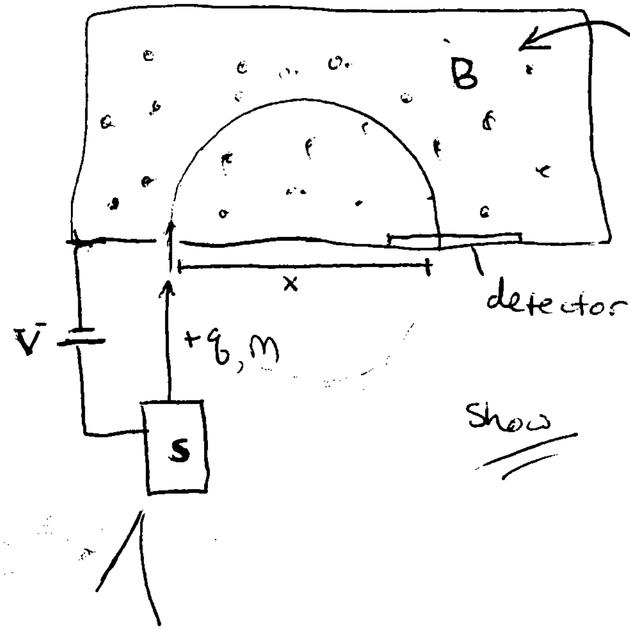
Mass Spectrometer



uniform B
Coming out of board

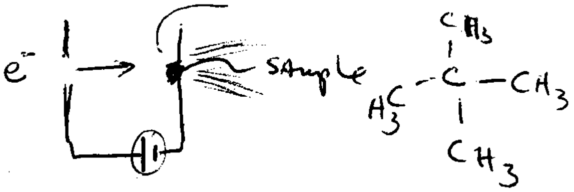
depends on ion

Show $$M = \frac{B^2 q}{8V} x^2$$

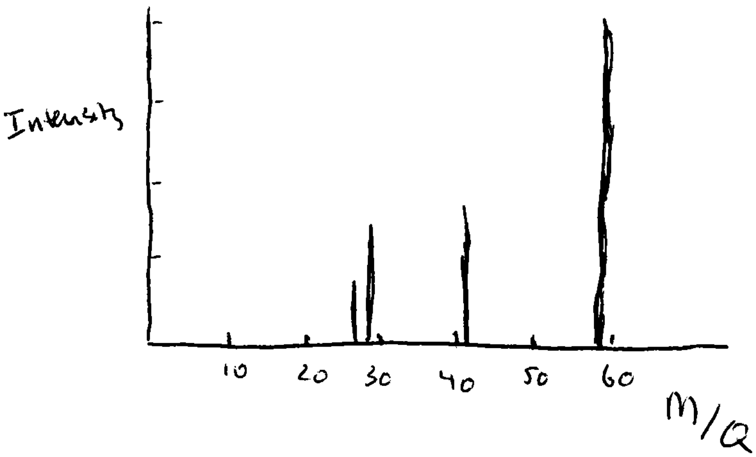
fixed

Potential diff

effectively Position on Detector



	$\frac{M}{q}$	Rel Intensity
$(C_4H_9)^+$	57	100
$(C_3H_5)^+$	41	41.5
$(C_2H_5)^+$	29	38.5
$(C_2H_3)^+$	27	15.7
⋮		



$F = qVB$ $\qquad F = m\frac{v^2}{R}$ (moves in circle)

$qVB = m\frac{v^2}{R}$ $\qquad m = \frac{qRB}{V}$

velocity

Must Relate velocity at opening to Mass spectrometer to the Potential Diff V

$$KE = +q|e|\,V = \frac{1}{2} m v^2$$

$$v = \left(\frac{2qV}{m}\right)^{1/2}$$

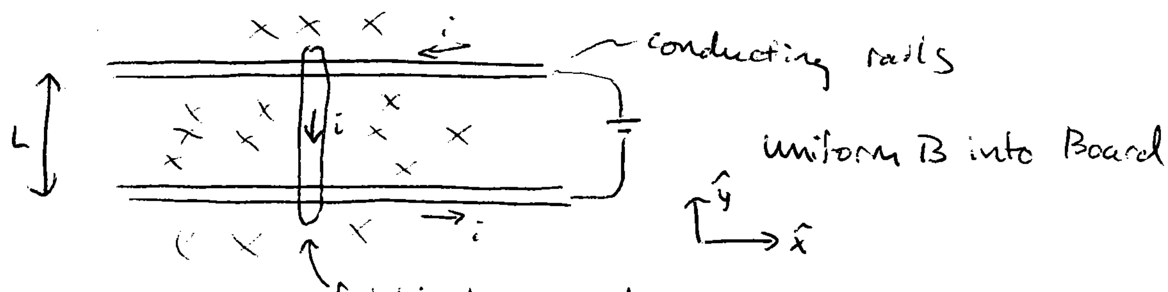
$m = \frac{qRB}{v}$ $\therefore$

$$m = \frac{qRB}{\sqrt{\frac{2Vq}{m}}} \quad \text{or} \quad m = \frac{q R^2 B^2}{2V}$$

Now $R = \frac{1}{2}x$

$\therefore$

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



Frictionless conducting support, bar Mass M

What is $\bar{a}$ of bar?

