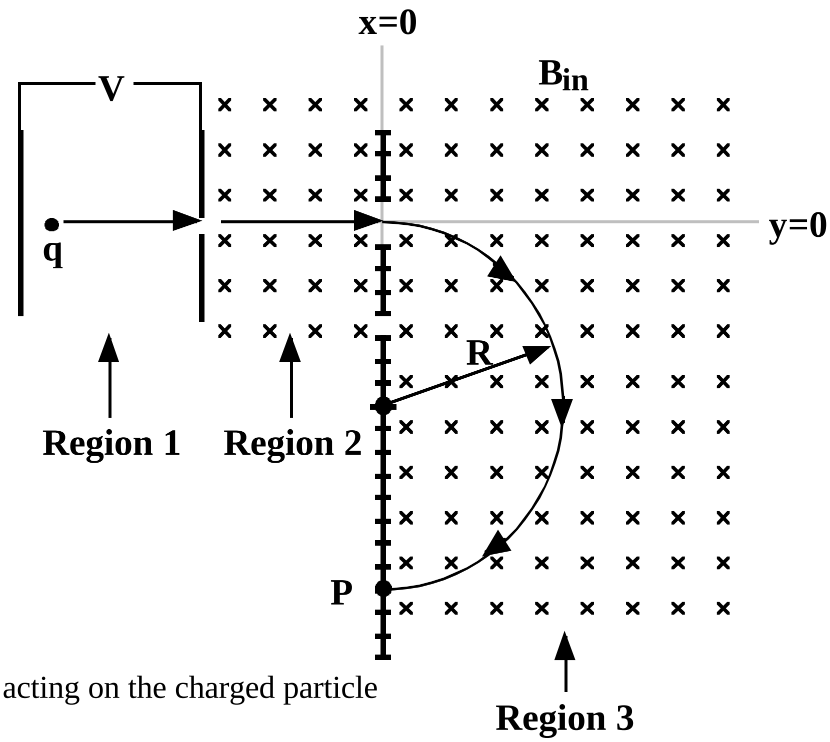
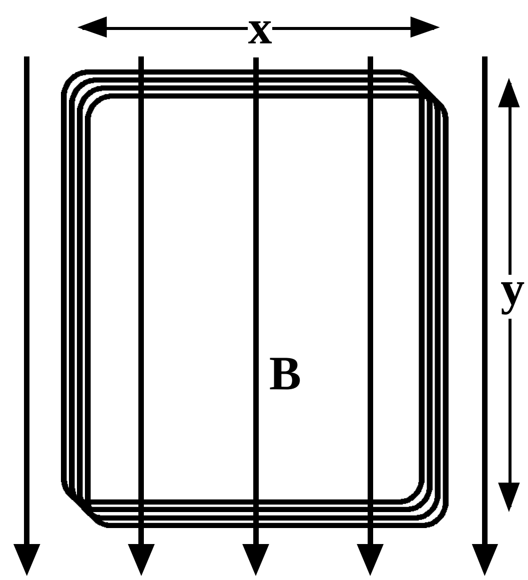
SENIOR PROJECT PHYSICS TEST 100 PTS 1997-1998

CHAPTERS 24-25 MAGNETIC FORCES AND FIELDS

OF THE FOLLOWING PROBLEMS YOU MUST DO FOUR (4)!

