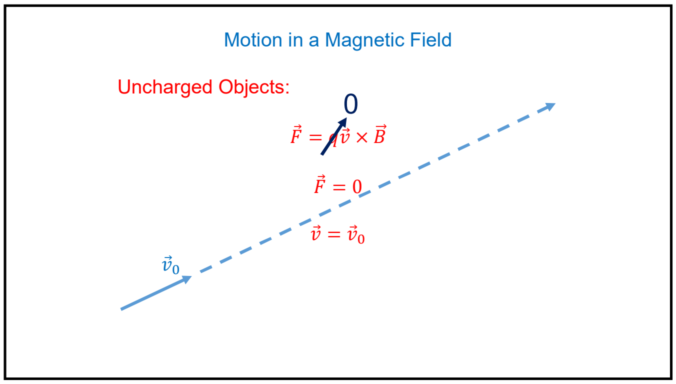
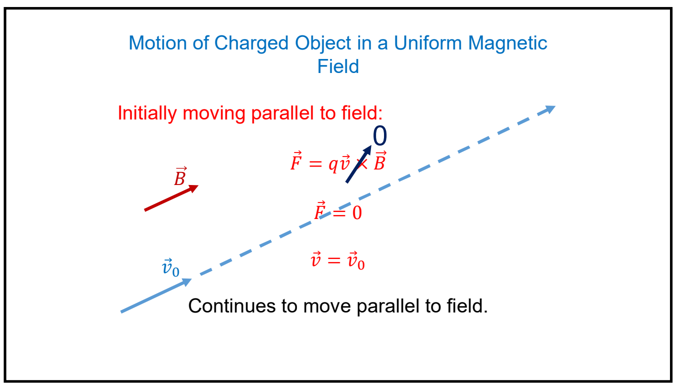
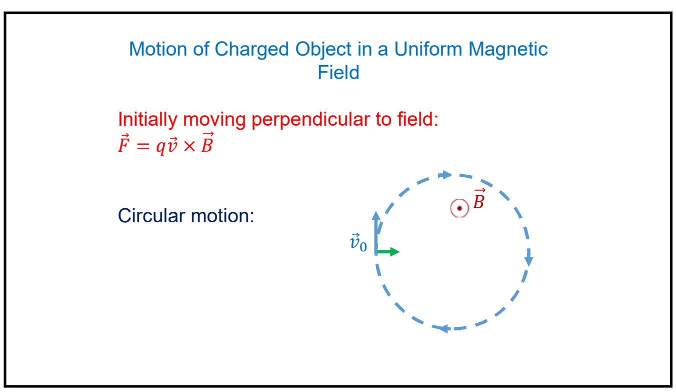

Motion in a Magnetic Field
Uncharged Objects:
0
$\vec{F} = q\vec{v} \times \vec{B}$
$\vec{F} = 0$
$\vec{v} = \vec{v}_0$
$\vec{v}_0$


Motion of Charged Object in a Uniform Magnetic Field
Initially moving parallel to field:
0
$\vec{F} = q\vec{v} \times \vec{B}$
$\vec{B}$
$\vec{F} = 0$
$\vec{v}_0$
$\vec{v} = \vec{v}_0$
Continues to move parallel to field.


Motion of Charged Object in a Uniform Magnetic Field
Initially moving perpendicular to field:
$\vec{F} = q\vec{v} \times \vec{B}$
Circular motion:
$\vec{B}$
$\vec{v}_0$

Motion of Charged Object in a Uniform Magnetic Field

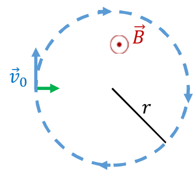
Initially moving perpendicular to field:

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

Force, $F_r = -|q|vB$

Circular motion:

$F_r = -\frac{mv_t^2}{r}$



Motion of Charged Object in a Uniform Magnetic Field

Initially moving perpendicular to field:

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

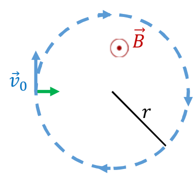
Force, $F_r = -|q|vB$

Circular motion:

$F_r = -\frac{mv_t^2}{r}$

$-|q|v_0B = -\frac{mv_0^2}{r}$

$r = \frac{mv_0}{|q|B}$



Motion of Charged Object in a Uniform Magnetic Field

Initially moving perpendicular to field:

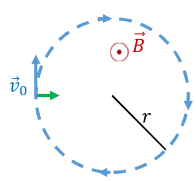
Force, $F_r = -|q|vB$

Radius, $r = \frac{mv_0}{|q|B}$

Period:

$T = \frac{2\pi r}{v} = \frac{2\pi r}{\left(\frac{|q|Br}{m}\right)}$

$T = \frac{2\pi m}{|q|B}$



Motion of Charged Object in a Uniform Magnetic Field

Initially moving perpendicular to field:

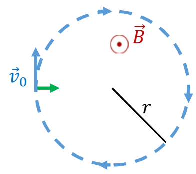
Force, $F_r = -|q|vB$

Radius, $r = \frac{mv_0}{|q|B}$

Period, $T = \frac{2\pi m}{|q|B}$

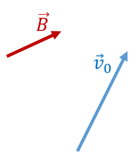
Frequency:

