Physics 142 - October 26, 2010

- Oops – I forgot to make the presentation assignments as promise.
  Will try to do that today

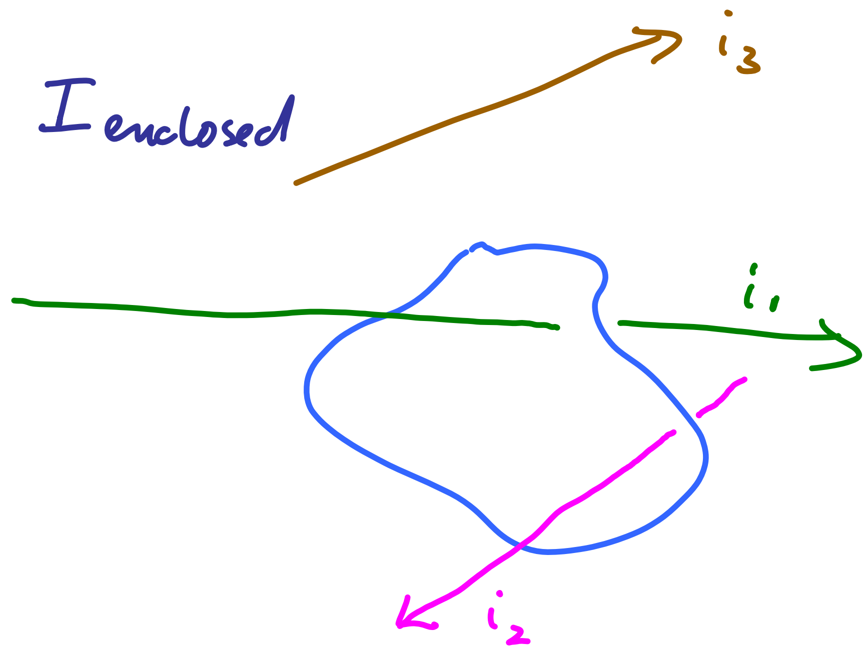
Last Time

$$\vec{B} = \int_{\text{currents}} \frac{i\, d\vec{l} \times \hat{r}}{r^2}$$ Biot-Savart

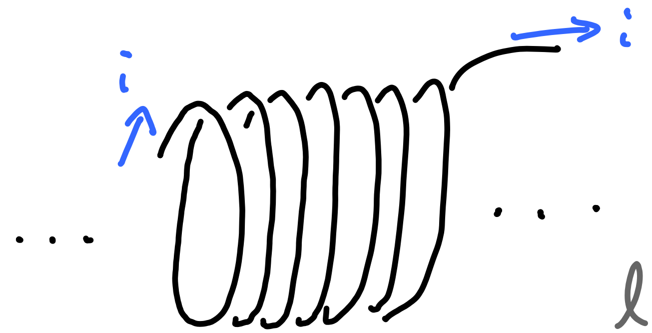
Gauss' Law $\int \vec{E}\cdot d\vec{A} = Q_{enc}/\epsilon_0$ Electrostatics

