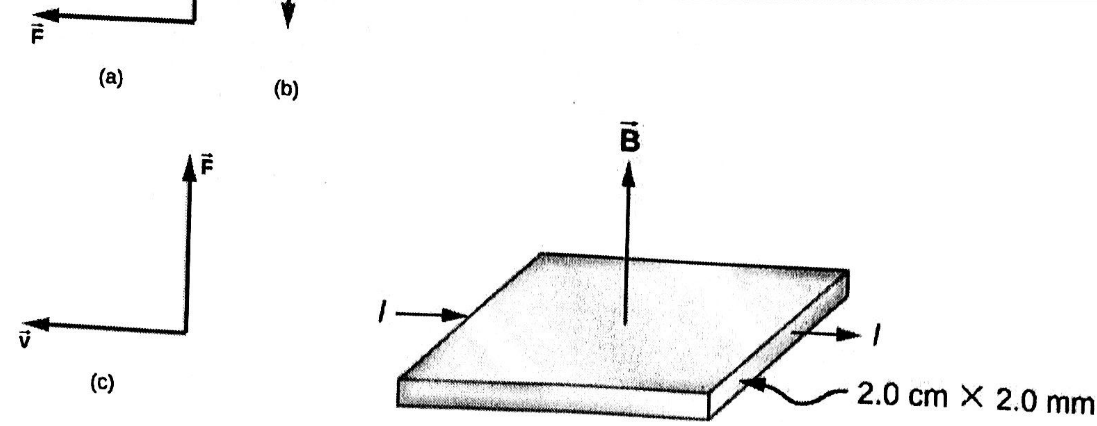

Figure 1: (Left) A current I experiences a force F in a B-field.

2 Chapter 11: Magnetic Forces and Fields

1. Consider Fig. 1 (left). In each of the three cases, determine the direction of the B-field given that F is the Lorentz force.
   - a: $B = F \times V = (-\hat{i} \times \hat{j}) = -k$ $\boxed{\text{into the page}}$
   - b: $B = F \times V = (-k) \times (-j)$ $B = -i$ $\boxed{\text{to the left}}$
   - c: $B = F \times V = j \times (i) = k$ ~~into~~ $\boxed{\text{out of the page}}$

2. Consider Fig. 1 (right). **The Hall Effect**. An E-field exists in the vertical direction and a B-field is perpendicular to the direction of charge velocity. (a) Show that if the E-field force on a charge balances the Lorentz force on a charge, that $v = E/B$. (b) If the E-field is constant, $E = \Delta V/\Delta x$. Show that

$$\Delta V = \frac{B \Delta x I}{n q_e A} \quad (1)$$

where n is the charge carrier density, q_e is the electron charge, A is the cross-sectional area of the conductor, and I is the current. Plug in $B = 1.33$ T, $\Delta x = 2$ cm, $I = 10$ A, $n = 2 \times 10^{28}$ m^{-3}, $A = 1$ mm^2, and q_e is the charge of an electron.

a. $F_E = F_B$

$qE = qVB\sin\theta$

$\theta = 90$

$qE = qVB \to E = VB$

$\boxed{V = \frac{E}{B}}$

b. $\Delta V = \frac{B(\Delta X) I}{n q_e A}$

$\Delta V = \frac{1.33(2\times10^{-2})\times10}{(2\times10^{28})\times(1.6\times10^{-19})\times(1\times10^{-3})^2}$

$\boxed{\Delta V = 8.31\times10^{-5}\,V}$

3. A proton has a magnetic field due to its spin. The field is similar to that created by a circular current loop 0.65×10^{-15} m in radius with a current of 1.05×10^4 A. Find the maximum torque on a proton in a 2.50-T field. (This is a significant torque on a small particle.)

$\tau = NIAB\sin\theta$

$A = \pi r^2$ $A = \pi(0.65\times10^{-15}\,m)^2 = 1.33\times10^{-30}\,m^2$

$\tau = 1(1.05\times10^{4}A)(1.33\times10^{-3}m^2)(2.50)(\sin 90)$

$\boxed{3.48\times10^{-26}\,N\,m}$

Chapter 12: Sources of Magnetic Fields

1. (a) What is the B-field inside a solenoid with 500 turns per meter, carrying a current of 0.3 A? (b) Suppose we insert a piece of metal inside the solenoid, boosting μ_0 by a factor of 5000. What is the new B-field?

