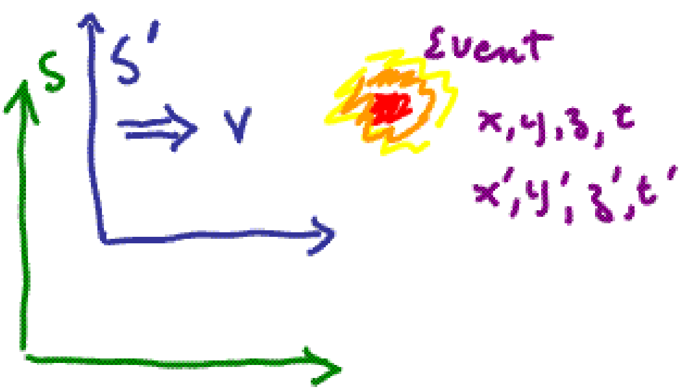
Physics 142 – October 21, 2008

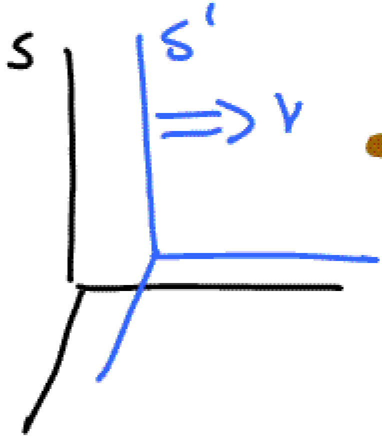
- Forgot to set up presentation groups
  ... will try to do soon.

Last Time



Lorentz Transformations

$$\begin{cases} x' = \gamma(x - vt) \\ y' = y \\ z' = z \\ t' = \gamma\left(t - \frac{vx}{c^2}\right) \end{cases}$$



$\vec{u} \equiv$ velocity of object in S

Relativistic velocity Transformation

$$u_x' = \frac{u_x - v}{1 - \frac{v}{c^2} u_x}$$

$$u_y' = \frac{u_y}{\gamma\left(1 - \frac{u_x v}{c^2}\right)}$$

$$u_z' = \frac{u_z}{\gamma\left(1 - \frac{u_x v}{c^2}\right)}$$

proper time $\equiv \tau$ – Time measured in rest frame of event

define proper velocity $\quad \eta = \frac{dx}{d\tau} = \gamma \frac{dx}{dt} = \gamma v$

Spacetime "4-vector" x, y, z, t

Energy-Momentum "4-vector"

define $p = m\eta = m\gamma v$ $\qquad p_x, p_y, p_z, E$

$$E \equiv \gamma m c^2$$

E, P Lorentz transforms just like x, t

$$x' = \gamma(x - vt) \qquad p_x' = \gamma(p_x - vE)$$

$$y' = y \qquad p_y' = p_y$$

$$z' = z \qquad p_z' = p_z$$

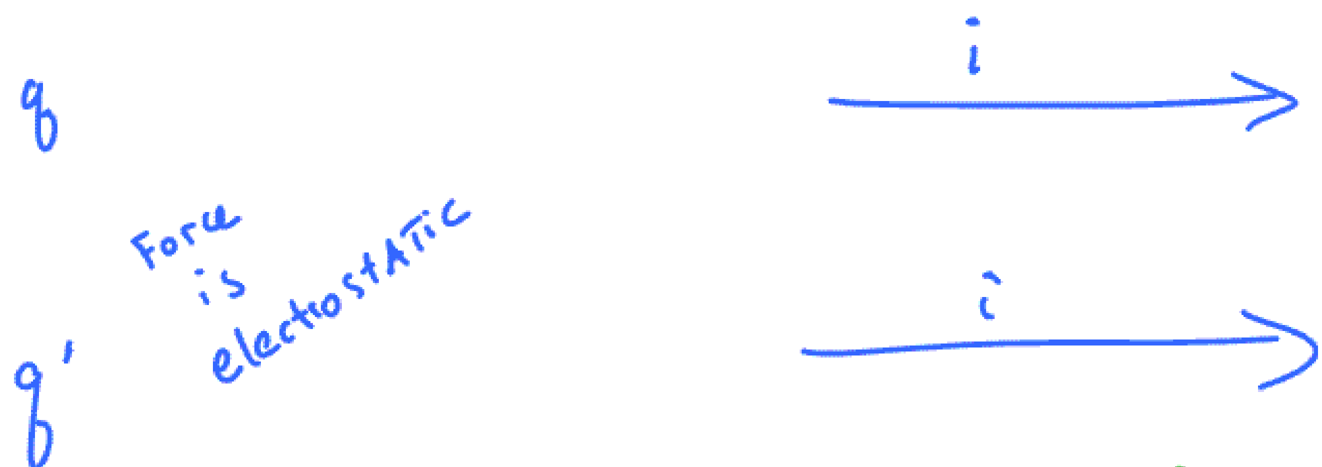
$$t' = \gamma\left(t - \frac{vx}{c^2}\right) \qquad E' = \gamma\left(E - \frac{vp_x}{c^2}\right)$$

$$E = mc^2 + \tfrac{1}{2}mv^2 + \text{h.o.t.}$$

Relativistic Energy

m ≡ "rest mass" (constant)