Ampere's Law Magnetism

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

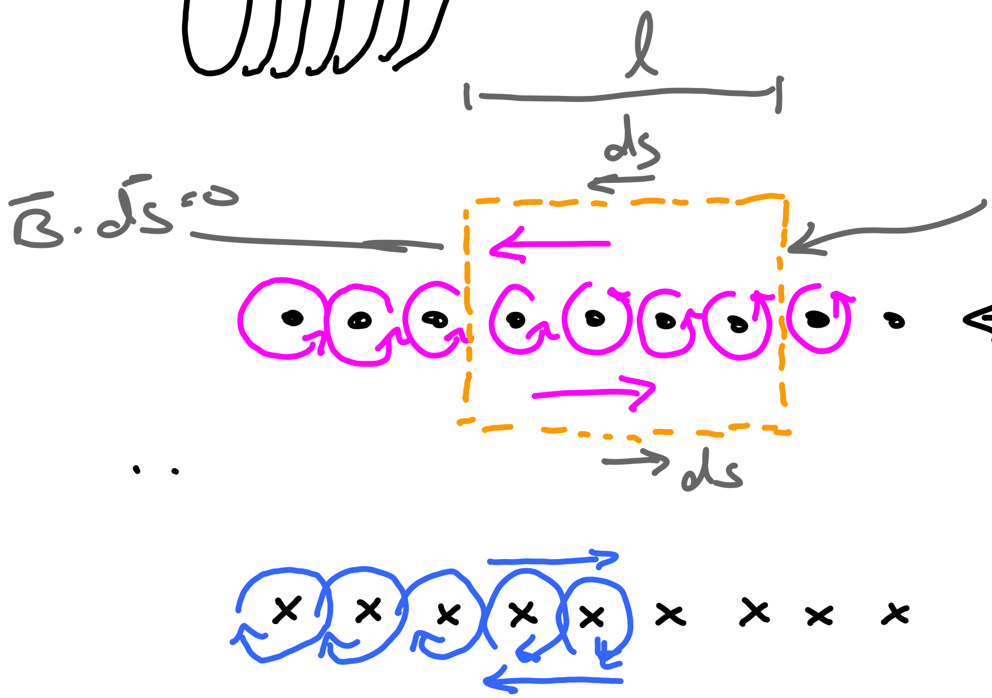


Solenoid



Field of ∞ solenoid

n loops/unit length



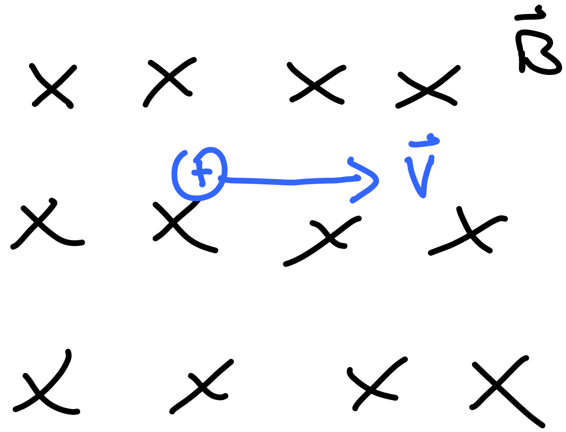
$$\oint \vec{B} \cdot d\vec{s} = \mu_0 I_{encl}$$