$\mu_0 n I = 4\pi\times10^{-7}(500)(.3)$

$1884.9\times10^{-7} = \boxed{1.88\times10^{-4}\,T}$

b. $5000 \times \mu_0 n I$

$5000\times1.88\times10^{-4} = \boxed{0.94\,T}$

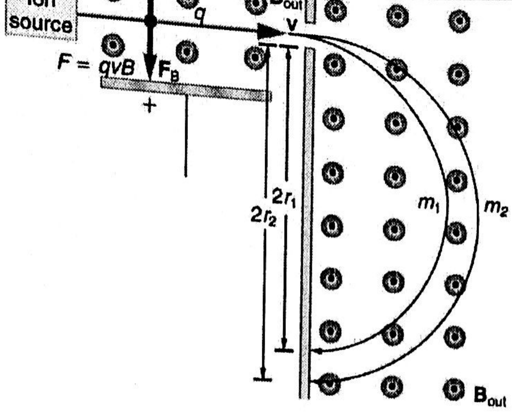

Figure 2: A basic diagram of a *toroid*, which is a solenoid wrapped into a circular tube.

2. Consider Fig. 2. **Mass spectrometer**. Suppose that the velocity of the charged particles moving to the right is $v = E/B$. (a) Show that if $v = E/B$, $F_{net} = 0$ in the region in the top left[1]. (b) Recall that the centripetal force on a particle of mass m is mv^2/r. Set this equal to the magnitude of the Lorentz force to prove that

$$r = \frac{mE}{qB^2} \tag{2}$$

The mass of an oxygen nucleus is 16 times that of a proton (mass of proton: 1.67×10^{-27} kg). Suppose oxygen ions with the charge of 1 proton are sent through the mass-sepctrometer. The E-field is 10 V/m, and the B-field is 0.01 T. What is the distance r?

a. $F_{total} = F_{electrical} + F_{magnetic} = 0$

$q[E + v \times B] = 0$

$F_{total} = q(E - vB) = 0$

$E = vB \rightarrow v = \frac{E}{B}$ for $F_{net} = 0$

b. $r = \frac{m\frac{E}{B}}{qB} = \frac{mE}{qB^2} \rightarrow$ radius =

$\frac{(16)(1.67 \times 10^{-27}) \cdot (10)}{(1.602) \times (10^{-19}) \cdot (0.01)^2} = \boxed{1.67 \text{ cm}}$

Chapter 13: Electromagnetic Induction

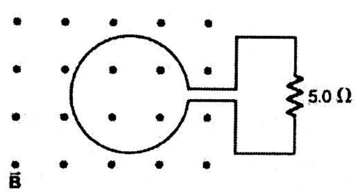

Figure 3: A voltage is induced on a loop by a changing B-field.

1. The magnetic field in Fig. 3 flows out of the page through a single ($N = 1$) loop, and changes in magnitude according to

$$\frac{\Delta B}{\Delta t} = \frac{B_0}{T_0}(\sin(2\pi f t)) \tag{3}$$

The loop has a radius r. (a) In terms of the given variables, what is the induced voltage in the circuit? (b) If $B_0 = 0.1$ T, $r = 0.1$ m, $f = 10^3$ Hz, and $T = 1$ ms, what is the induced emf at $t = 0$? (c) What about $t_1 = 0.16$ ms? (d) What is the current through the resistor at t_1?

$\frac{d\phi}{dt} = \frac{d(BA)}{dt}$

$\frac{\Delta B}{\Delta t}$

$\boxed{e = \pi r^2 \cdot \frac{B_0}{T_0} \sin(2\pi f t)}$

b. induced emf at $t=0$ is zero

c. $e = \pi \cdot (0.1)^2 \cdot \frac{0.1}{1m} \sin(2\pi \times 10^3 \times 0.16 \times 10^{-3})$

$e = 3.14 \times \frac{(0.1)^3}{1ms} \times 0.0175 =$

$\boxed{0.055V}$

d. $I = \frac{e}{R}$ $\frac{0.055}{5}$ $\boxed{I = 0.011 A}$

[1] Molecules that do not have this velocity will hit the sides of this portion of the instrument.

Chapter 14: Inductance

. What is (a) the rate at which the current though a 0.50-H coil is changing if an emf of 0.150 V is in
the coil?

$$\frac{emf}{\text{Inductive}} = -\frac{0.15}{0.50} = \boxed{-0.3}$$

2. When a camera uses a flash, a fully charged capacitor discharges through an inductor. In what t
0.100-A current through a 2.00-mH inductor be switched on or off to induce a 500-V emf?

$$\varepsilon = L\frac{dI}{dt} \qquad dt = \frac{L}{\varepsilon}\,dI$$

$$dt = \frac{2.00\,mH}{500\,V}(.100\,A) = \boxed{4.00 \times 10^{-7}\,s}$$