Kinetic Energy



We are at rest w/ respect to charges

If we run to left → 2 current Force is magnetic

Magnetism

Magnetic field $\equiv \vec{B}$

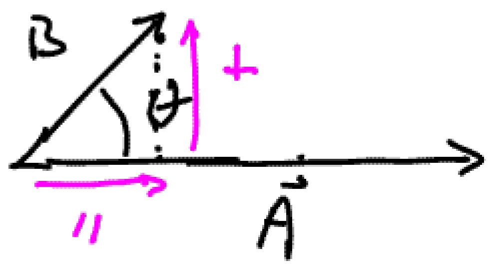
MKS units
Tesla

Lorentz Force law

$$\boxed{\vec{F} = q\vec{E} + q\vec{v}\times\vec{B}}$$

Force on charged particle
moving w/ velocity $\vec{v}$ in
region of electric field $\vec{E}$
and magnetic field $\vec{B}$

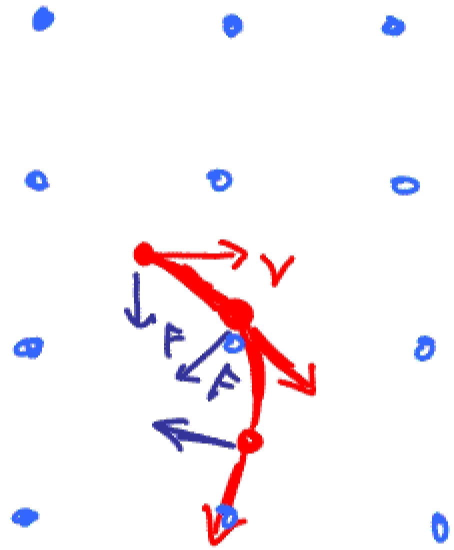
$$|\vec{A} \times \vec{B}| = |\vec{A}|\,|\vec{B}| \sin\theta$$



$$\vec{A} \times \vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix} = \hat{i}(A_y B_z - A_z B_y)$$