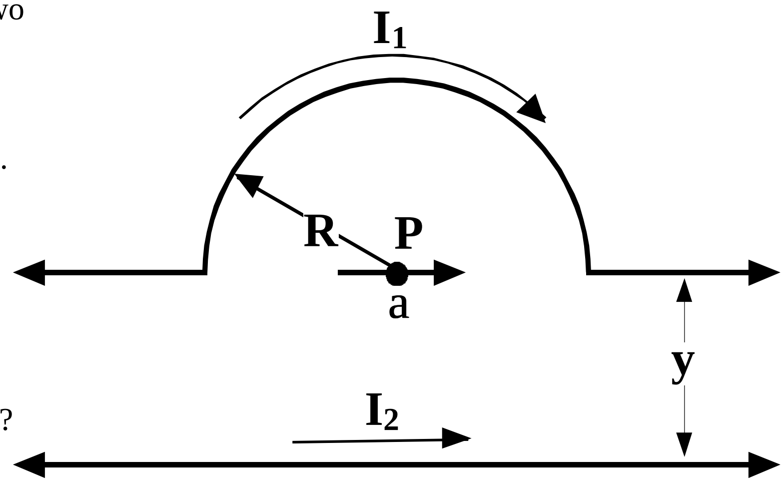


1. A particle, which has a charge of $q = -6.40 \times 10^{-19}$ C and a mass of 1.85×10^{-26} kg, is accelerated through **Region 1** by two parallel plates connected to a potential difference of V as shown to the right. When the particle reaches the second vertical plate it passes through a small hole and then passes into **Region 2** where there exist both a uniform electric field E and a uniform magnetic field B_{in} which is directed into the paper and which has a field strength of $B_{in} = 8.20$ Tesla. Finally, this charge passes into **Region 3** where there is only a magnetic field B_{in} as shown. This particle then follows a curved path until it collides with a detector at point P which is located a distance of 16.0 mm below the point where the particle entered **Region 3**.
   - A. What is the magnitude of the **magnetic force** acting on the charged particle while in Region 3? [5 pts]
   - B. What is the **speed** of this charged particle as it passes through Region 2? [5 pts]
   - C. What will be the **direction** [5 pts] and **magnitude** of the electric field **E** in **Region 2** [5 pts]?
   - D. What is the magnitude of the accelerating voltage **V** in **Region 1**? [5 pts]

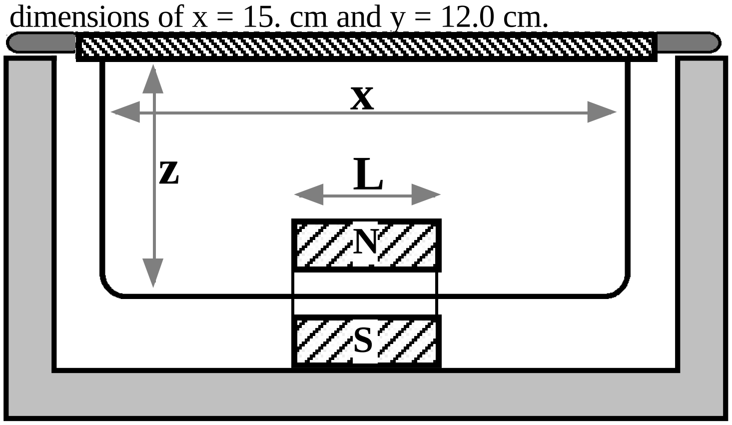


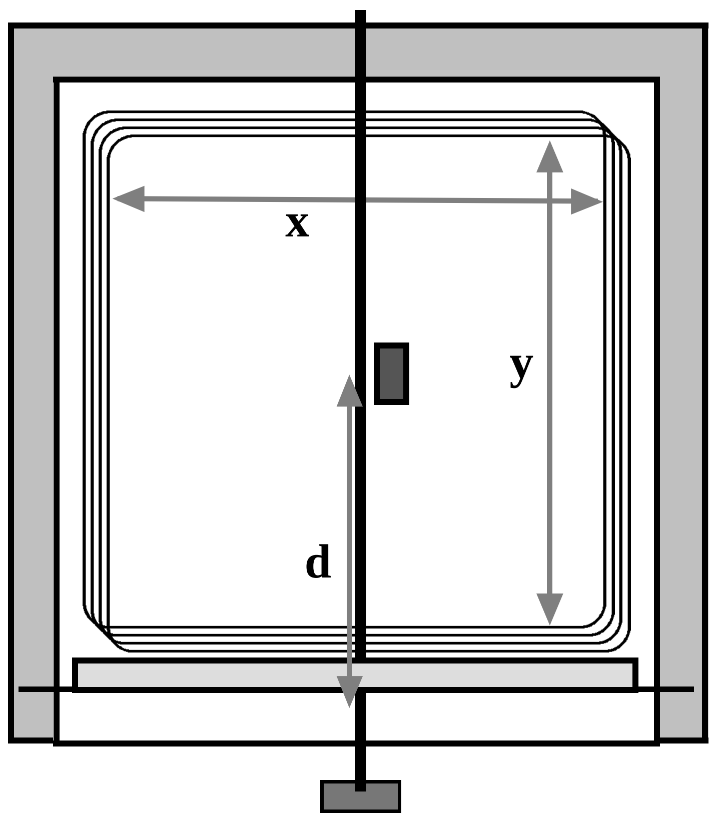
2. A coil of wire is sitting in a magnetic field which has an intensity of B = 3.25 Tesla and is directed as shown. A current of 4.90 Amps is flowing counter-clockwise around the coil. The coil is x = 12.0 cm wide, y = 17.0 cm high and contains 200 loops.
   - A. What will be the direction and the magnitude of the magnetic force on the upper segment of the coil? Explain! [5 pts]
   - B. What will be the direction and the magnitude of the magnetic force on the left segment of the coil? Explain! [5 pts]
   - C. What will be the magnitude and direction of the resulting torque acting on this coil? [5 pts]
   - D. What is the magnetic moment of this coil? [5 pts]
   - E. What would be the resulting effect on the coil if the magnetic field B was directed out of the paper rather than as shown? [5 pts]

