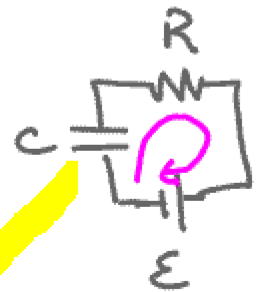
P114 - March 9, 2006

Last time:

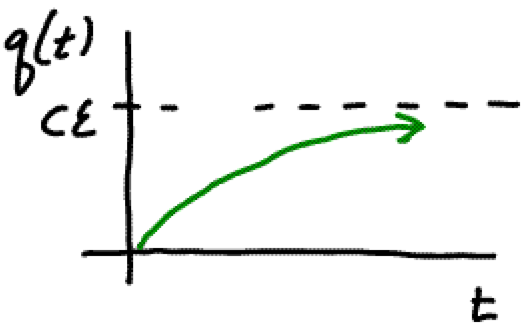
RC circuits

$RC \equiv$ Time constant

Charging →

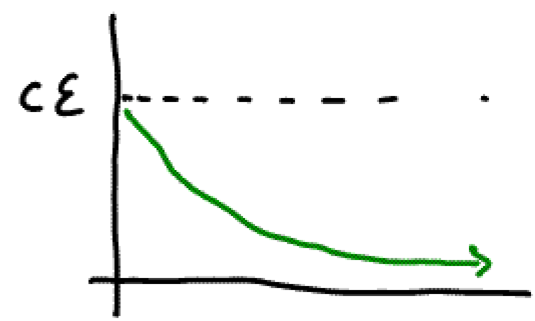


$$q(t) = C\mathcal{E}\left(1 - e^{-t/RC}\right)$$



Discharging →

$$q(t) = q_0 e^{-t/RC}$$

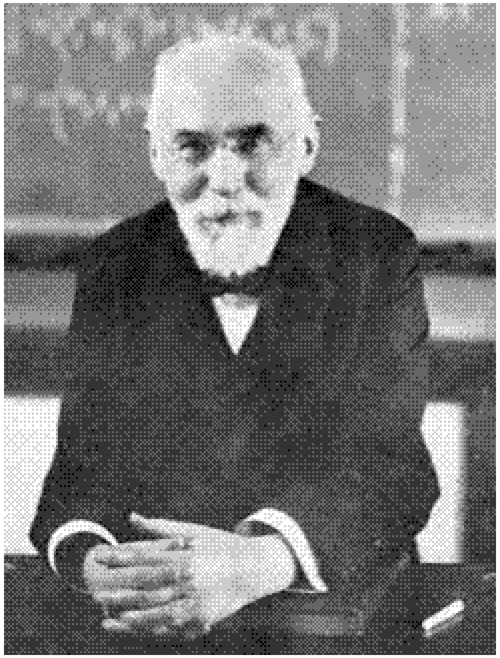


Magnetism – Lorentz Force Law

