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4/24/2020

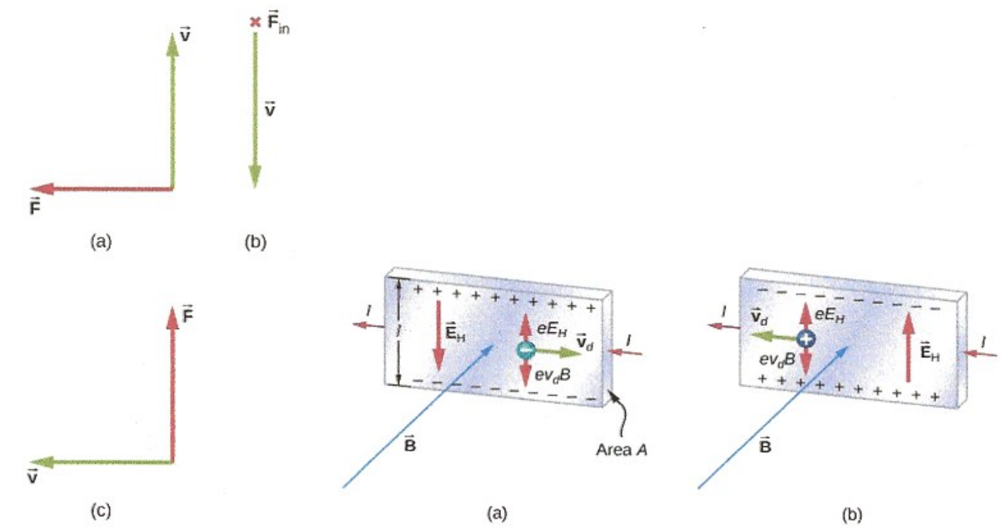

Figure 1: (Left) A current I experiences a force F in a B-field.

2 Chapter 11: Magnetic Forces and Fields

1. Consider Fig. 1 (left). In each of the three cases, determine the direction of the current given that F is the Lorentz force.

   - a: out
   - b: left
   - c: in

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

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

   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.

force B field $F_B = qvB$ — $qvB = qE$
force E field $F_E = qE$
B+ field is perpendicular $\boxed{V = E/B}$
the two force are equal
(1)

$E = \Delta V/\Delta x$
$\Delta V = E(\Delta x)$ $V = E/B$
$= Bv(\Delta x)$
(2)

$I = neAv$
$v = neA$
$v = Bi(\Delta x)/neA$
$= \dfrac{1.33\,T(10)(0.02\,m)}{(2\times10^{28})(1.9\times10^{-19})(0.001\,m)} = \boxed{7\times10^{-8}\ m/s}$

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.)

   $t_{max} = NIAB$
   $= (1.05\times10^4)(\pi(0.65\times10^{-15})^2)(2.50$
   $\boxed{t_{max} = 3.48\times10^{-26}\ N\cdot M}$

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?

   $B = \mu_0 nI = 4\pi\times10^{-7}(500)(0.3)$
   a) $\boxed{B = 1.88\times10^{-5}\,T}$
   b) $B = 5000(4\pi\times10^{-7})\times(500)(0.3)$
   $\boxed{B = 0.0942\,T}$

a) $F_e = qE$

$F_B = qvB$

$F_{total} = 0$

$qE + qvB = 0$

$q(E - vB) = 0$

$(E - vB) = 0$

$E = vB$

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

B) $F = qvB$

$F = mv^2/R$

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

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

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

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

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

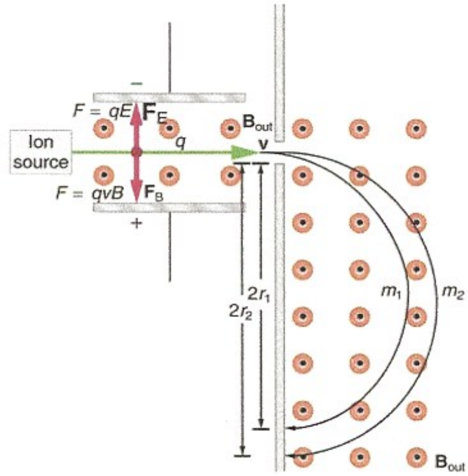

Figure 2: A basic diagram of a *toroid*, which is a solenoid wrapped into a circular tube.

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?

$r = \frac{mE}{qB^2}$ $\quad \frac{16(1.67\times10^{-27})(10)}{1.6\times10^{-19}(0.01)}$ $\quad \boxed{r = 1.67\times10^{-6}\ m}$

4 Chapter 13: Electromagnetic Induction

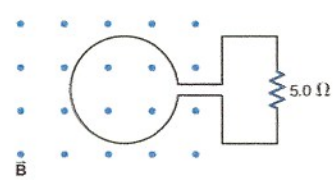

Figure 3: A voltage is induced on a loop by a changing B-field.

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

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

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?

[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?

$\Delta V = -L \cdot (dI/dt)$ $\quad \frac{dI}{dt} = \frac{(0.150)}{(0.50\ H)} = \boxed{V = 0.3\ Vs\,A^{-1}}$

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?

$500 = 2.00\ (dI/dt)$

$dt = \frac{2.00 \times 10^{-3}}{500}(0.100)$

$\boxed{dt = 4 \times 10^{-7}\ s}$