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

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

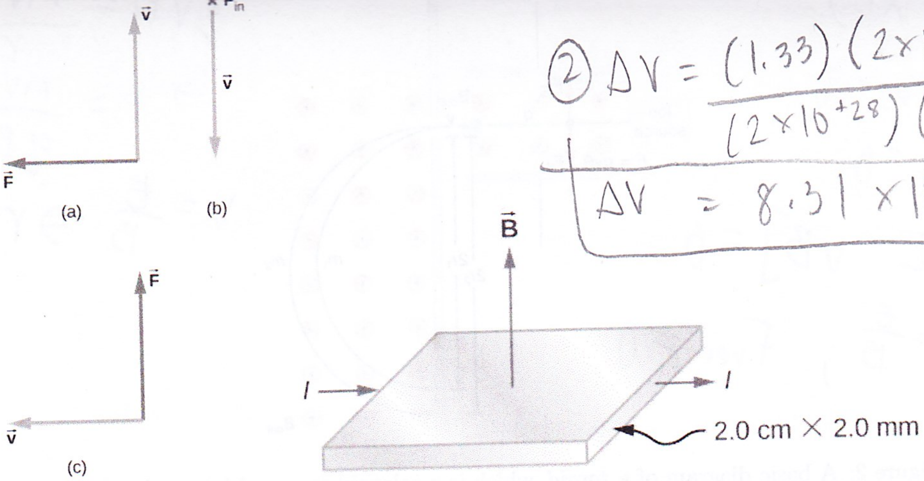

Figure 1: (Left) A current I experiences a force F in a B-field.

2 Chapter 11: Magnetic Forces and Fields

1. Consider Fig. 1 (left). In each of the three cases, determine the direction of the ~~current~~ B-field given that F is the Lorentz force.
   - a: Into page
   - b: Left
   - c: 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, $n = 2\times10^{28}$ m^{-3}, $A = 1$ mm^2, and q_e is the charge of an electron.

a) $F_E = F_B \Rightarrow qE = qvB\sin\theta$

$(\theta = 90°)$

$\hookrightarrow qE = qvB \Rightarrow E = vB$

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

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

$\Delta V = (vB)\Delta x$

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

$v_d = \frac{I}{n q_e A}$

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

$\hookrightarrow \boxed{\Delta V = \frac{B\Delta x I}{n q_e A}}$

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.)

$\tau_{max} = NIAB = NI\pi r^2 B \longrightarrow (1)(1.05\times10^4\,A)(\pi)(0.65\times10^{-15}\,m)^2(2.50\,T)$

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

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) $B = \mu_0 n I$

$= (4\pi\times10^{-7})(500)(0.3) = \boxed{1.88\times10^{-4}\ T}$

b) $(4\pi\times10^{-7})(5000)(500)(0.3)$

$= \boxed{9.42\times10^{-1}\ T}$

$\hookrightarrow (1.88\times10^{-4}\ T)(5000) = 0.94\,T$

a) $F = q\vec{E}$

$F_{mag} = q(\vec{v} \times \vec{B})$

$F_{tot} = F_{elec} + F_{mag} = 0$

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

$|F_{tot}| = q[E - vB] = 0$

$E = vB \Rightarrow v = \frac{E}{B}$; $F_{net} = 0$

b) Cent. force $= \frac{mv^2}{r}$

$qvB = \frac{mv^2}{r}$

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

$v = \frac{E}{B} \Rightarrow r = \frac{m\frac{E}{B}}{qB} = \frac{mE}{qB^2}$

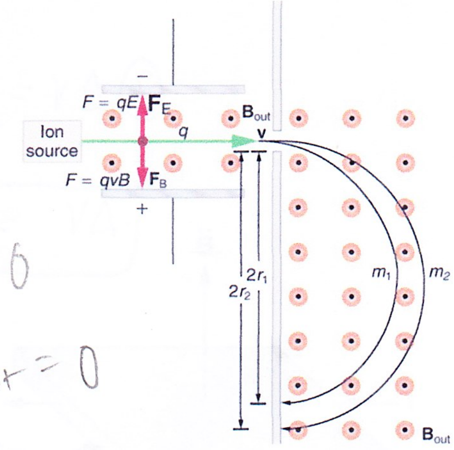

Figure 2: A basic diagram of a *toroid*, which is a solenoid wrapped into a circular tube.

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?

$r = \frac{m\frac{E}{B}}{qB} = \frac{mE}{qB^2} = \frac{(16)(1.67\times10^{-27})(10)}{(1.62\times10^{-19})(0.01)^2} \approx 1.65\times10^{-2} = 0.0165\text{ m} = \boxed{1.65\text{ cm}}$

4 Chapter 13: Electromagnetic Induction

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

$e = A\frac{dB}{dt}$

$\boxed{e = \pi r^2 \times \frac{B_0}{T_0}\sin(2\pi ft)}$

b) $t = 0$ sec

$\sin 0 = 0$

$\boxed{\text{So, enduced emf } e = 0}$

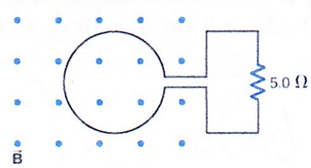

Figure 3: A voltage is induced on a loop by a changing B-field.

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

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

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?

c) $e = \pi(0.1)^2 \times \frac{0.1}{1\times10^{-3}} \times \sin(2\pi\times10^3\times0.16\times10^{-3}) = \boxed{0.055\text{ V}}$

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

[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?

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?

① $\mathcal{E} = -L\dfrac{dI}{dt}$

$$\frac{dI}{dt} = \left|-\frac{\mathcal{E}}{L}\right| = \frac{0.15\ V}{0.50\ H} = \boxed{0.3\ \frac{A}{s}}$$

② $I = 0.100\ A$

$L = 2.00\ mH = 2.00 \times 10^{-3}\ H$

$\mathcal{E} = 500\ V$

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

$$\frac{dI}{dt} = \left|-\frac{\mathcal{E}}{L}\right| = \frac{500\ V}{(2.00 \times 10^{-3}\ H)} = 250 \times 10^{-3}\ \frac{A}{s}$$

$$\frac{\cancel{d}I}{\cancel{d}t} = \frac{I}{t} \Rightarrow t = \frac{I}{dI/dt}$$

$$t = \frac{I}{dI/dt} = \frac{0.100\ A}{250 \times 10^{3}\ A/s} = \boxed{4.0 \times 10^{-7}\ sec}$$