Applications of Moving Charge in B-Fields & the Hall Effect

"Drill for oil? You mean drill into the ground to try and find oil? You're crazy." Drillers who Edwin L. Drake tried to enlist to his project to drill for oil in 1859.

Circular Motion

- What is the equation for the force on a charge particle moving in a B-Field?

$F = qv \times B$

- Does this force change the speed of the particle?

No

- Solve for the radius, angular speed, and period of the circle motion.

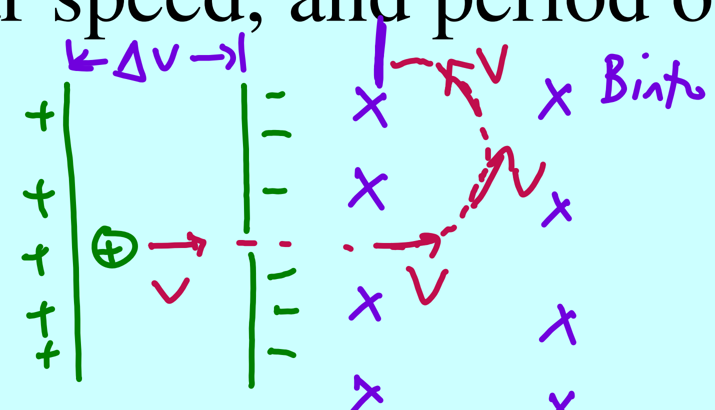
$\Sigma F = ma$

$qvB = m\frac{v^2}{r}$

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

$v = \omega r$

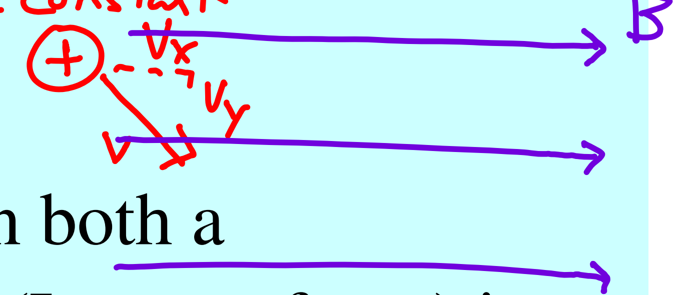
$T = \frac{2\pi}{\omega}$



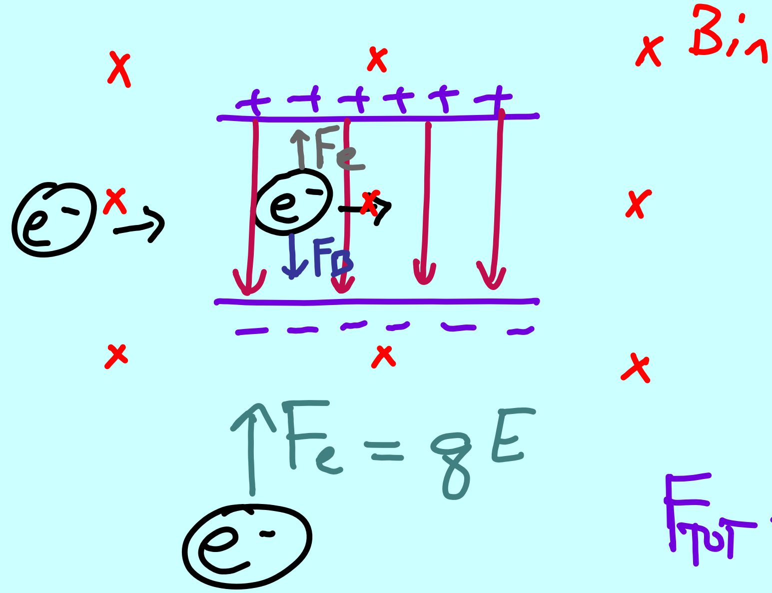
Other Motions

- What if the particle has a velocity vector with components both perpendicular and parallel to the B-field? helical path

  F_y causes circular motion in y/z plane. $F_x = 0 \Rightarrow V_x = \text{constant}$



- Magnetic Bottle – transparency
- Often the charged particles will move in both a B- field and an E-field. The total force (Lorentz force) is



