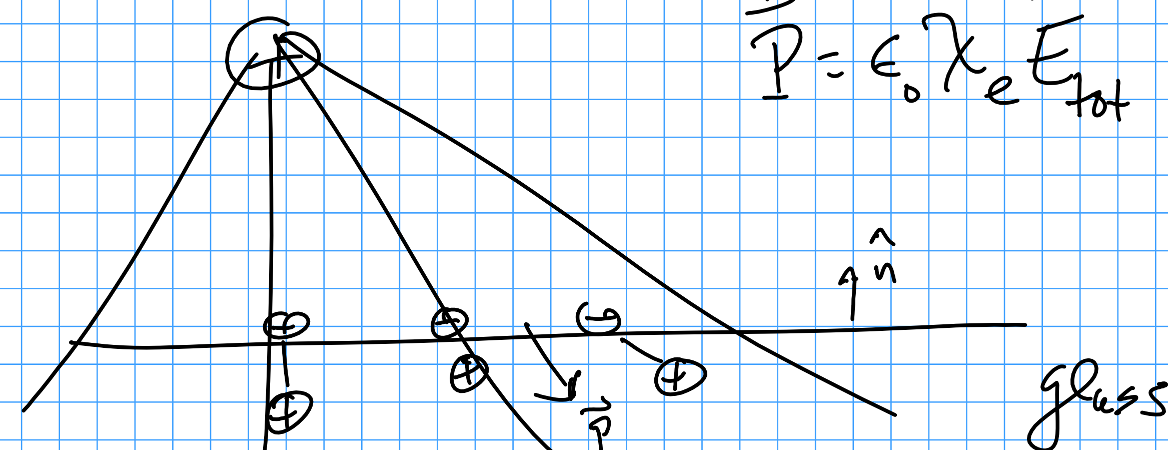
$$\underset{\substack{\uparrow\\ \text{upper}}}{BL} + \underset{\substack{\uparrow\\ \text{lower}}}{BL} = \mu_0 \underbrace{\int \vec{J}\cdot d\vec{a}}_{I} = \mu_0 \underset{\substack{\uparrow\\ \text{wires/length}}}{n}\, \overset{\text{current/wire}}{I_0}\, L$$

$$\frac{\cancel{\text{wires}}}{\text{length}}\;\frac{\text{current}}{\cancel{\text{wire}}}$$

$$2BL = \mu_0 n I_0$$

$$B = \frac{\mu n I_0}{2}$$

$$\vec{P} = \epsilon_0 \chi_e \vec{E}_{tot}$$



We want to find bound charge & then use all these charges to determine $\vec{E}$ everywhere

σ_b & pt charge

$$\sigma_b = \underline{\vec{P}} \cdot \hat{n} = \underline{P}_{\perp}$$