$$2B\ell = \mu_0 n \ell i$$

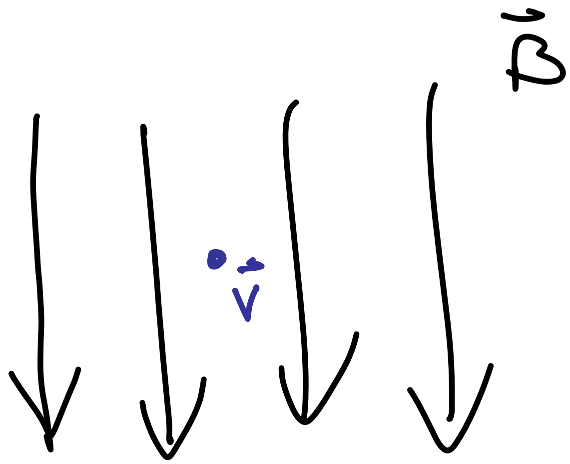
$$B = \frac{\mu_0 n}{2} i$$

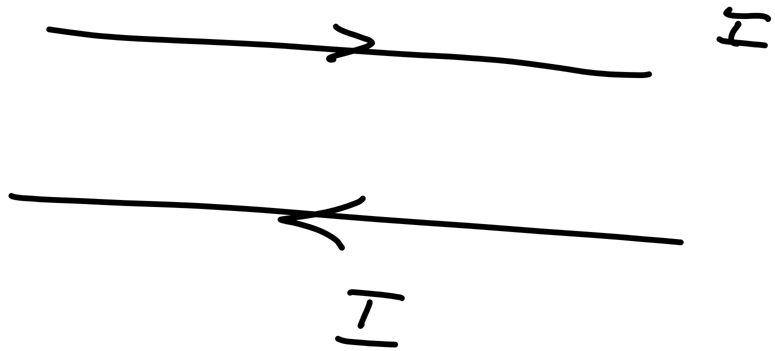
outside solenoid $\vec{B} = 0$

inside solenoid $|B| = 2\,\frac{\mu_0 n i}{2} = \mu_0 n i$



up
down
Forward
Backward
Right
left



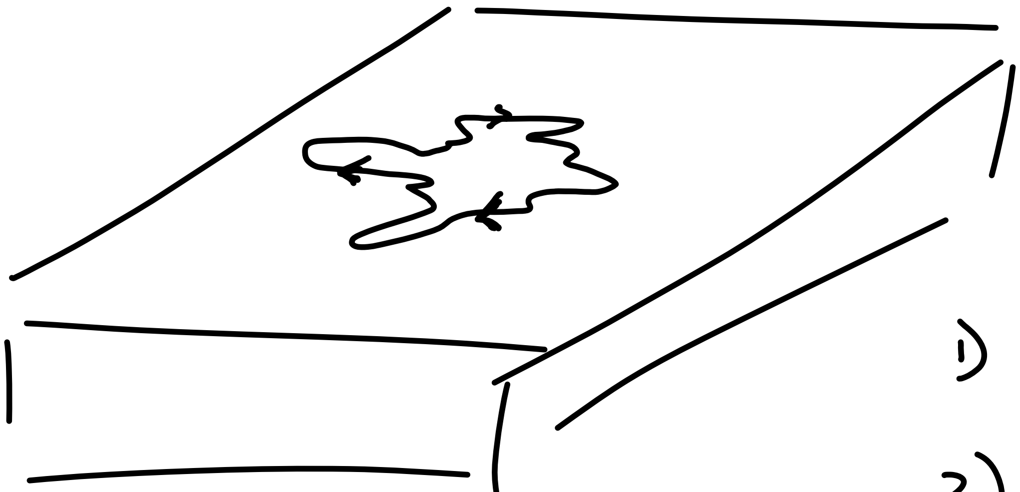


Force between wires

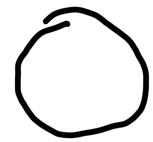
zero

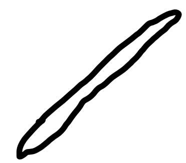
Attractive

Repulsive



1) nothing

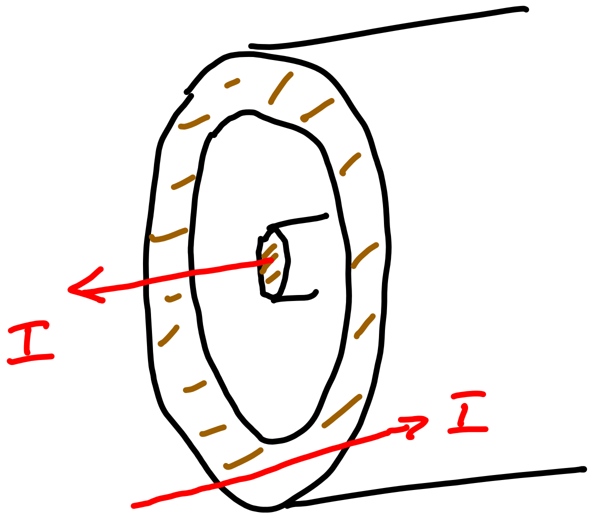
2) 

