Physics 142 - October 30, 2014

- Exam 2 cometh!
- Nov. 6 at 8 am
  in B+L 109

- Capacitance to end of Ampere's Law
- Rather have Q+A Tues. or Wed.?

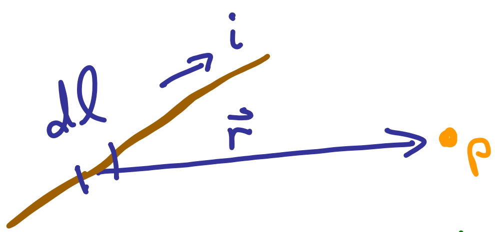
Last time

Law of Biot-Savart

discrete charge

$$\vec{B}_{\text{at } P \text{ due to } Q} = \frac{\mu_0}{4\pi} \frac{Q \vec{v} \times \hat{r}}{r^2}$$

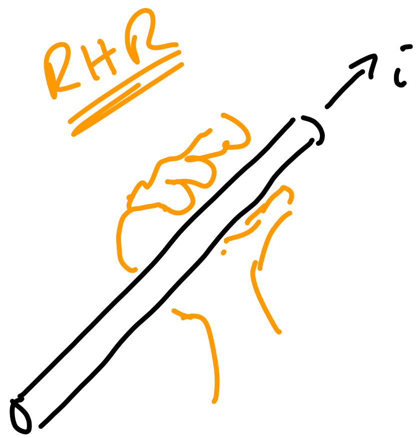
current

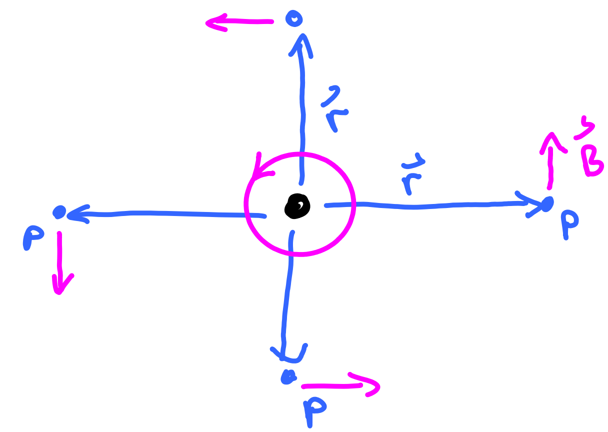


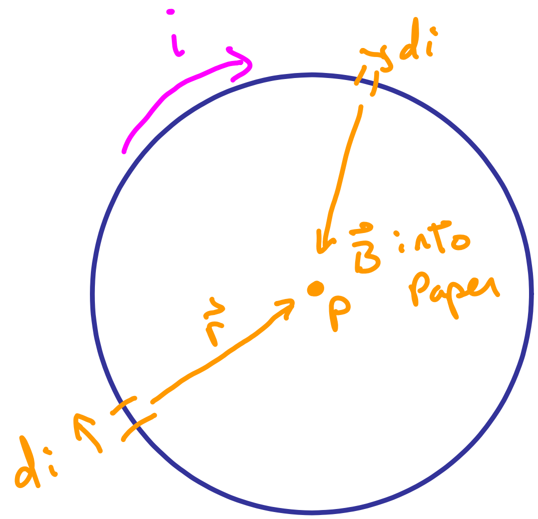
$$d\vec{B}_P = \frac{\mu_0}{4\pi} \frac{i\, d\vec{l} \times \hat{r}}{r^2}$$

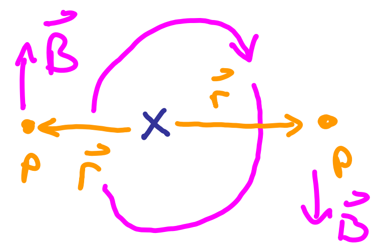
$$\vec{B}_P = \frac{\mu_0}{4\pi} \int \frac{i\, d\vec{l} \times \hat{r}}{r^2}$$

current distr.