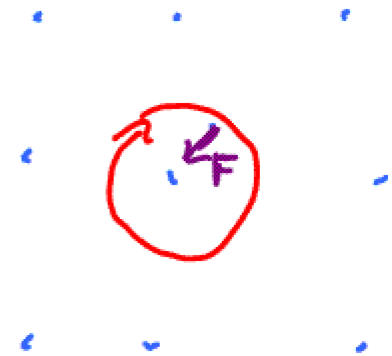
$$- \hat{j}(A_x B_z - A_z B_x)$$

$$+ \hat{k}(A_x B_y - A_y B_x)$$



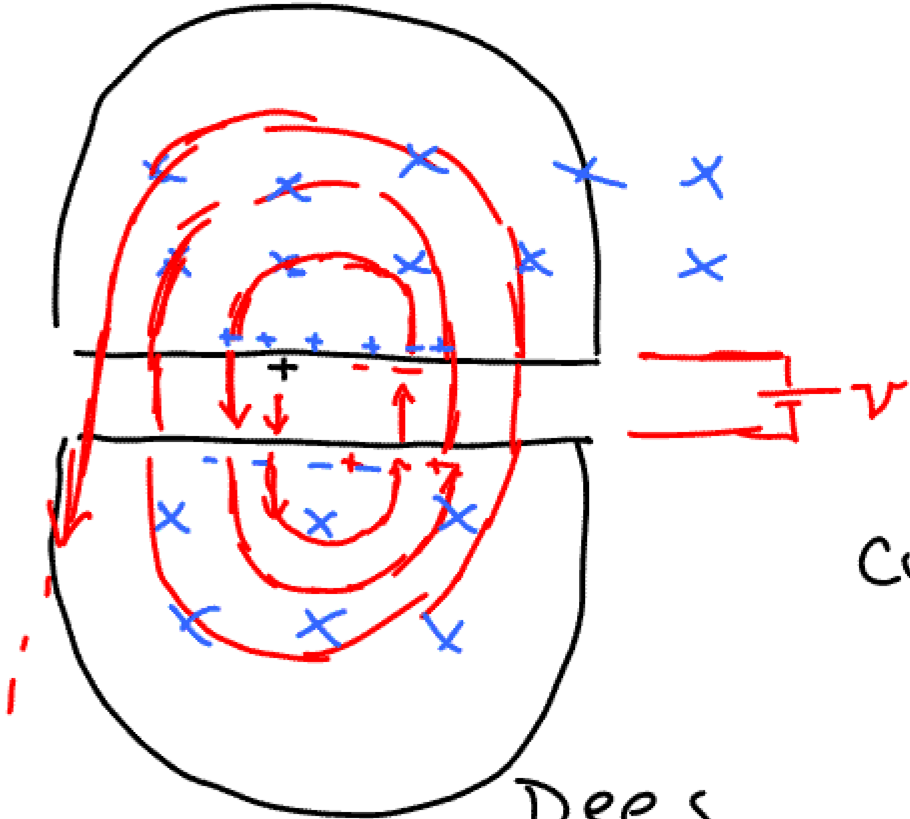
$\vec{B}$

CONSTANT



$$F_c = \frac{mv^2}{R} = qvB$$

$$R = \frac{mv}{qB}$$

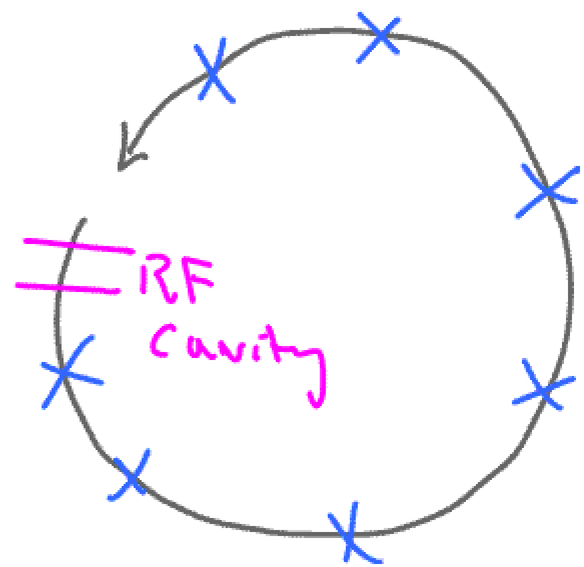


$E = qV$

Cyclotron

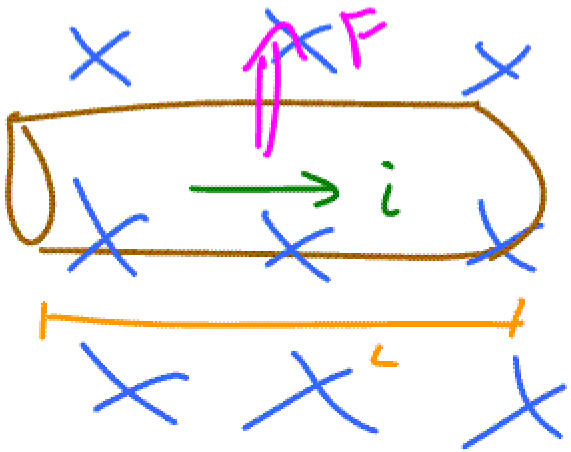
Dees

Synchrotron



Current in a wire → moving charges

Expect a Magnetic force on current carrying wires



x sectional Area

$$\vec{F}_{wire} = (q\vec{v}_d \times \vec{B})\, n A L$$

drift velocity

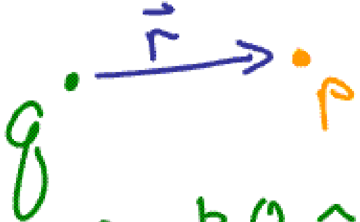
charges / unit volume

$$i = nqv_d A$$

$$\boxed{\vec{F}_{wire} = L\vec{i} \times \vec{B} \quad \text{or} \quad i\vec{L} \times \vec{B}}$$