3. The diagram at the right shows the currents through two wires. The first current is I_1 = 11.5 Amperes and the second current is I_2 = 7.50 Amperes. The distance between the wires is y = 4.50 cm and the curved portion of the upper loop has a radius of R = 5.50 cm. An Alpha particle, which has a mass of 6.7 x 10^{-27} kg and a charge of 3.2 x 10^{-19} kg., is moving in the direction shown at point P with a speed of 4.80 x 10^{6} m/sec. [Note that not all of each wire is shown in the diagram, each wire extends off to infinity!] What will be the direction [5 pts] and magnitude [20 pts] of the magnetic force acting on the Alpha particle at point P?



4. . The two diagrams below describe the the lab where a wire loop is suspended in a magnetic field B. The length of the horizontal section of the suspended wire is x = 15.0 cm., the distance between the suspended section of the loop and the center of rotation is z = 8.50 cm, the width of the permanent magnet is L = 2.75 cm, the coil in the bottom of the box contains N = 20 loops and has dimensions of x = 15. cm and y = 12.0 cm.





In the first step of this lab the magnetic field of the permanent magnet is measured with a Voltmeter which was calibrated to read 8.5 Volts when exposed to a magnetic field of 850 Gauss. The reading on the Voltmeter is 5.25 Volts. The suspended loop is connected to a power supply and ammeter. A counter weight of 500 milligrams is placed on the crossbar a distance of d = 18.0 cm from the center of rotation so as to generate equilibrium.

A. What is the **direction** and **magnitude** of the current flowing in the suspended loop? [5 + 5 pts]

The permanent magnet is removed and the coil in the bottom of the box is connected in series with the suspended loop so that the current through the ammeter is now 7.50 Amperes. The 500 milligram weight is replaced by a 100 milligram weight which is placed d = 9.70 cm from the center of rotation so as to generate equilibrium.