$\vec{B}$ alone

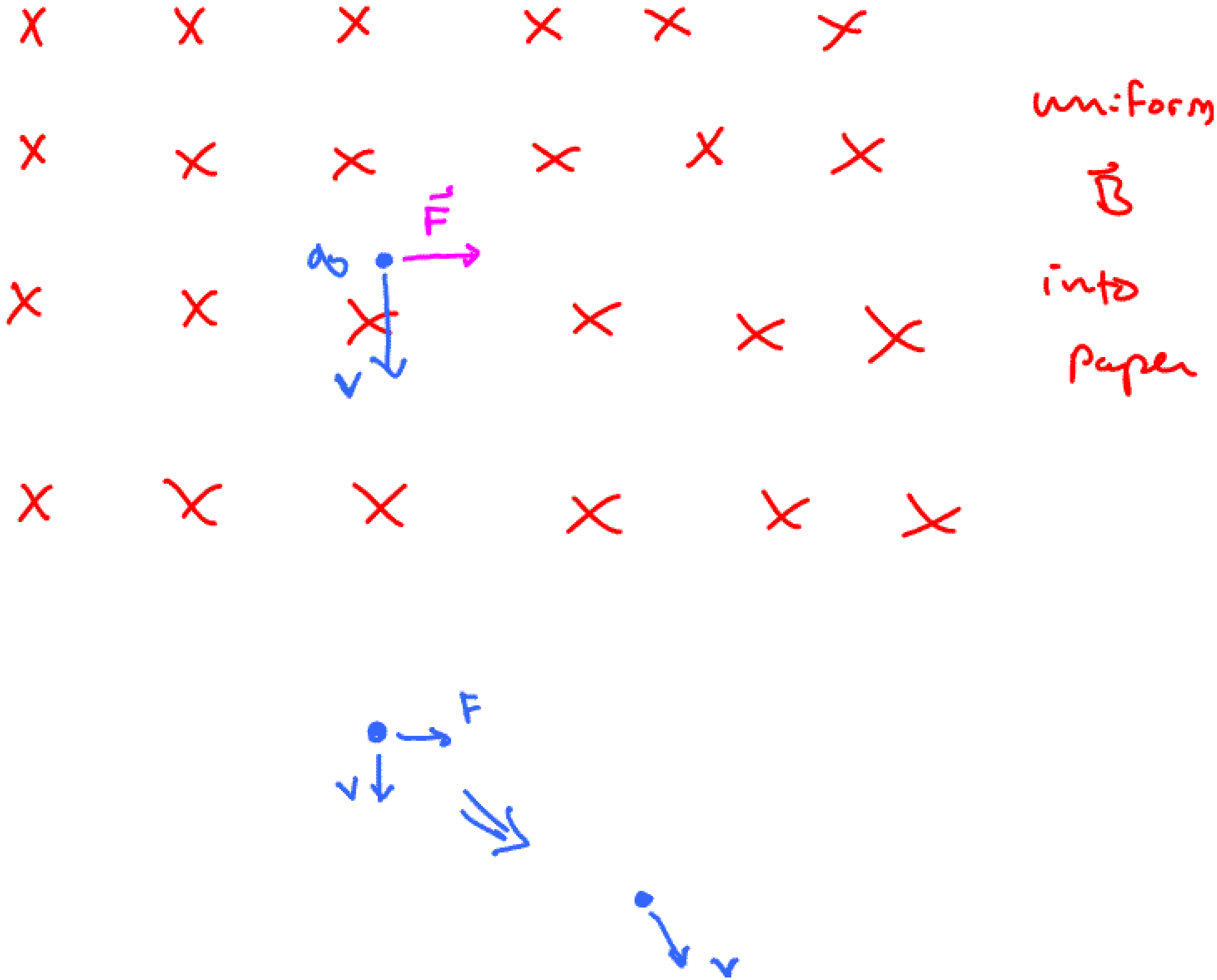
$\vec{F} = q\,\vec{v} \times \vec{B}$

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



Hendrik Antoon Lorentz
(1853 - 1928)
Dutch physicist
1902 Nobel Prize

Would've made a great Santa Claus if he let his beard grow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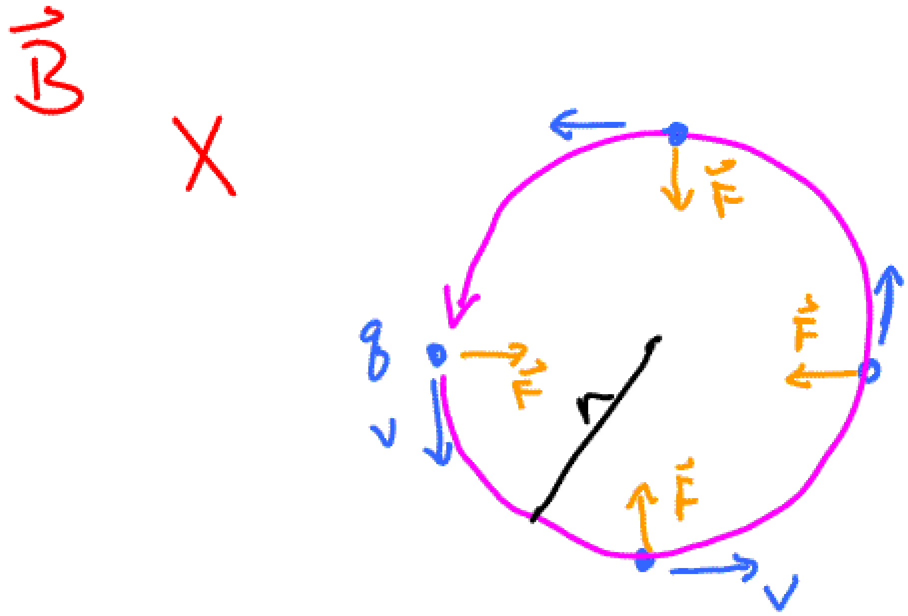