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

$$m\vec{a} = L|i||B|\,\hat{x}$$

$$\bar{a} = \frac{L|i||B|}{m}\,\hat{x} \rightarrow \text{CONSTANT}$$

can use Const Accel eqns

e.g.

For current = 1 Amp
$B = .3$ Tesla
$L = 2$ Meter
$M = 3$ kg

$$\vec{a} = \frac{(2\,m)(1\,A)(.3\,T)}{3\,kg} = .2\,m/s^2\,\hat{x}$$

After 10 seconds

$$V_x = V_{0x} + a_x t = 0 + (.2)(10)$$

$$V = 2\,m/s$$

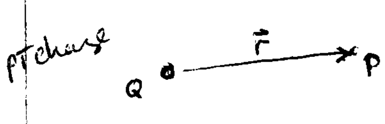
Up to Now $\rightarrow$ Effect of B field on Moving charged particle

What about field produced by moving charges

Production of Magnetic Fields by Charges and Currents

Electrostatics

$F = qE$ + Coulomb's law

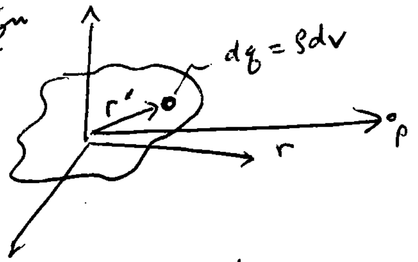


$$\vec{E} = \frac{kQ}{r^2}\hat{r}$$

$\vec{E}$ at pT P due to Q

$$k = \frac{1}{4\pi\epsilon_0}$$

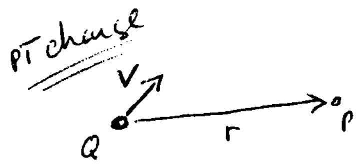
Distribution



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

Magnetostatics

Biot-Savart law

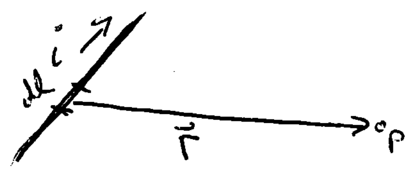


$$\underset{\text{at } p \text{ due to } Q}{\vec{B}} = \frac{\mu_0}{4\pi}\frac{Q\vec{v}\times\hat{r}}{r^2}$$

μ_0 = CONSTANT = Permeability of free space

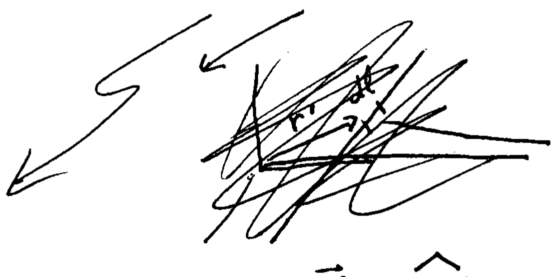
$$\mu = 4\pi \times 10^{-7}\ \frac{T \cdot M}{A}$$

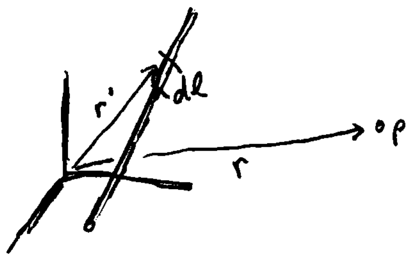
Distribution (currents, NOT Charges)



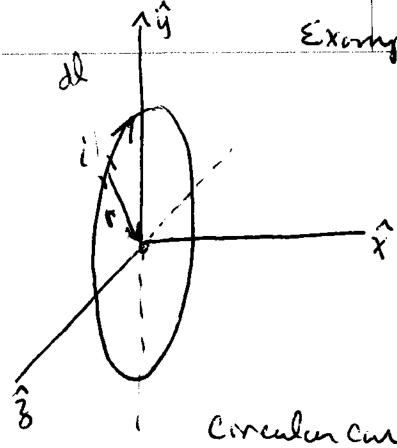
$$d\vec{B}(p) = \frac{\mu_0}{4\pi}\frac{i\,d\vec{\ell}\times\hat{r}}{r^2}$$

or





$$d\vec{B}(p) = \frac{\mu_0}{4\pi}\frac{i\,d\vec{\ell}\times(\widehat{r-r'})}{|\vec{r}-\vec{r}'|^2}$$



Example - calculate the B Field at the center of a current loop.

Right Hand rule
B-thru wire loop

Circular current loop - find $\vec{B}$ at origin

$$i d\vec{l} \times \hat{r} = i\,dl(-\hat{z})$$

do B around Wire DEMO

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

$$\frac{\mu_0}{4\pi}\,\frac{i}{r^2}\int_0^{2\pi r} dl \qquad \frac{\mu_0 i}{2r}$$

$$\vec{B}(0,0,0) = \frac{\mu_0}{4\pi}\int_0^{2\pi r}\frac{i\,dl}{r^2} = \frac{\mu_0}{4\pi}\,\frac{i\,2\pi}{r}(-\hat{x}) = \frac{\mu_0 i}{2r}(-\hat{x})$$

Electrostatics

Gauss's law

$$\int_{\text{Surface}} E\cdot dA = \frac{Q_{encl}}{\epsilon_0}$$

very useful when symmetry allows

Magnetostatics

Ampere's law

$$\int_{\text{Closed Curve}} \vec{B}\cdot d\vec{l} = \mu_0 I_{enclosed}$$