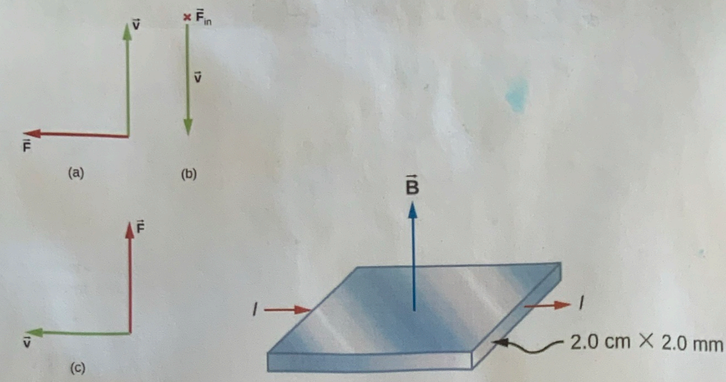

Figure 1: (Left) A current I experiences a force F in a B-field.

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: into the paper
   - b: Left
   - c: out of the paper

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

   a) I E-field = magnetic force, then: $qE = qvB$
   q cancels out, so $\therefore E = vB \rightarrow v = \frac{E}{B}$

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

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.

$\frac{1.33 \cdot 0.02 \cdot 10}{(2 \cdot 10^{28}) \cdot 0.0001 \cdot q_e} = \Delta V = -8.30 \cdot 10^{-7}$

b) $\frac{-8.30 \cdot 10^{-7}}{0.02} = -4.15 \cdot 10^{-5} = E$

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 $\times 10^{-15}$ 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.)

$\tau = NIAB\sin(\theta)$ $A = 1.33 \cdot 10^{-30}$ $N = 1$

$\tau = 1.05 \cdot 10^4 \cdot 2.50 \cdot A \cdot 1 \cdot \sin(90^\circ)$

$\tau = 3.48 \cdot 10^{-26}$ N·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?

$B = \mu_0 n I$ $B = (4\pi \cdot 10^{-7}) 500 \cdot 0.3$

a) $B = 1.9 \cdot 10^{-4}$ T

b) $B = 0.9$ T

$\frac{mE}{qB^2}$

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

$F = q\vec{v} \cdot \vec{B}$, so,

$$r = \frac{mE}{qB^2} \quad (2)$$

a) $F = qE$ & $F = qvB$, The forces equall out to 0, this is $qE = qvB \rightarrow v = \frac{E}{B}$

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?

$r = \frac{(1.67 \cdot 10^{-27} kg) \cdot 10 \frac{V}{m}}{(0.01)^2 \cdot (1.6 \cdot 10^{-19} coul)}$

$r = 1.04 \cdot 10^{-5} m$

4 Chapter 13: Electromagnetic Induction

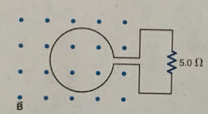

Figure 3: A voltage is induced on a loop by a changing B-field. $\mathcal{E} = -N \frac{\Delta \Phi}{\Delta t}$

$\mathcal{E} =$

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

a) emf $= \frac{\Delta(BA)}{\Delta t}$

b) 0 V

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

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) 0.055 V

$I = \frac{0.055 V}{5.0 \Omega} \approx 0.011 A$

$\frac{0.1}{0.001} (\sin(2\pi \cdot 10^3 \cdot 0.00016)) = 1.75 (\pi 0.1^2)$

d) 0.011 A

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

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?

$\frac{\Delta I}{\Delta t} = \frac{\varepsilon}{L}$ $\frac{0.150V}{0.50} = 0.3 A/s$

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?

$\cancel{500} = L$

$500 = 0.002 \frac{0.1}{\Delta t}$

$\Delta t = \frac{0.002 \cdot 0.1}{500}$

$\cancel{t = 1.0 \cdot 10^{-7} sec}$

$t = 4.0 \cdot 10^{-7} sec$