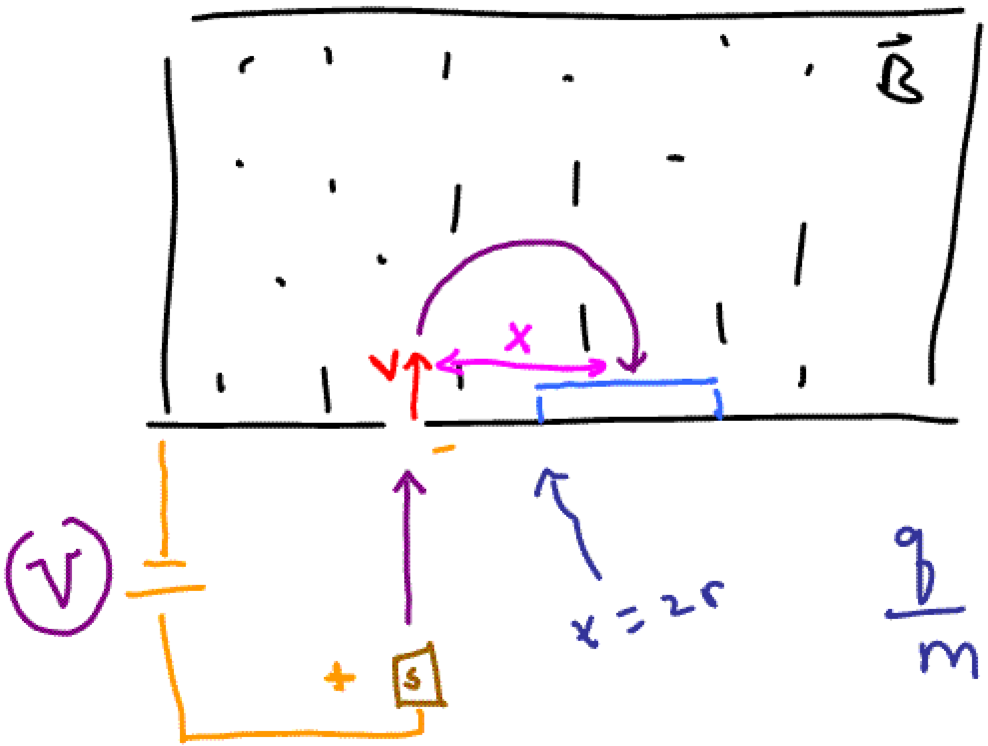
$$F_{centripetal} = \frac{mv^2}{r}$$

$$q|\vec{v} \times \vec{B}| = qvB$$

$$qvB = \frac{mv^2}{r}$$

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

Mass Spectrometer



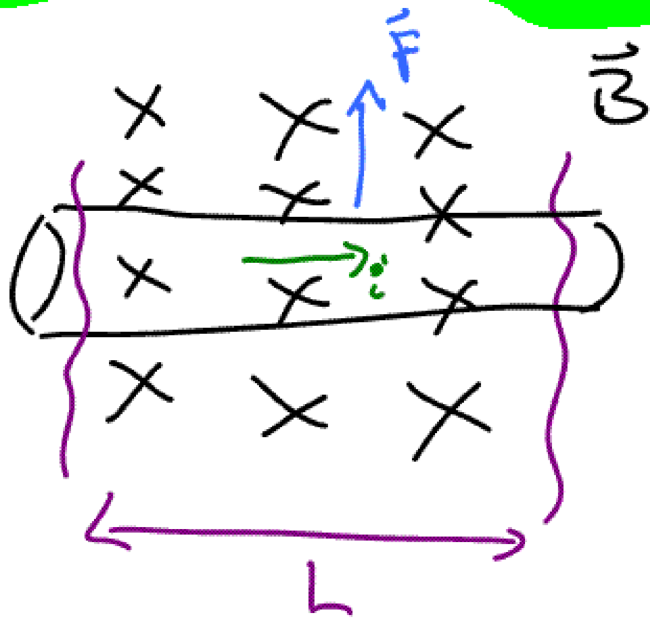
$$\frac{q}{m} = \frac{v}{rB}$$

$$\frac{1}{2}mv^2 = qV$$

