Diego Vergara

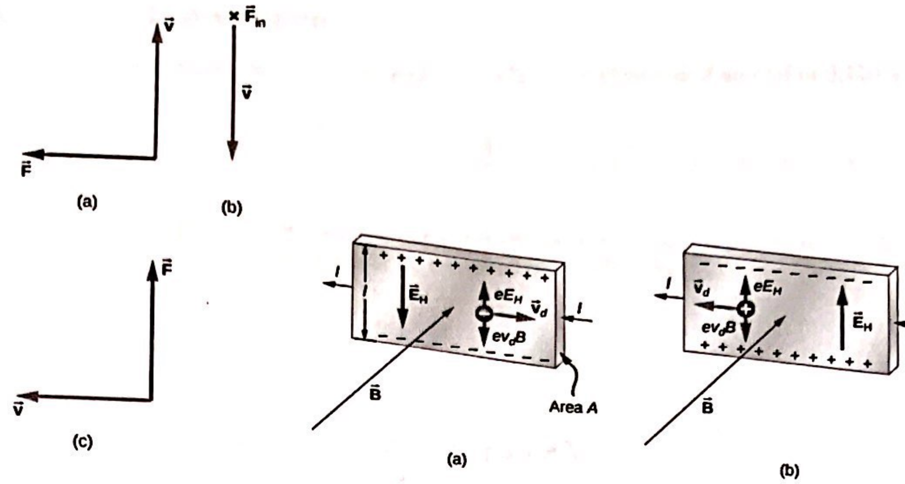

Figure 1: (Left) A current I experiences a force F in a B-field.

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: Down, into page
   - b: left
   - c: up, away from 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) $F_E = F_B \Rightarrow qE = q v B \sin\theta$, $\theta = 90°$

$qE = qvB$

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

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

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

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

$\Delta V = \frac{(1.33)(2\times10^{-2})\times 10}{2\times10^{28}(1.6\times10^{-19})(1\times10^{-6})}$

$\boxed{\Delta V = 8.312\times10^{-5}\ V}$

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.)

$\tau_{max} = N I \pi r^2 B$

$= 1(1.05\times10^4\ A)\ \pi\ (0.65\times10^{-15}\ m)^2\ (2.50\ T)$ $= \boxed{3.48\times10^{-26}\ N m}$

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?

a) $B = \mu_0 n I$

$= 4\pi\times10^{-7} \times 500 \times .3\ T$

$= \boxed{1.885\times10^{-4}\ T}$

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

$B = \boxed{.942478\ T \text{ or } 9424.8\times10^{-4}\ T}$

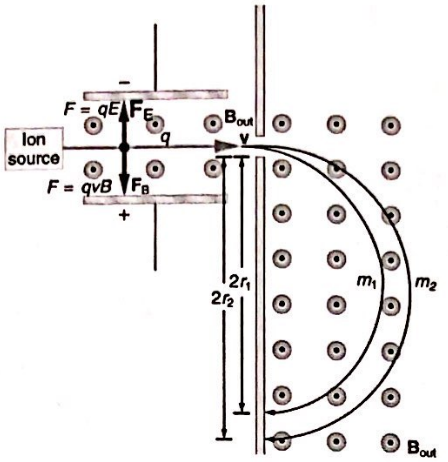

Figure 2: A basic diagram of a *toroid*, which is a solenoid wrapped into a circular tube.

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)

4 Chapter 13: Electromagnetic Induction

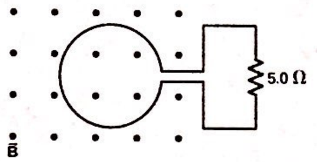

Figure 3: A voltage is induced on a loop by a changing B-field.

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) $e = \frac{d\phi}{dt} = \frac{d}{dt}(Br)$

$\boxed{e = \pi r^2 \times \frac{B_0}{T_0}\left(\frac{1}{2} + \frac{2}{\pi}\sin(2\pi ft) + \frac{2}{3\pi}(6\pi ft) + \frac{2}{5\pi}\sin(10\pi ft)\right)}$

b) $\sin 0 = 0$

$B_0\left(\frac{1}{2}\right) = B(t)$

$\boxed{B(t) = .05}$

[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?

$$\varepsilon = -L\frac{dI}{dt} \Rightarrow \frac{dI}{dt} = \left|-\frac{\varepsilon}{L}\right| = \frac{.15\ V}{.50\ H} = \boxed{.3\ A/s}$$

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?

$$\varepsilon = L\frac{dI}{dt} \Rightarrow dt = \frac{L}{\varepsilon}dI$$

$$dt = \frac{2\ mH}{500\ V}(.100\ A)$$

$$= \frac{2\ mH \cdot \frac{.001\ H}{1\ mH}}{500\ V}(.100\ A)$$

$$= \boxed{4.00 \times 10^{-7}\ s}$$

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