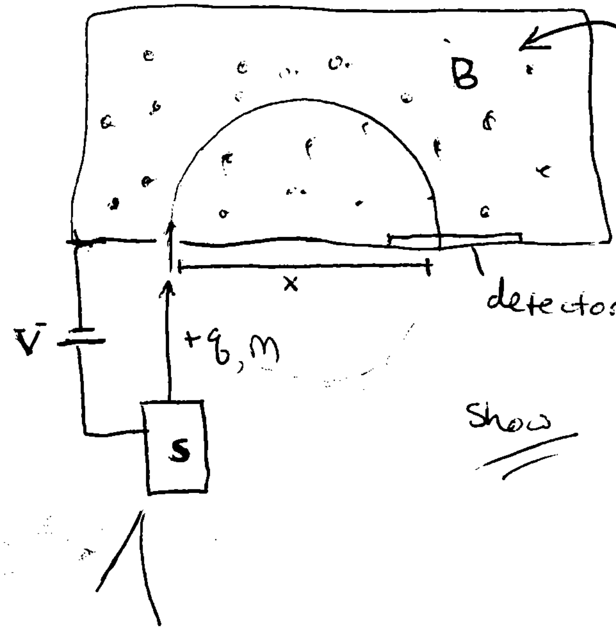
# Mass Spectrometer



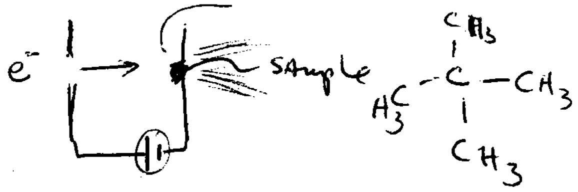

Show $M = \dfrac{B^2 q}{8V} x^2$

depends on ion

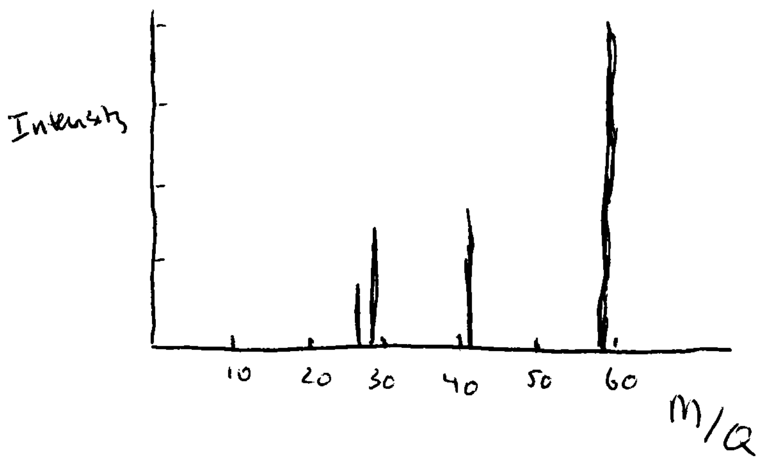
fixed

Potential diff

effectively Position on Detector




| | $M/q$ | 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 |
| ⋮ | | |




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

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

velocity

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

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

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

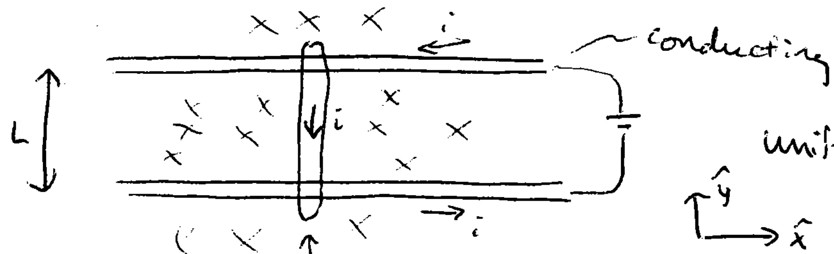
$m = \frac{qRB}{v}$ $\therefore$

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

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

$\therefore$

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




conducting rails

uniform B into Board

frictionless conducting support, bar Mass M

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

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

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

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

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

$V = 2\,m/s$

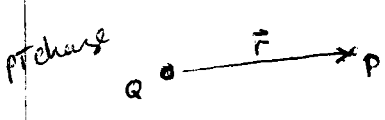
Up to Now → Effect of B field on Moving charged particle

