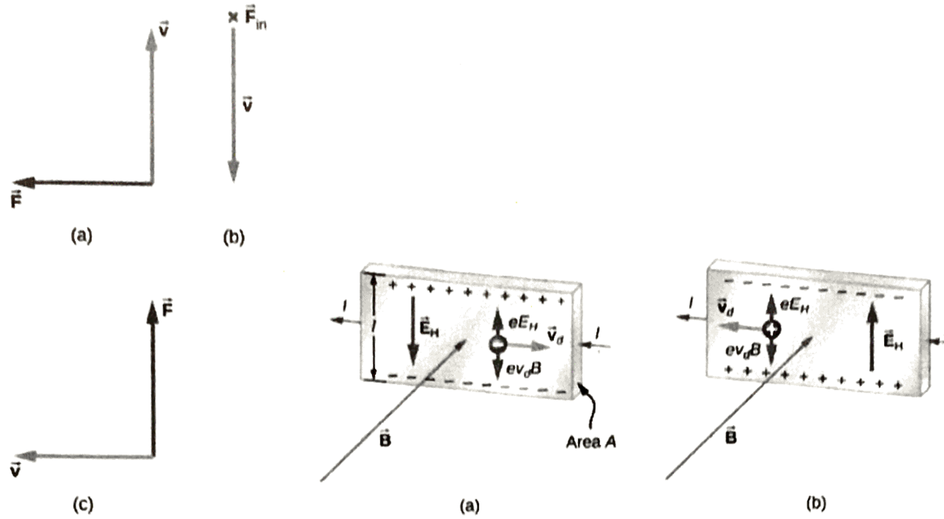

Figure 1: (Left) A current I experiences a force F in a B-field.

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: $\hat{B} = \hat{F} \times \hat{v} = (-\hat{i} \times \hat{j}) = -\hat{k}$, $\boxed{\text{Into page}}$
   - b: $\boxed{\text{Towards left}}$
   - c: $\hat{B} = \hat{F} \times \hat{v} = (\hat{j} \times (-\hat{i})) = \hat{k}$, $\boxed{\text{out of page}}$

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

$$\Delta V = \frac{B\Delta x I}{n q_e A} \tag{1}$$

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) $F_E = F_B$

$\theta = 90°$ $qE = qvB\sin\theta$

$qE = qvB$

$E = vB$

$\boxed{v = E/B}$

b) $E = \frac{\Delta V}{\Delta x}$

$\Delta V = vB\Delta x$

$\Delta V = B(\Delta x)v$

$\Delta V = B(\Delta x) \cdot \frac{I}{nq_eA}$

$= \boxed{\frac{B\Delta x I}{nq_eA}}$

$\Delta V = \frac{1.33(2)(10)}{(2\times10^{28})(1.6\times10^{-19})(1\times10^{-3})} = \boxed{8.3125\times10^{5}\ v}$

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.)

$\tau = NIAB\sin\theta$, $n = 1$, $\theta = 90$

$A = \pi r^2 = \pi(.65\times10^{-15})^2 = 1.33\times10^{-30}$ m^2

$\tau = (1)(1.33\times10^{-30})(2.50)(\sin 90)$

$= \boxed{3.48\times10^{-26}\ \text{Nm}}$

3 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?

a) $n = 500$ turns/m, $I = 0.3$A

$B = \mu_0 n I$

$= (4\pi\times10^{-7})(500)(0.3) = \boxed{1.885\times10^{-4}\ \text{T}}$

b) $B = (5000)(4\pi\times10^{-7})(500)(.3)$

$= \boxed{0.942478\ \text{T}}$

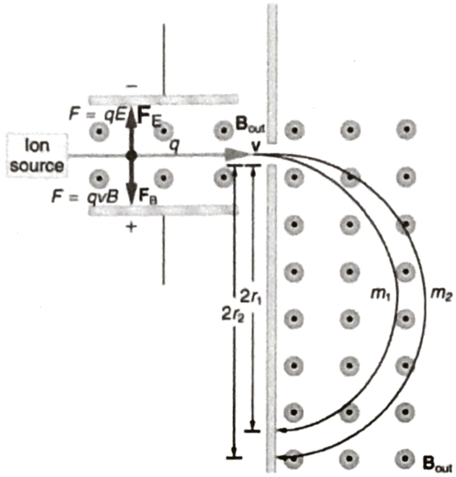

Figure 2: A basic diagram of a *toroid*, which is a solenoid wrapped into a circular tube.

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) $F_e = q\vec{E}$ $\quad F_{TOT} = F_e + F_m = 0$ $\quad E = vB$ $\quad \boxed{v = \frac{E}{B}}$

$F_m = q(\vec{v} \times \vec{B})$ $\quad q(\vec{E} + \vec{v} \times \vec{B}) = 0$

$|F_T| = q|E - vB| = 0$

b) $\frac{mE}{qB^2} = \frac{m\frac{E}{B}}{qB}$

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

4 Chapter 13: Electromagnetic Induction

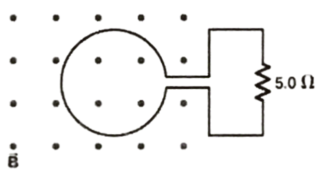

Figure 3: A voltage is induced on a loop by a changing B-field.

1. The magnetic field in Fig. 3 flows out of the page through a single ($N = 1$) loop, and is tuned to follow the form

$$B(t) = B_0 \left(\frac{1}{2} + \frac{2}{\pi} \sin(2\pi f t) + \frac{2}{3\pi} \sin(6\pi f t) + \frac{2}{5\pi} \sin(10\pi f t) \right) \tag{3}$$

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, and $f = 10^3$ Hz, what is the induced emf at $t = 0$? (c) What is the current through the resistor at $t = 1$ ms?

a) $e = \left|\frac{d\phi}{dt}\right| = \frac{d(BA)}{dt}$

$\boxed{e = A\frac{dB}{dt} = (\pi r^2)\left(\frac{B_0}{T_0}\right)\sin 2\pi f t}$

b) $B_0 = 0.1, r = 0.1, F = 10^3$

will be 0, since $\sin 2\pi f t = 0$

c) Current at T_1 $I = \frac{e}{R} = \frac{0.05}{5} = \boxed{0.011\text{A}}$

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

5 Chapter 14: Inductance

1. 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 induced across the coil? $emf = .150\,V$ $\quad \frac{dI}{dt} = ?$

$$emf = -L\frac{dI}{dt} \qquad \frac{dI}{dt} = \frac{-emf}{I} = -\frac{0.15}{.50} = \boxed{-0.3}$$

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

$$\mathcal{E} = -L\frac{\partial I}{\partial t}$$

$$\mathcal{E} = L\frac{dI}{dt}$$

$$500 = 2\times10^{-3}\,H\frac{\partial I}{\partial t}$$

$$2.5\times10^{5} = \frac{\partial I}{\partial t}$$

$$dI = 2.5\times10^{5}\,dt$$

$$\int dI = \int 2.5\times10^{5}\,dt$$

$$I = 2.5\times10^{5}\,t$$

$$t = \frac{I}{2.5\times10^{5}} = \frac{0.1000}{2.5\times10^{5}} = \boxed{4\times10^{-7}\ \text{sec}}$$