RHR
i


$\vec{r}$
$\vec{B}$
P


i
di
$\vec{B}$ into paper
$\vec{r}$
P


$\vec{B}$
$\vec{r}$
P

Electrostatics

Gauss' law

$$\oint \vec{E}\cdot d\vec{A} = \frac{Q_{encl}}{\epsilon_0}$$

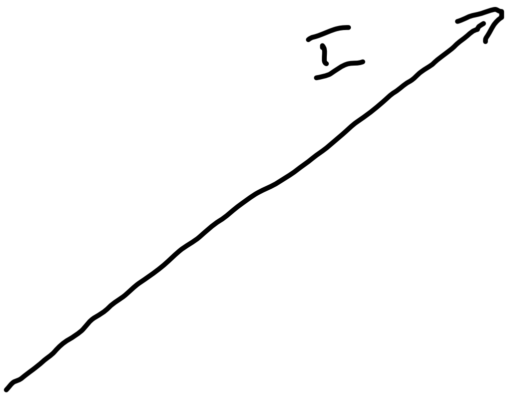
Magnetostatics

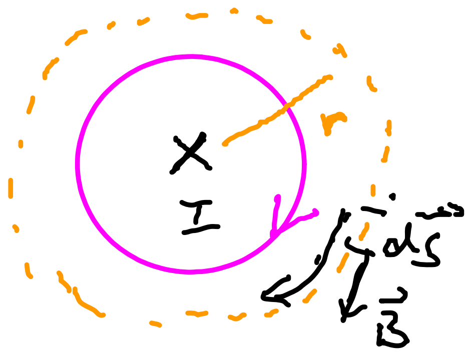
Ampere's Law

$$\int_{\text{closed curve}} \vec{B}\cdot d\vec{s} = \mu_0 I_{enclosed}$$

closed curve

∞ line current Find $\vec{B}$



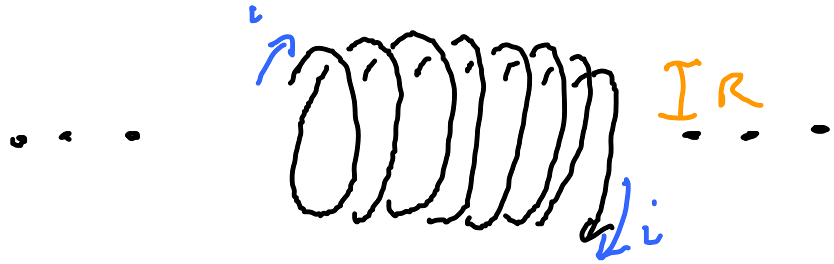


$$\int_{loop} \vec{B}\cdot d\vec{s} = \mu_0 I_{encl}$$

$$\int \vec{B}\cdot d\vec{s} = \int_0^{2\pi r} B\,ds = B\,2\pi r = \mu_0 I$$

$$B = \frac{\mu_0 I}{2\pi r}$$

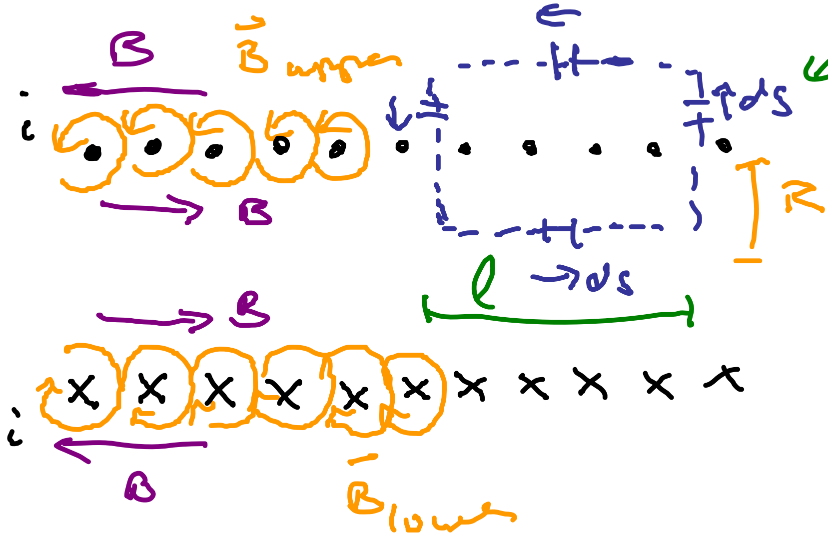
Solenoid



Field of an ∞ solenoid

$\vec{B}\cdot d\vec{s} = B\,ds$

$\vec{B}\cdot d\vec{s} \to 0$



$\oint \vec{B}\cdot d\vec{s} = \mu_0 I_{enc}$

$2Bl = \mu_0 n l i$

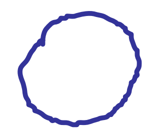
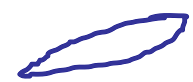
wires/length