B. What is the distance between the suspended wire and the coil of wire in the bottom of the box? [15 pts]

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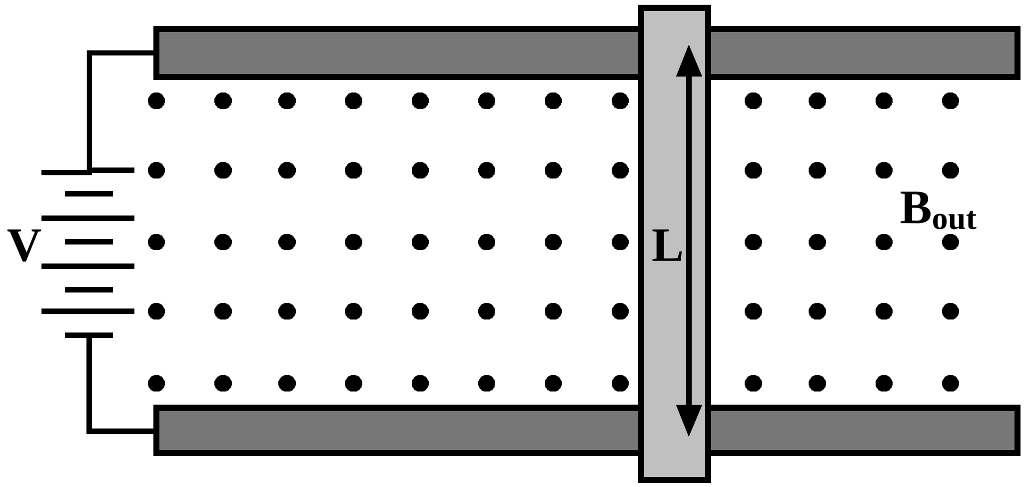
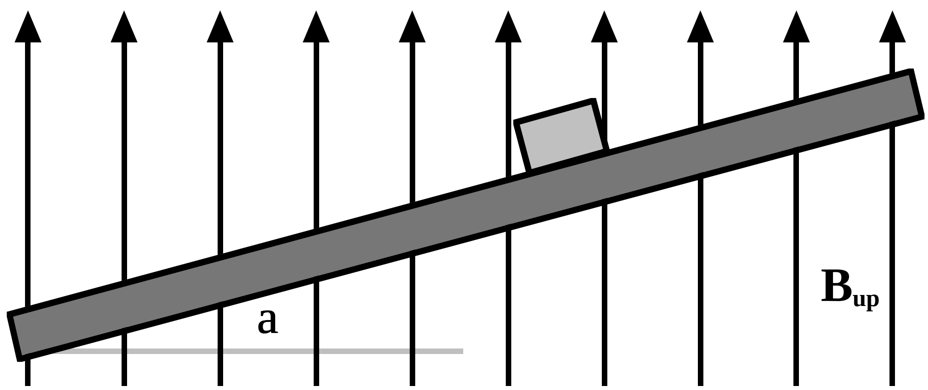
5. Consider two parallel rails which are 15.0 cm apart. The two rails are connected together by a variable DC power supply. A bar, which has a resistance of 3.0 Ω and a mass of 225 grams, is placed across the two rails as shown. The entire apparatus is placed in a vertical, uniform magnetic field which has an intensity of B = 7.25 Tesla. The apparatus is tilted at an angle $\alpha = 28.0^{o}$ as shown in the second diagram. The coefficient of between the bar and the rails is $\mu = 0.220$. The power supply is adjusted until the bar remains stationary. What is the direction [5 pts] and magnitude [20 pts] of the DC voltage being applied by the power supply?





SP Physics Test 1997-98 Magnetic Forces and Fields

1. $q := -6.4 \cdot 10^{-19} \cdot C$ $m_q := 1.85 \cdot 10^{-26} \cdot kg$ $B_{in} := 8.20 \cdot T$ $r := 8.0 \cdot mm$

a. $\frac{m_q \cdot v^2}{r} = q \cdot v \cdot B_{in}$ $v := \left| q \cdot \frac{B_{in}}{m_q} \cdot r \right|$ $v = 2.269 \times 10^6 \frac{m}{sec}$

$F_m := \frac{m_q \cdot v^2}{r}$ $F_m = 1.191 \times 10^{-11} N$ **1a. The magnetic force acting on the charged particle. [5 pts]**

b. $v = 2.269 \times 10^6 \frac{m}{sec}$ **1b. The speed of the charged particle within the magnetic field. [5 pts]**

c. $q \cdot v \cdot B_{in} = E \cdot q$ $E := v \cdot B_{in}$ $E = 1.861 \times 10^7 \frac{N}{C}$ **1c. The required electric field will be directed toward the bottom of the page[5 pts] with the given magnitude. [5 pts]**

d. $V \cdot q = \frac{1}{2} \cdot m_q \cdot v^2$ $V := \left| \frac{1}{2} \cdot \frac{m_q \cdot v^2}{q} \right|$ $V = 74436 \, volt$ **1d. The required accelerating potential. [5 pts]**

2. $B := 3.26 \cdot T$ $I := 4.90 \cdot A$ $x := 12 \cdot cm$ $y := 17 \cdot cm$ $n := 200$

a. $F_m := I \cdot n \cdot x \cdot B$ $F_m = 383 \, N$ **2a. The magnetic force acting on the upper segment is directed OUT of the paper. [5 pts]**

b. $F_{mleft} := 0 \cdot N$ **2b. There will be NO magnetic force acting on this segment since it is parallel to the magnetic field. [5 pts]**

c. $T := 2 \cdot n \cdot I \cdot x \cdot \frac{y}{2} \cdot B$ $T = 65.174 \, N \cdot m$ **2c. The maximum torque exerted on this coil of wire. [5 ptsp]**
[Top out of page, bottom into page.]