$F_{TOT} = F_e + F_B$

$\uparrow F_e = qE$

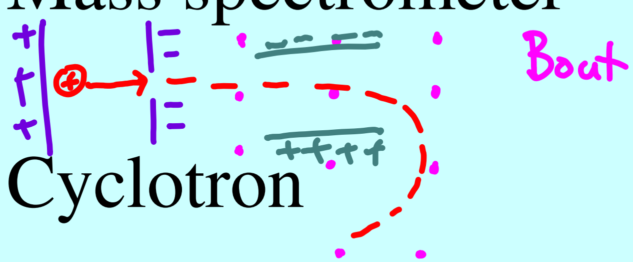
$\downarrow F_B = qvB$

if $F_e = F_B \Rightarrow qE = qvB \Rightarrow V = \frac{E}{B}$

- Velocity Selector

  only 1 velocity travel straight

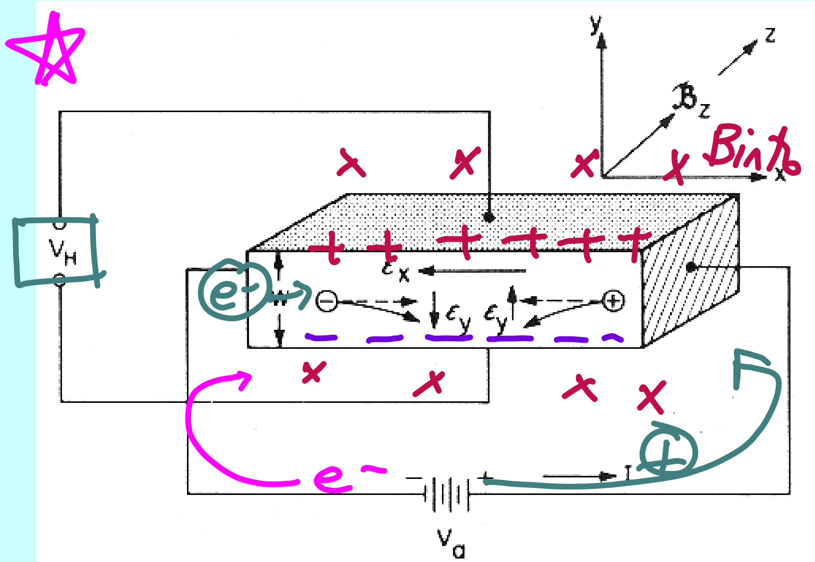
- Mass spectrometer



- Cyclotron

The Hall Effect

- When a current-carrying conductor is placed in a B-field, a ___ΔV___ is generated in a direction ___⊥___ to both the current and the B-field. This is known as the *Hall effect*. ☆



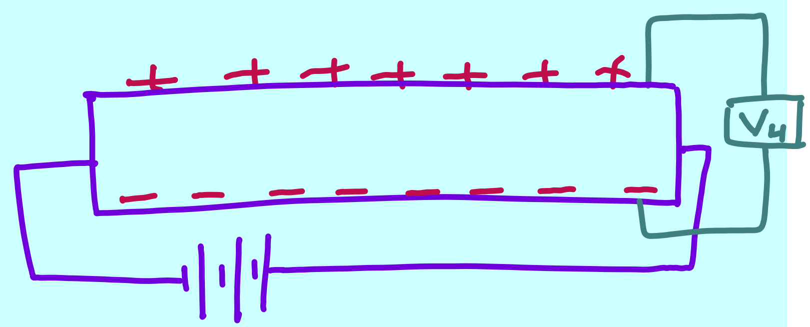
- Electrons are deflected down

- This leaves a net ___+___ charge at the top and a net ___−___ charge at the bottom. Therefore a potential difference is established across *a* and *c*.

Hall Voltage

- Equilibrium is reached when the electric force resulting from the charge separation is balanced by the ___F_B___. This resultant potential difference is known as the ___Hall voltage___, ΔV_H.

- If the charge carries are positive the force is ___down___ on them. This produces a potential difference that is opposite in sign to the Hall voltage resulting from ___−___ flow. The sign ^of voltage can determine the ___sign___ of the charge carriers.



Hall Voltage

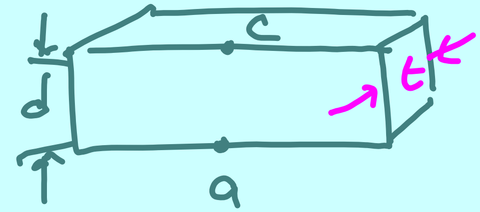
- $\sum F = 0$

$d(q v_d B = q E_H)$

v_d - drift velocity

E_H - Hall field

$\Delta V = \int E \cdot ds$



- $\Delta V_H = E_H d = v_d B d$
- Thus a given voltage can determine drift velocity.
- $v_d = I/(nqA)$ Ch. 27
- $\Delta V_H = \frac{IBd}{nqA}$ & $A = t \cdot d$ (area)
- $\Delta V_H = \frac{IBd}{nq(t \cdot d)} = \frac{IB}{nqt}$

$\Delta V_H = \frac{R_H IB}{t}$

$R_H = \frac{1}{nq}$ Hall coefficient

used to measure unknown B.

Summary of Ch. 29

- Force of charge moving in B-field =

$$F = qv \times B$$

- Force on a current-carrying wire in B-field =

$$F = I l \times B$$

- Torque on current-carrying wire in B-field =

$$\tau = N I A \times B$$

N - # of coils