

### 3-6-2019: Cross-Field Applications and Current

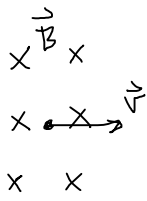
Wednesday, March 6, 2019 3:05 PM

Let's review from last lecture...


$$\vec{F}_B = q(\vec{v} \times \vec{B}) \quad , \quad \text{cross field} \quad \vec{E} \perp \vec{B} \quad F_E = F_B$$

$$qE = qvB \Rightarrow v = \frac{E}{B}$$

$$m\left(\frac{v^2}{r}\right) = qvB$$

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


Now let's return to our helical case...

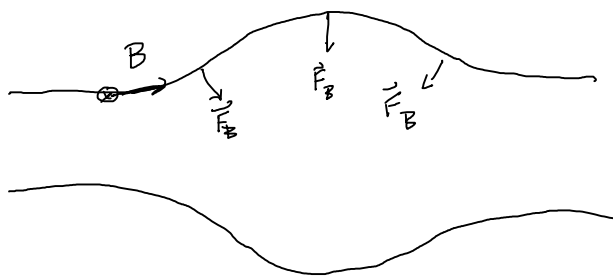


$$v_{||} = v \cos \phi$$

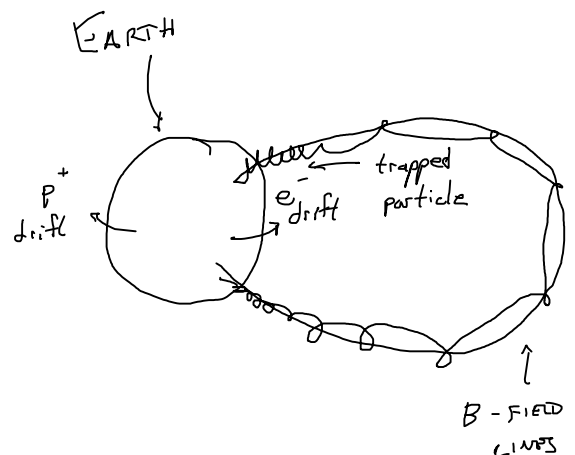
$$v_{\perp} = v \sin \phi$$

$$R = \frac{mv_{\perp}}{qB}$$

Here's another situation! The magnetic "bottle"...



This is how the aurora borealis forms at the poles.



Another application of the cross field is the Mass Spectrometer.



Mass Spec:



$B \odot$

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

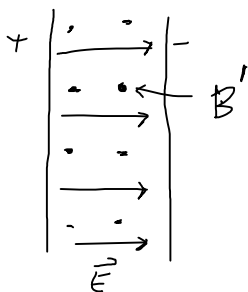
Work-Energy  
↓

$$m = \frac{RqB}{v}$$

$$\frac{1}{2}mv^2 = q\varepsilon \Rightarrow v = \sqrt{\frac{2q\varepsilon}{m}}$$

$$m = \frac{RqB}{\sqrt{\frac{2q\varepsilon}{m}}} = \frac{\sqrt{m} q B R}{\sqrt{2} \sqrt{q} \sqrt{\varepsilon}}$$

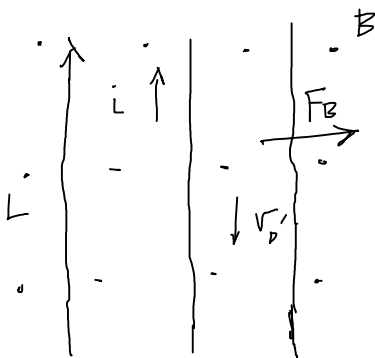
Velocity Selector --



$$F_E = F_B, \quad qE = qvB', \quad v = \frac{E}{B'}$$

$$\sqrt{m} = \sqrt{\frac{q}{2\varepsilon}} BR \Rightarrow m = \frac{R^2 B^2 q}{2\varepsilon}$$

$$r = \frac{mv}{qB} = \frac{m(\frac{E}{B'})}{qB} = \frac{mE}{qBB'}, \quad m = \frac{qBB'r}{E} \Rightarrow \boxed{\frac{q}{m} = \frac{E}{rB'B'}}$$



$$i = \frac{dq}{dt}$$

$$q = it = i \frac{L}{v_b}$$

$$\vec{F}_B = qv_b B \sin \phi$$

$$= i \left( \frac{L}{v_b} \right) v_b B \sin \phi = iLB \sin \phi$$

$$\vec{F}_B = i(\vec{L} \times \vec{B}) = iLB \sin \phi, \quad \phi < 90^\circ \text{ w/ } i \nparallel B.$$