What about field produced by moving charges

## Production of Magnetic Fields by Charges and Currents

**Electrostatics**

$F = qE$ + Coulomb's law

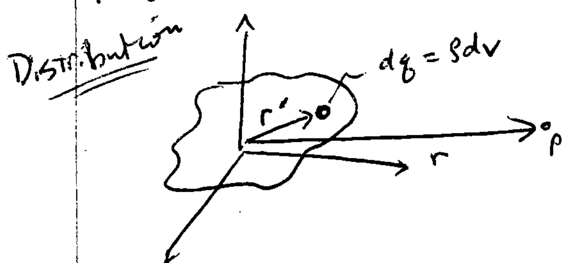



$$\vec{E} = \frac{kQ}{r^2}\hat{r}$$

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

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

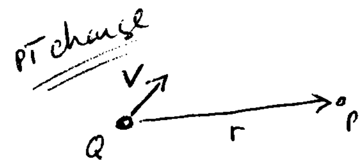
Distribution




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

**Magnetostatics**

Biot-Savart law



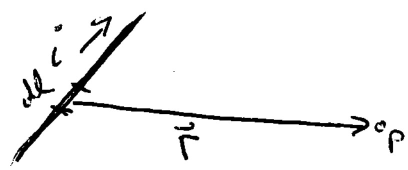

$$\vec{B} = \frac{\mu_0}{4\pi}\frac{Q\vec{v}\times\hat{r}}{r^2}$$

at p due to Q

$\mu_0$ ≡ CONSTANT ≡ Permeability of free space

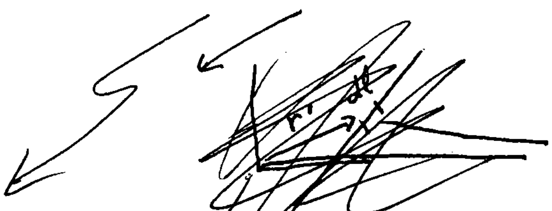
$$\mu = 4\pi\times10^{-7}\ \frac{T.m}{A}$$

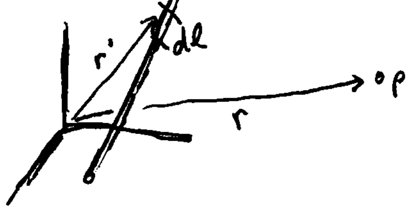
Distribution (currents, NOT charges)




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

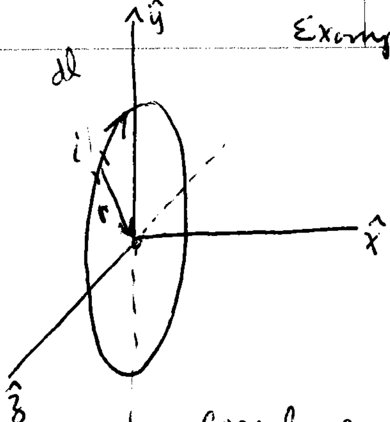
or






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

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

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

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

do B around Wire DEMO

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

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

$$\frac{\mu_0 i}{2r}$$

| Electrostatics | Magnetostatics |
| --- | --- |
| Gauss's law | Ampere's law |
| $\int_{Surface} E\cdot dA = \frac{Q_{encl}}{\epsilon_0}$ | $\int_{\text{Closed Curve}} \vec{B}\cdot\vec{dl} = \mu_0 I_{enclosed}$ |
| very useful when Symmetry allows | |