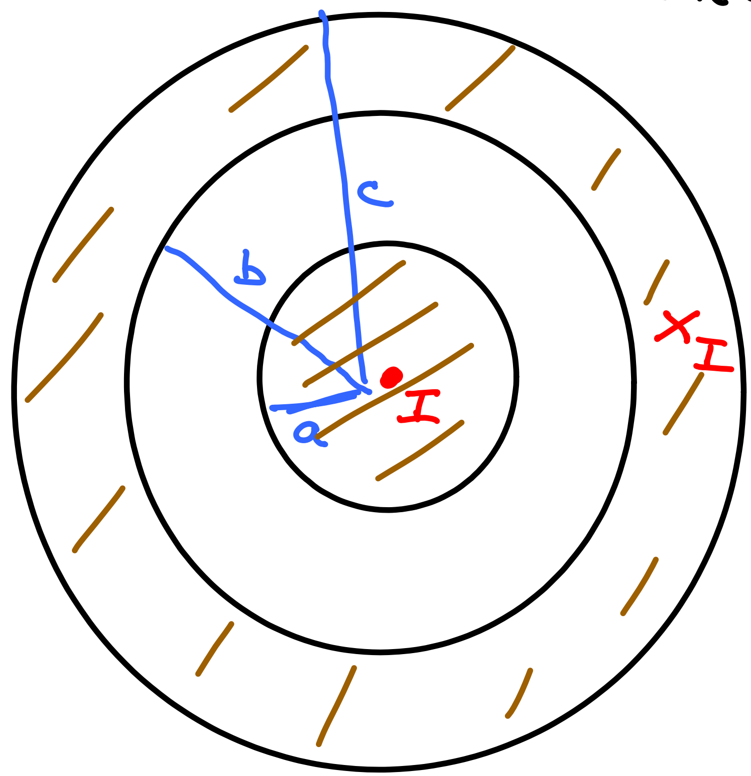
3) 

4) 

Coaxial cable (long)

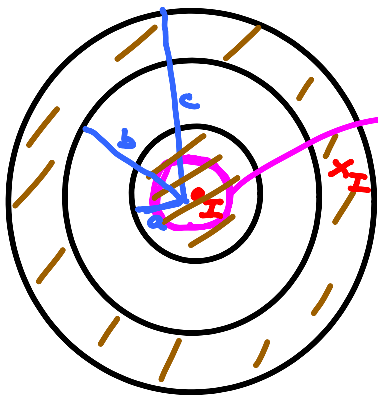
Assume
I uniform across
both inner
+ outer
conductors