$$v = \sqrt{\frac{2qV}{m}}$$

$$\frac{m}{q} = \frac{r^2 B^2 x^2}{2V} = \frac{B^2 x^2}{8V}$$

Shows how m/q of fragments depend on x position



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

n: $\frac{\text{Chg}}{\text{Vol}}$

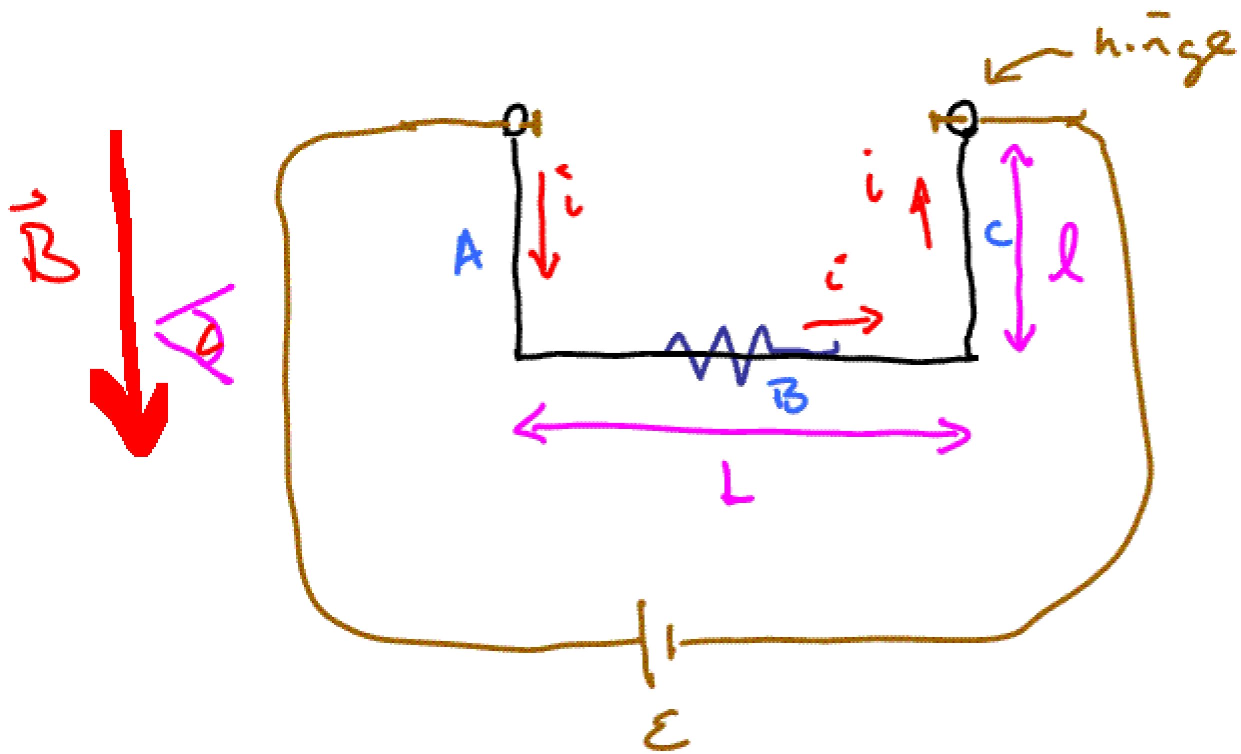
A: x sect. Area