Wire pitch

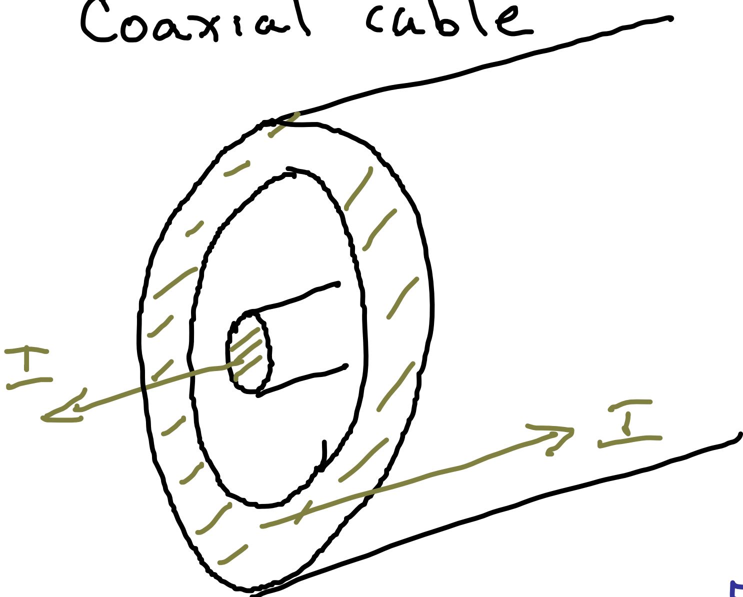
$B_{top} = \frac{\mu_0 n i}{2} = \mu_0 n\, i/2$

$B_{inside} = \mu_0 n i$

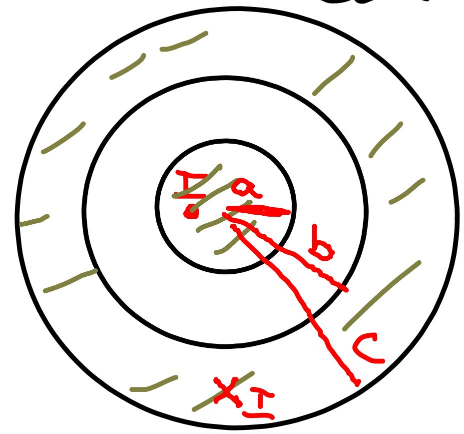
$B_{outside} = 0$

1) nothing
2) 
3) 
4) 

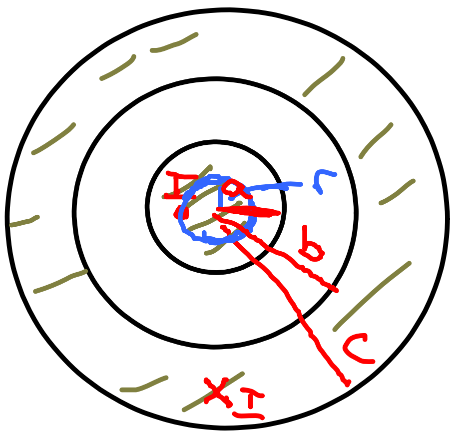
Coaxial cable



Assume I uniform across inner + outer conductors



Find $\vec{B}$ in all space



$r<a$

$$\oint \vec{B}\cdot d\vec{s} = \mu_0 I_{encl}$$

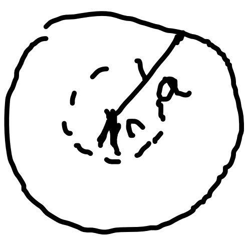
$$B\,2\pi r = \mu_0 I_{encl}$$

CONSTANT here

$$j(r) \equiv \text{current density}$$

Area density

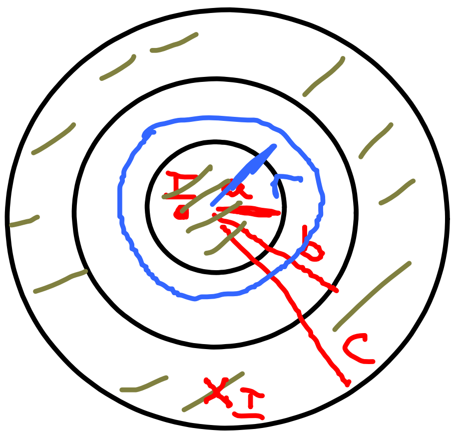
$$j(r) = \frac{I}{\pi a^2} = \text{CONSTANT}$$