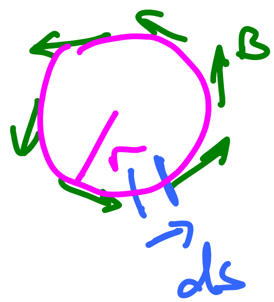
Find $\vec{B}$
in all space

$r < a$



Amperian loop radius $r < a$

$$\int \vec{B} \cdot \vec{ds} = \mu_0 I_{enc}$$



$$\int_0^{2\pi r} B\, ds$$

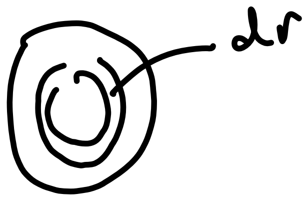
$$|\vec{B}|\, 2\pi r = \mu_0 I_{encl}$$

$j(r) \equiv$ current density
Area density

happens to constant here

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

$$I_{encl} = \int_0^r j\, da = \int_0^r j\, 2\pi r\, dr = j\, \pi r^2$$

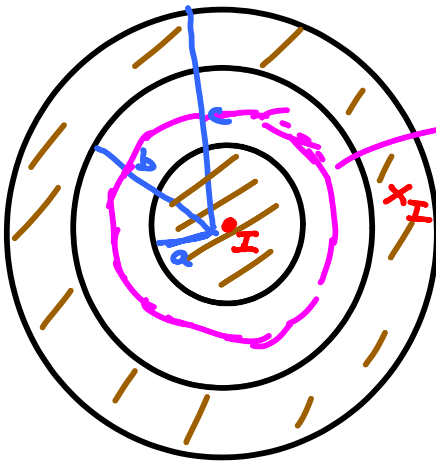


$$I_{enc} = \frac{I}{\pi a^2}\pi r^2 = \frac{I r^2}{a^2}$$

$$|\vec{B}|\, 2\pi r = \mu_0\, I\, r^2/a^2$$

$$|\vec{B}|_{r<a} = \frac{\mu_0 I r}{2\pi a^2}$$

$\vec{B}$ counterclockwise



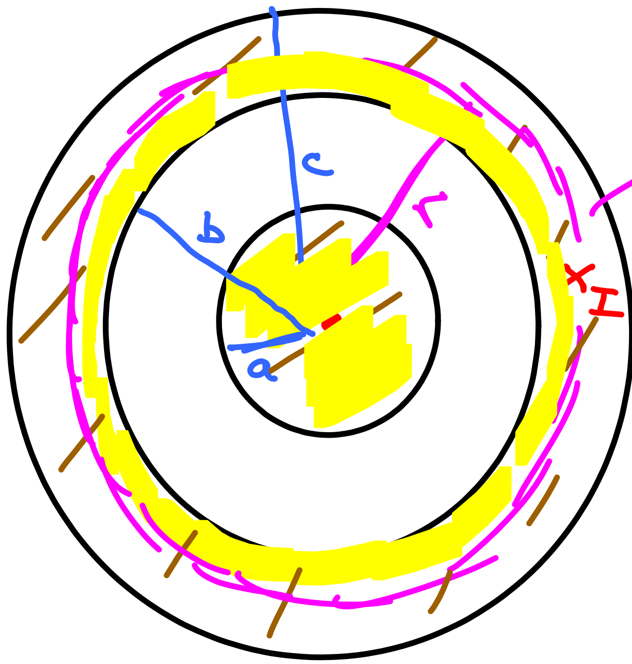
$a < r < b$ ← Amperian loop w/ r

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

$$|\vec{B}| 2\pi r = \mu_0 I$$

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

$\vec{B}$ is counter clockwise



$b < r < c$

$$\int \vec{B} \cdot d\vec{\ell} = \mu_0 I_{encl}$$

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

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

const

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

$$|\vec{B}|_{b<r<c} = \frac{\mu_0}{2\pi r}\left[I - I\frac{(\pi r^2 - \pi b^2)}{(\pi c^2 - \pi b^2)}\right]$$