d. $mm := n \cdot I \cdot (x \cdot y)$ $mm = 19.992 \frac{N \cdot m}{T}$ **2d. The magnetic moment of this coil. [5 pts]**

e. **If the magnetic field was directed out of the page the resulting effect would be for the coil to be stretched outward. [5 pts]**

3. $I_1 := 11.5 \cdot A$ $I_2 := 7.5 \cdot A$ $y := 4.58cm$ $R := 5.50 \cdot cm$ $v := 4.8 \cdot 10^6 \cdot \frac{m}{sec}$ $q := 3.2 \cdot 10^{-19} \cdot C$ $\mu_o := 4 \cdot \pi \cdot 10^{-7} \frac{N}{A^2}$

$B_2 := \frac{\mu_o \cdot I_2}{2 \cdot \pi \cdot y}$ $B_2 = 3.275 \times 10^{-5} T$ **out** $B_1 := \frac{\mu_o}{4 \cdot \pi} \cdot \frac{I_1 \cdot \pi \cdot R}{R^2}$ $B_1 = 6.569 \times 10^{-5} T$ **in**

$B_{total} := B_2 - B_1$ $B_{total} = -3.294 \times 10^{-5} T$ **in**

$F_m := q \cdot v \cdot B_{total}$ $F_m = -5.059 \times 10^{-17} N$ **top of page** **3. The direction [5 pts] and the magnitude of the magnetic force acting on the alpha particle. [20 pts]**

4. $x := 15 \cdot cm$ $z := 8.5 \cdot cm$ $L := 2.75 \cdot cm$ $n := 20$ $y := 12 \cdot cm$ $V_{max} := 8.5 \cdot volt$ $V := 5.25 \cdot volt$ $B_m := 850 \cdot gauss$

$counterweight := 500 \cdot mg$ $d := 18.0 \cdot cm$ $T_1 := counterweight \cdot g \cdot d$ $T_1 = 8.826 \times 10^{-4} \, N \cdot m$

$B_{magnet} := 525 \cdot gauss$ $T_2 = I \cdot L \cdot B_{magnet} \cdot z$

a. $I := \frac{T_1}{(L \cdot B_{magnet} \cdot z)}$ $I = 7.192\,A$ **right** **4a. The current through the wire [5 pts] is directed toward the right. [5 pts]**

b. $I := 7.5 \cdot A$ $counterweight := 100 \cdot mg$ $d := 9.7cm$

$B_1 = \frac{\mu_o \cdot I_1}{2 \cdot \pi \cdot R}$ $F_m = I_2 \cdot L \cdot B_1 = I_2 \cdot L \cdot \frac{\mu_o \cdot I_1}{2 \cdot \pi \cdot R}$ $F_m = \frac{counterweight \cdot g \cdot d}{z}$

$\frac{counterweight \cdot g \cdot d}{z} = I_2 \cdot L \cdot \frac{\mu_o \cdot I_1}{2 \cdot \pi \cdot R}$ $L := x$ $L = 0.15\,m$ $I_1 := 7.5 \cdot A$ $I_2 := I_1$ $I_2 = 7.5\,A$

$R := \frac{1}{2} \cdot I_2 \cdot L \cdot \mu_o \cdot I_1 \cdot \frac{z}{[counterweight \cdot [g \cdot (d \cdot \pi)]]}$ $R = 1.508 \times 10^{-3}\,m$ **4b. The disance between the wires when at equilibrium. [15 pts]**

5. $L := 15.0 \cdot cm$ $R := 3.0 \cdot ohm$ $m_{bar} := 225 \cdot gm$ $B := 7.25 \cdot tesla$ $\alpha := 28 \cdot deg$ $\mu := 0.220$ $F_m := 100 \cdot N$

Given $F_m \cdot \cos(\alpha) = m_{bar} \cdot g \cdot \sin(\alpha) - \mu \cdot (F_m \cdot \sin(\alpha) + m_{bar} \cdot g \cdot \cos(\alpha))$

$F_m := Find(F_m)$ $F_m = 0.616\,N$

$F_m = \frac{V}{R} \cdot L \cdot B \cdot \cos(\alpha)$ $V := F_m \cdot \frac{R}{[L \cdot (B \cdot \cos(\alpha))]}$ $V = 1.924\,volt$ **5. The voltage applied by the battery [20 pts] must be directed counter-clockwise. [5 pts]**

$I := \frac{V}{R}$ $I = 0.641\,A$