$$i = n q v_d A$$

magnetic force on a wire

$$\vec{F} = i\,\vec{L} \times \vec{B}$$

$$\vec{F} = L\,\vec{i} \times \vec{B}$$

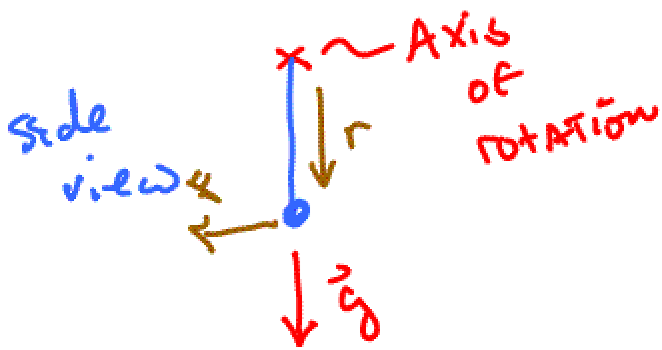


$\Rightarrow \vec{\tau}$

$\varepsilon = iR$

$i = \varepsilon / R$

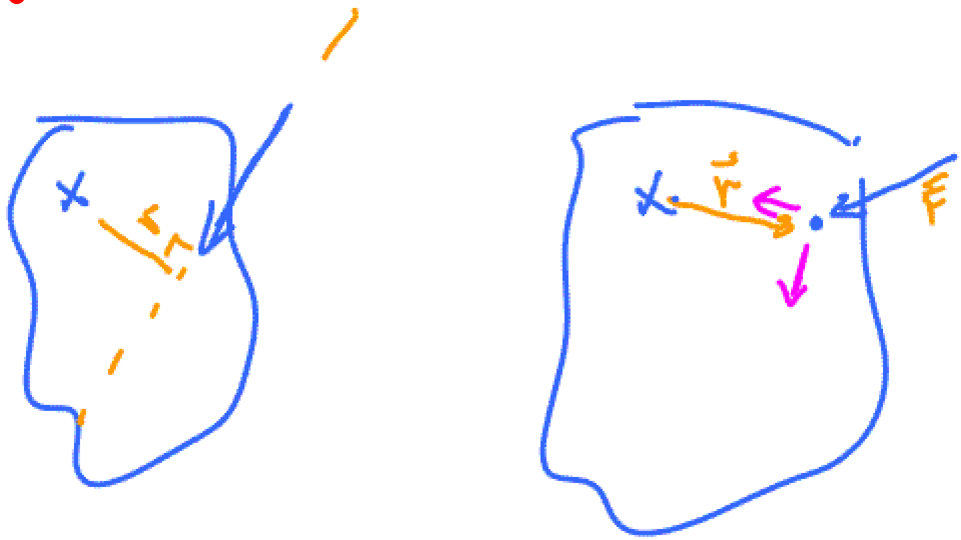
What is the torque on hanging loop?



