Mass Spectrometer

\[ F = qVB \]

\[ F = m \frac{V^2}{R} \]  (mass in circle)

\[ qVB = m \frac{V^2}{R^2} \]

\[ m = \frac{qRB}{V} \]

Intensity

- Sample: \( \text{C}_2\text{H}_6 \)
- \( \text{C}_3\text{H}_5 \)
- \( \text{C}_4\text{H}_9 \)
- \( \text{C}_2\text{H}_3 \)

Relative Intensity

- \( \frac{M}{2} \)
- \( \frac{57}{100} \)
- \( \frac{41}{41.5} \)
- \( \frac{29}{38.5} \)
- \( \frac{27}{15.7} \)
Must Relate velocity at opening to Mass Spectrometer to the Potential Diff V

\[ KE = \frac{1}{2} m V^2 \]

\[ V = \left( \frac{2q\nu}{m} \right)^{\frac{1}{2}} \]

\[ m = \frac{qRB}{2V} \]

or

\[ m^2 = \frac{q^2 R^2 B^2}{2V} \frac{1}{m^2} \]

Now

\[ R = \frac{1}{2} x \]

\[ m = \frac{q^2 R^2 B^2 x^2}{8V} \]

What is \( \ddot{a} \) of bar?

\[ \ddot{F} = L \ddot{i} \times \bar{B} = L i \bar{B} \hat{x} \]

\[ m \ddot{a} = L i \bar{B} \hat{x} \]

\[ \ddot{a} = \frac{L i \bar{B}}{m} \hat{x} \]

\[ \ddot{a} \rightarrow \text{constant} \]

\[ \text{can use constant acceleration} \]

For current = 1 Amp

\[ B = 3 \text{ Tesla} \]

\[ L = 2 \text{ Meters} \]

\[ m = 3 \text{ kg} \]

\[ \ddot{a} = \frac{(2 \text{ m})(1 \text{ A})(3 \text{ T})}{3 \text{ kg}} = 1.2 \text{ m/s}^2 \hat{x} \]

\[ \text{After 10 seconds} \]

\[ V_x = V_{0x} + \ddot{a}_x t = 0 + (1.2)(10) \]

\[ V = 2 \text{ m/s} \]
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**

$$E = qE + \text{Coulomb's law}$$

$$\vec{E} = \frac{kQ}{r^2}$$
due to $Q$

**Magnetostatics**

**Biot-Savart law**

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

due to $Q$

$\mu_0$ = constant = Permeability of free space

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

**Distribution** (currents, not charges)

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

$$d\vec{B}(r) = \frac{\mu_0}{4\pi} \frac{i \vec{d}l \times (r - r')}{|r - r'|^2}$$
Example - calculate the $B$ field at the center of a current loop.

\[ \mathbf{i} \times \hat{z} = \mathbf{i} \times \mathbf{B} = \mathbf{B} \]

\[ \mathbf{d} \mathbf{B} = \frac{\mu_0}{4\pi} \frac{i \mathbf{dl} \times \hat{z}}{r^2} = \frac{\mu_0}{4\pi} \frac{2\pi r}{r^2} \mathbf{i} = \frac{\mu_0 i}{2\pi} \hat{r} \]

\[ \mathbf{B} (0, 0, 0) = \frac{\mu_0 i}{4\pi} \int_0^{2\pi} \frac{\mathbf{i} \mathbf{dl}}{r^2} = \frac{\mu_0 i}{4\pi} \frac{2\pi}{r} \left( \frac{2\pi}{r} \right) \]

**Electrostatics**

**Ampere's Law**

\[ \oint \mathbf{E} \cdot d\mathbf{A} = \frac{Q_{enc}}{\varepsilon_0} \quad \text{(Surface integral)} \]

**Magnetostatics**

\[ \oint \mathbf{B} \cdot d\mathbf{l} = \mu_0 I_{\text{enclosed}} \quad \text{(Closed curve)} \]

**Curl**

\[ \mathbf{E} = \hat{z} \times \mathbf{B} \]

**Div**

\[ \nabla \cdot \mathbf{B} = 0 \]