$f = \frac{1}{T} = \frac{|q|B}{2\pi m}$



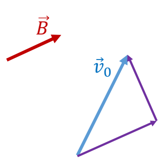
Motion of Charged Object in a Uniform Magnetic Field

Motion neither parallel nor perpendicular to field:



Motion of Charged Object in a Uniform Magnetic Field

Motion neither parallel nor perpendicular to field:

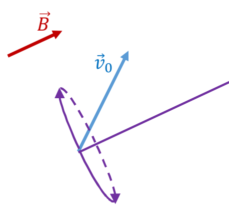


Velocity broken into two components

- Parallel to $\vec{B}$
- Perpendicular to $\vec{B}$

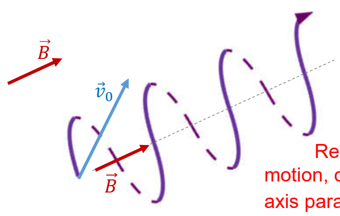
Motion of Charged Object in a Uniform Magnetic Field

Motion neither parallel nor perpendicular to field:



Motion of Charged Object in a Uniform Magnetic Field

Motion neither parallel nor perpendicular to field:



Motion in Electric and Magnetic Fields
Lorentz Force

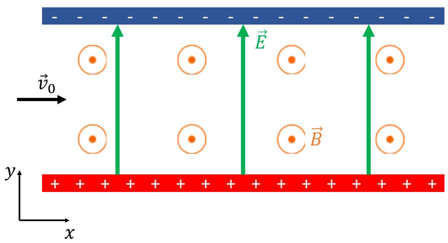
Combining $\vec{F} = q\vec{E}$ and $\vec{F} = q\vec{v} \times \vec{B}$

$$\vec{F} = q\left(\vec{E} + \vec{v} \times \vec{B}\right)$$

Some conditions result in simple motion:

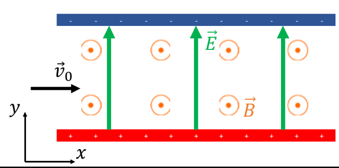
- Uniform $\vec{E}$ with $\vec{B} = 0$
- Uniform $\vec{B}$ with $\vec{E} = 0$
- $\vec{E} \perp \vec{v}_0$, $\vec{B} \perp \vec{v}_0$ and $\vec{B} \perp \vec{E}$ (Crossed fields)

Crossed Fields
Velocity Selector



Crossed Fields
Velocity Selector

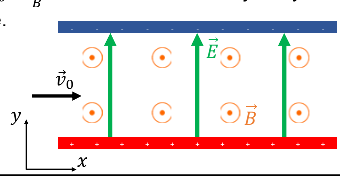
$$\left.\begin{array}{l}\vec{v} = v_0\hat{\imath} \\ \vec{E} = E\hat{\jmath} \\ \vec{B} = B\hat{k}\end{array}\right\} \begin{array}{l}\vec{F} = q\left(E\hat{\jmath} + v_0\hat{\imath} \times B\hat{k}\right) \\ \vec{F} = q(E - v_0 B)\hat{\jmath}\end{array}$$



Crossed Fields
Velocity Selector

$$\left.\begin{array}{l}\vec{v} = v_0\hat{\imath} \\ \vec{E} = E\hat{\jmath} \\ \vec{B} = B\hat{k}\end{array}\right\} \begin{array}{l}\vec{F} = q\left(E\hat{\jmath} + v_0\hat{\imath} \times B\hat{k}\right) \\ \vec{F} = q(E - v_0 B)\hat{\jmath}\end{array}$$

If $v_0 = \frac{E}{B}$, then $\vec{F} = 0$ and the trajectory is a straight line.



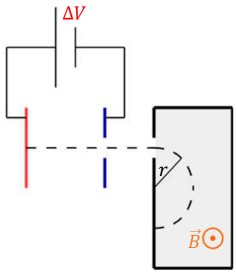
Mass Spectrometer

Charge accelerates between plates, gaining energy, $\Delta U = q\Delta V$.

Velocity is function of ΔV.

$$\frac{1}{2}mv^2 = q\Delta V$$

$$v = \sqrt{\frac{2q\Delta V}{m}}$$



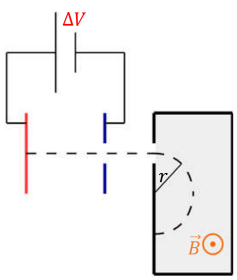
Mass Spectrometer

Charge moves in circular path in spectrometer.

Radius of path is function of mass.

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

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



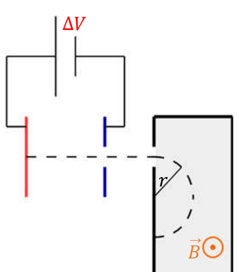
Mass Spectrometer

Combining

$$v = \sqrt{\frac{2q\Delta V}{m}} \quad \& \quad r = \frac{mv}{qB}$$

yields

$$r = \frac{1}{B}\sqrt{\frac{2m\Delta V}{q}}$$



Radius is a function of mass/charge ratio.