$\vec{\tau} = \vec{r} \times \vec{F}$

$|\vec{\tau}| = rF = liLB$

Review Torque



$\vec{B} \equiv$ units of Tesla $\equiv$ T

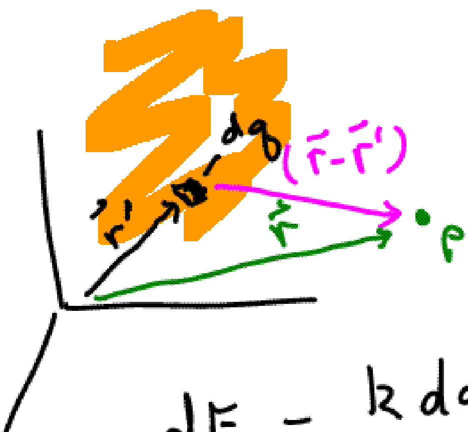
gauss

Electrostatics

Coulomb's Law

$$\vec{E} = \frac{kq}{r^2}\hat{r} \qquad k = \frac{1}{4\pi\varepsilon_0}$$

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



$$dE_p = \frac{k\,dq}{(\vec{r}-\vec{r}')^2}\,\widehat{(\vec{r}-\vec{r}')}$$

magnetostatics

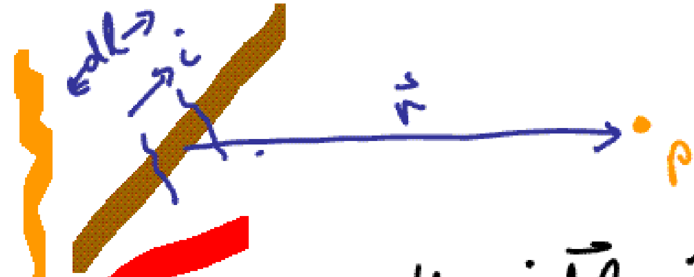
steady currents

Law of Biot-Savart

$$\vec{B}_{\text{at } p \text{ due to } q} = \frac{\mu_0}{4\pi}\frac{q\vec{V}\times\hat{r}}{r^2}$$

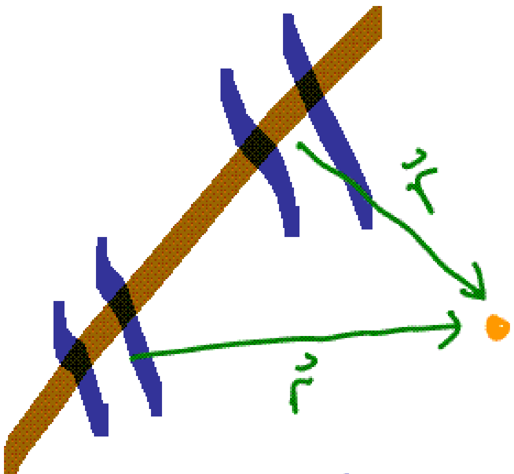
$\mu_0 \equiv$ const $\equiv$ Permeability of free space

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



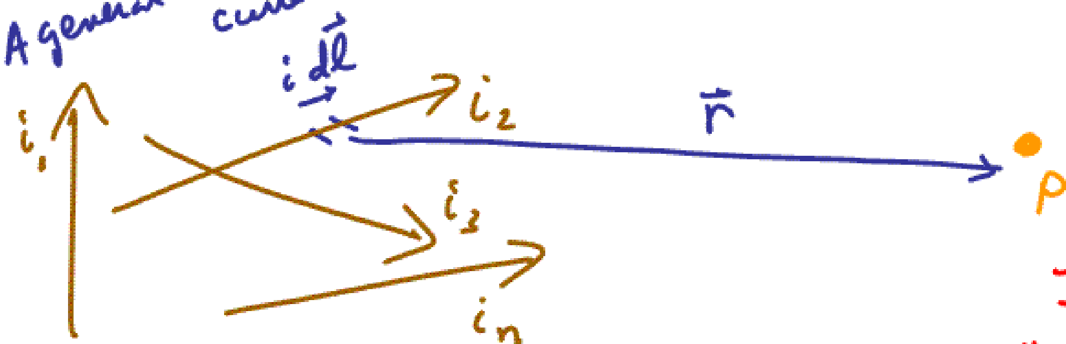
$$dB_P = \frac{\mu_0}{4\pi}\frac{i\,d\vec{l}\times\hat{r}}{r^2}$$

due to
dl of current



use this form of Biot-Savart for distributions of currents.
This gives $d\vec{B}$ at point P due to $i\,d\vec{l}$

A general distribution of currents



Integrate over all currents to get $\vec{B}$ at P.