FIELD LINES

$$d\Phi = B_\perp dA = B\cos\theta\, dA$$

If we define a vector $d\vec{A} \perp$ to surface element

$$d\Phi = \vec{B}\cdot d\vec{A}$$

Total magnetic flux is sum of contributions from all elements

$$\Phi = \int \vec{B}\cdot d\vec{A}$$

If B uniform over surface of total area A

$$\Phi = BA\cos\theta$$

If B also $\perp$ surface $\cos\theta = 1$

$$\Phi = BA$$

UNITS

Magnetic field $B = \frac{F}{qv} = \frac{N}{C\,ms^{-1}}$

$1\ T\ (\text{tesla}) = 1\ NA^{-1}m^{-1}$

Magnetic flux $\Phi = BA = 1\ NA^{-1}m^{-1}\cdot m^2$

$1\ (\text{Weber}) = 1\ N\,m\,A^{-1}$

Assuming $dA \perp B$ have

$$B = \frac{d\Phi}{dA} = Wb\,m^{-2} = T$$

flux per unit area.

cgs $\quad \Phi = 1$ maxwell

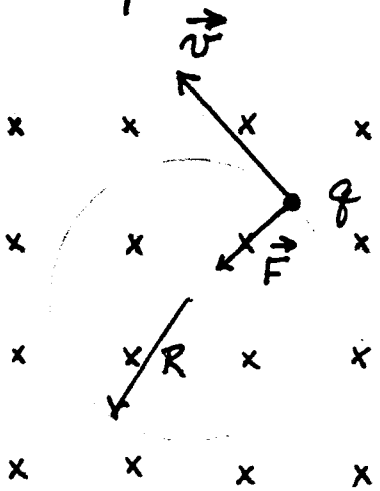
$B = 1$ maxwell $/ cm^2 = 1$ gauss (1G)

$1G = 10^{-4}\ Wb\ m^{-2}$

very common unit for expressing magnetic flux density.

Largest laboratory fields	$30T = 3 \times 10^5 G$
Earth, sun	$1G$
ISM	$10^{-6} G$
pulsar (rotating magnetized neutron star)	$10^{12} G$

Motion of Charged Particle in $\vec{B}$ field



Consider charged particle w/ initial velocity $\vec{v}$ in plane of blackboard w/ uniform $\vec{B} \perp \vec{v}$ in direction <u>into</u> bb.

$F_\perp$ $v \Rightarrow$ centripetal force

$$F = m a_\perp = m\left(\frac{v^2}{R}\right)$$

also

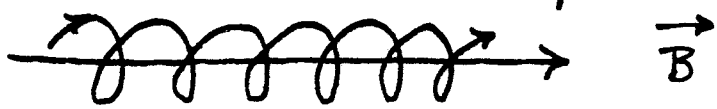
$$F = q v B \quad \text{since } v \perp B$$

$$\Rightarrow \quad m a_\perp = m \frac{v^2}{R} = F = q v B$$

Particle will move in circle w/ radius

$$R = \frac{mv}{Bq}$$

What if v not $\perp B$? Can consider components of velocity $\parallel, \perp B$



$v_{\parallel} \rightarrow$

Particle describes helix w/ $R = \frac{mv_{\perp}}{Bq}$

$v_{\parallel}$ constant

Note: since force is perpendicular to velocity

$$W = \int \vec{F} \cdot d\vec{s} = 0$$

$\vec{B}$ changes direction of motion but not magnitude of velocity or K.E.

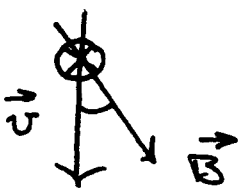
Property used extensively in research

Particle accelerators: tracks of particles created give energy of particle

In San Diego

$B \approx 5\times10^{-5}\,T$ at about 30° to vertical

solar wind e^- at .01 c



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

$$= 1.6\times10^{-19}\,C \cdot 3\times10^{4}\,m\,s^{-1} \cdot 5\times10^{-5}\,T \cdot \sin 30°$$

$$= 12\times10^{-18}\,N$$

But n.b. $F_g = mg = 9\times10^{-31}\,kg \cdot 9.8\,m\,s^{-2}$

$$= 9\times10^{-30}\,N$$

$$F_B/F_g \approx 10^{12}$$

$$R = \frac{m\,v_\perp}{Bq} = \frac{9\times10^{-31}\,kg \cdot 1.5\times10^{4}\,m\,s^{-1}}{5\times10^{-5}\,T \cdot 1.6\times10^{-19}\,C}$$

$$R = 0.169\,m$$