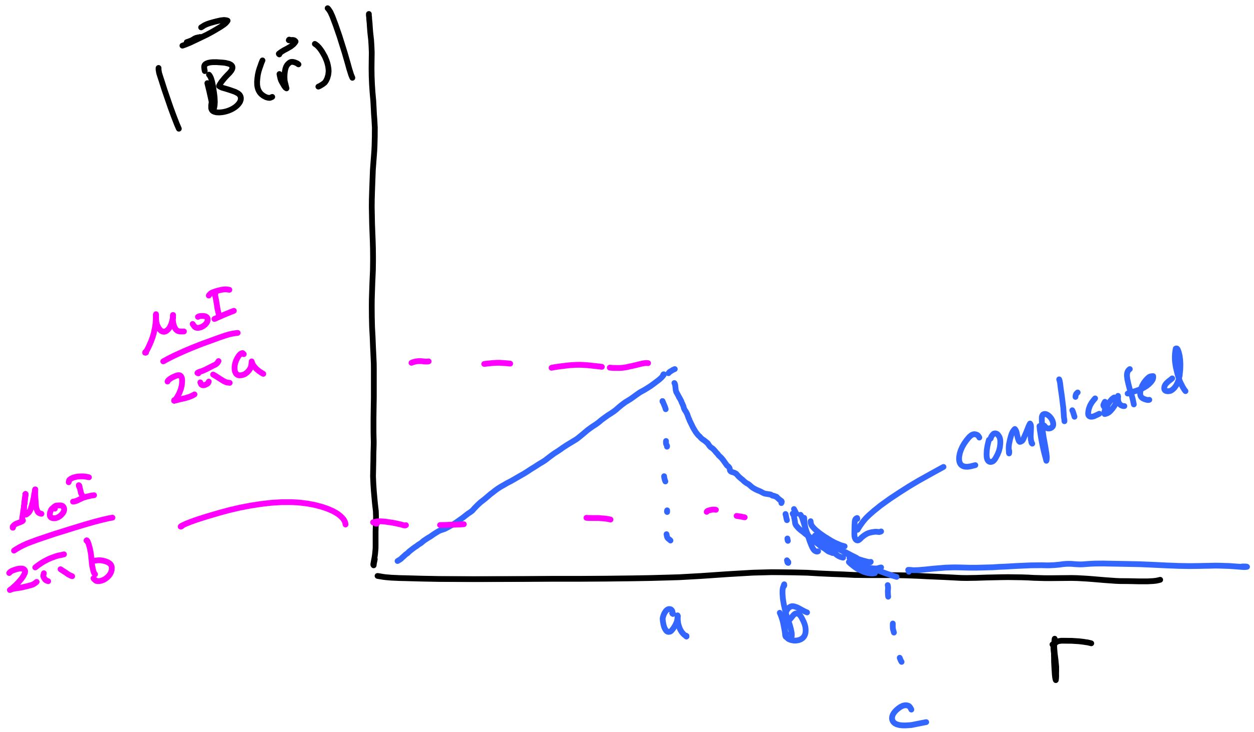
$$|\vec{B}|_{b<r<c} = \frac{\mu_0 I}{2\pi r}\left[1 - \frac{(\pi r^2 - \pi b^2)}{(\pi c^2 - \pi b^2)}\right]$$

$\vec{B}$ is counterclockwise

for $r > c$

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

0 0

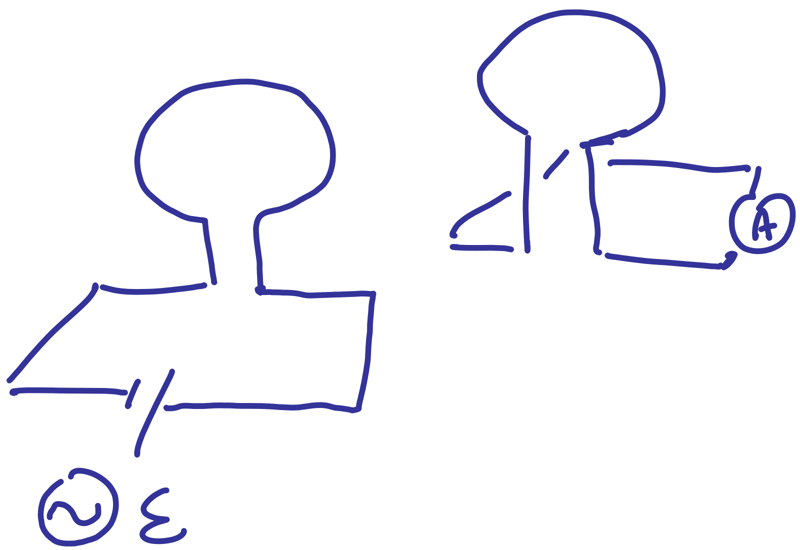


|B(r)|
μ₀I / 2πa
μ₀I / 2πb
complicated
a
b
c
r

Magnetic Induction

1830's

Michael Faraday (England)
Joseph Henry (US)



A changing Magnetic field "induces" a changing Electric field

Induction

Magnetostatics

Kirchoff

$$\sum_{\text{closed loop}} V = 0$$

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

Changing B field

induced EMF

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

Magnetic flux $\equiv \phi_M = \int \vec{B} \cdot \vec{dA}$