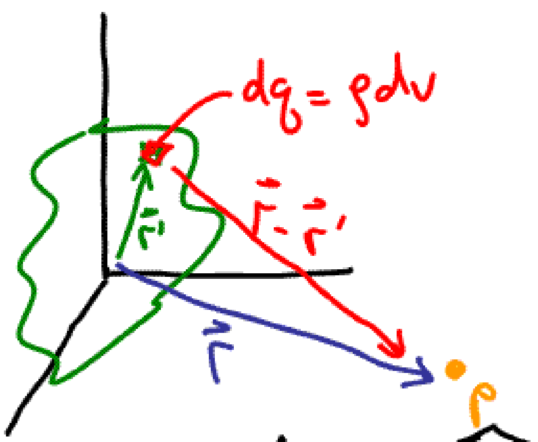
Electrostatics

Coulomb's law



$$\vec{E} = \frac{kQ}{r^2}\,\hat{r}$$

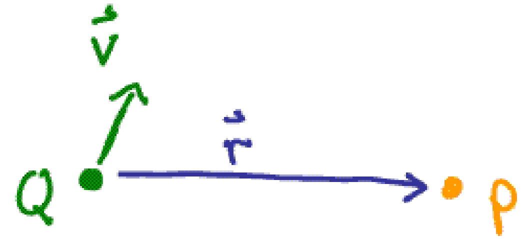
$$\vec{F} = q\,\vec{E}$$



$$d\vec{E}_p = \frac{k\,dq}{|r - r'|^2}\,\widehat{(\vec{r} - \vec{r}')}$$

Magnetostatics

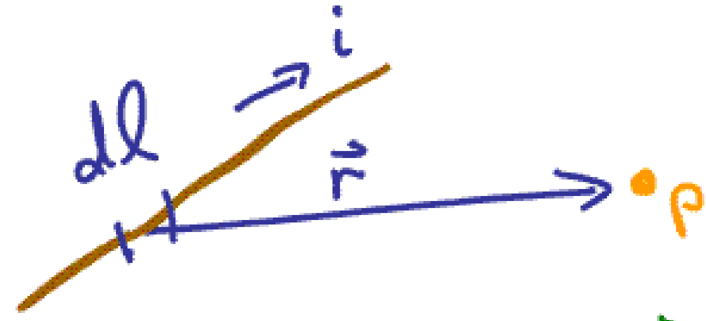
Law of Biot-Savart



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

$\mu_0 \equiv \text{Const} \equiv$ permeability of free space

$$= 4\pi \times 10^{-7}\ \frac{T \cdot m}{A}$$



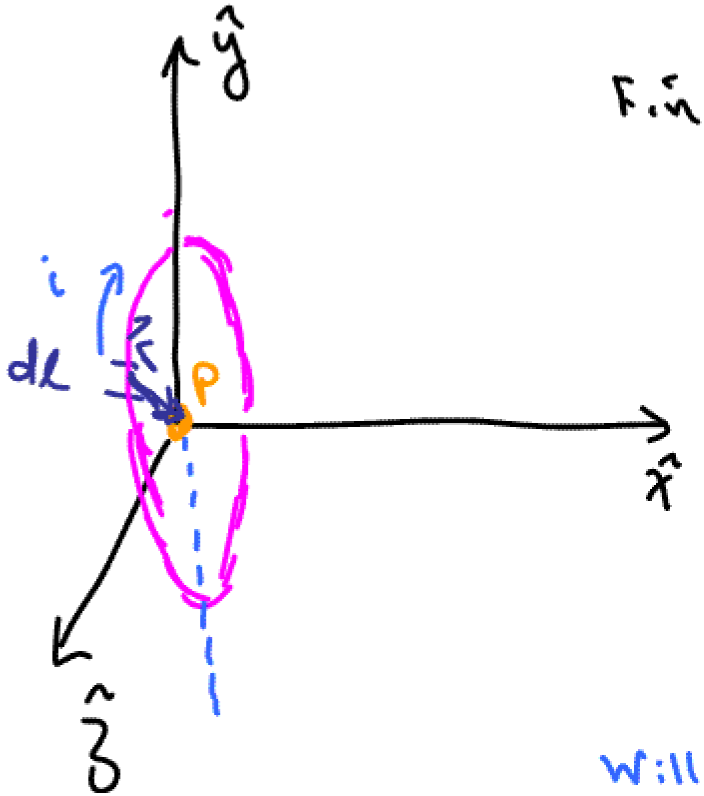
differential form of Biot-Savart

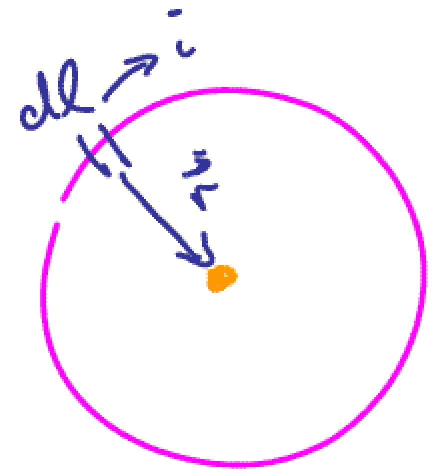
$$d\vec{B}_P = \frac{\mu_0}{4\pi} \frac{i\, d\vec{l} \times \hat{r}}{r^2}$$

due to differential length dl of current i

integrate over current distribution to get $\vec{B}_P$

Find $\vec{B}$ at origin





Will have to finish this next time . . .