$$B\,2\pi r = j(r)\,\pi r^2 \mu_0$$

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

counterclockwise

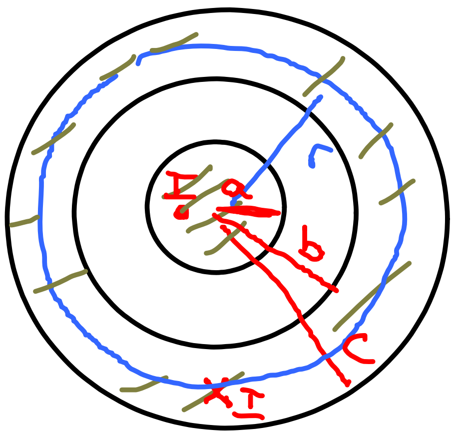


$a < r < b$

$$\oint \vec{B} \cdot d\vec{s} = \mu_0 I_{encl}$$

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

$$\vec{B} = \frac{\mu_0 I}{2\pi r} \quad \text{counterclockwis}$$



$b < r < c$

$$j(r)_{\text{outer conductor}} = -\frac{I}{\pi c^2 - \pi b^2}$$

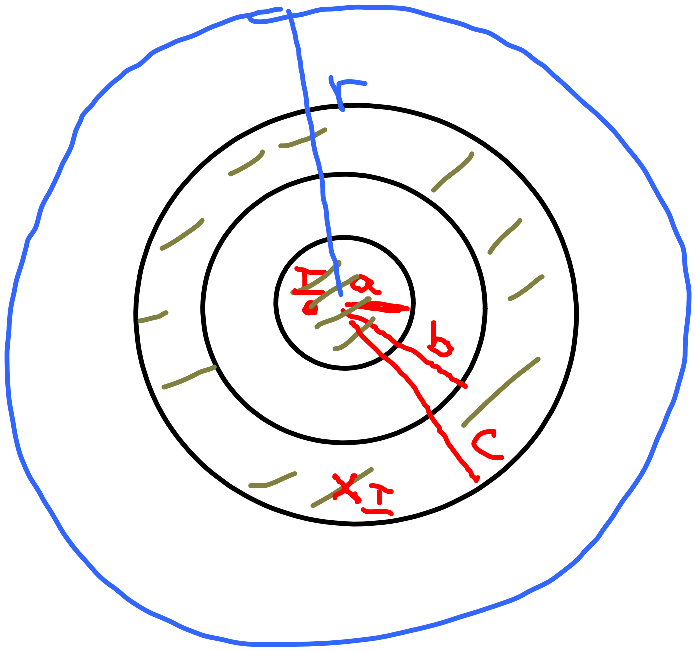
$$I_{\text{encl outer conductor}} = -\frac{I}{(\pi c^2 - \pi b^2)}(\pi r^2 - \pi b^2)$$

$\oint B \cdot ds = \mu_0 I_{encl}$

$$B\,2\pi r = \mu_0 \underbrace{\left[I - \frac{I}{(\pi c^2 - \pi b^2)}(\pi r^2 - \pi b^2) \right]}$$

$$\vec{B} = \frac{\mu_0}{2\pi r}\left[\quad \right]$$

counterclockwise



$r > c$

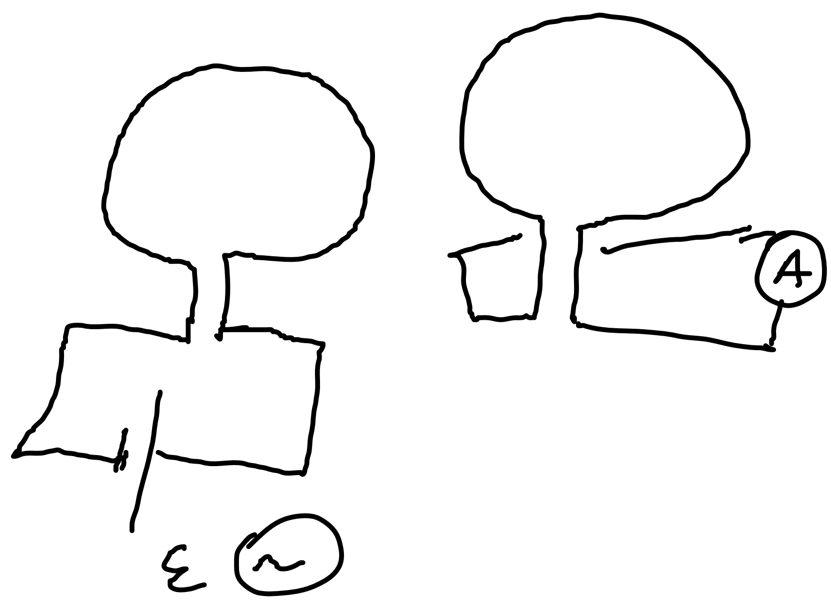
$$\oint \vec{B}\cdot d\vec{s} = \mu_0 \underbrace{I_{encl}}_{0}$$

$\vec{B} = 0$

Magnetic Induction

Michael Faraday (England)

Joseph Henry (US)



Induction

Magnetostatics

Kirchhoff

$$\Sigma V = 0$$

$$\oint \vec{E} \cdot d\vec{l} = 0$$

Changing $\vec{B}$ Field

induced emf

$$\mathcal{E} = \int_{\text{loop}} \vec{E} \cdot d\vec{l} = -\frac{d\phi_M}{dt}$$

$$\text{magnetic flux} \equiv \phi_M = \int \vec{B} \cdot d\vec{A}$$