

Name: \_\_\_\_\_

1. A circuit is set up as shown. Determine (a) the total resistance, (b) the total current, (c) the battery's voltage, and (d) the power dissipated by the  $85.0 \Omega$  resistor.

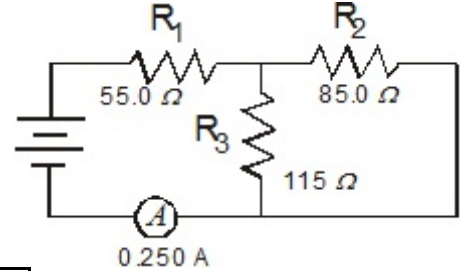
$$\begin{aligned} \text{a. } R_T &= R_1 + (R_2^{-1} + R_3^{-1})^{-1} = 55.0 \Omega + ((85.0^{-1} \Omega) + (115^{-1} \Omega)) \\ &= 103.875 \Omega = \boxed{104 \Omega} \end{aligned}$$

$$\text{b. } I_T = \boxed{0.250 \text{ A}} \quad (\text{as shown by ammeter})$$

$$\text{c. } V = RI = 103.875 \Omega \cdot 0.250 \text{ A} = 25.96875 \text{ V} = \boxed{26.0 \text{ V}}$$

$$\text{d. } V_{85} = V_T - V_{55} = 25.96875 \text{ V} - (0.250 \text{ A} \cdot 55.0 \Omega) = 12.21875 \text{ V}$$

$$P_{85} = V_{85}^2 / R_{85} = (12.21875 \text{ V})^2 / 85.0 \Omega = 1.75644531 \text{ W} = \boxed{1.76 \text{ W}}$$



2. What is the magnetic field 2.50 cm from a straight wire carrying a current of 0.858 A? If the current is from left to right, what is the direction of the magnetic field?

$$\begin{aligned} B &= \mu_0 I / 2\pi r = (4\pi \times 10^{-7} \text{ T}\cdot\text{m/A} \cdot 0.858 \text{ A}) / (2\pi \cdot 0.0250 \text{ m}) \\ &= 6.864 \times 10^{-6} \text{ T} = \boxed{6.86 \times 10^{-6} \text{ T or } 6.86 \mu\text{T}} \end{aligned}$$

The magnetic field is going in a circle around the wire coming out of the paper toward the reader on top of the wire and going back into the paper below the wire.

3. Two wires run parallel to each other. They are both 35.0 cm in length. They are separated by 5.00 cm. The wire on the left is carrying a current of 1.20 A and the wire on the right is carrying a current of 0.850 A. The currents have opposite directions. What is the force that is acting between them?

$$\begin{aligned} F_1 &= I_1 \ell_1 B_2 = I_1 \ell_1 (\mu_0 \cdot I_2) / 2\pi r = 1.20 \text{ A} \cdot 0.350 \text{ m} (4\pi \times 10^{-7} \text{ T}\cdot\text{m/A} \cdot 0.850 \text{ A}) / 2\pi \cdot 0.00500 \text{ m} \\ &= 1.428 \times 10^{-6} \text{ N} = \boxed{1.43 \times 10^{-6} \text{ N or } 1.43 \mu\text{N}} \end{aligned}$$

Directionality: Imagine the wires as 2 vertical lines on the page. The current on the left is traveling upward, on the right downward. By the right hand rule, the magnetic field from the wire on the right would be going into the page where the wire on the left is. This would cause the force to push the wire on the left further to the left or away from the wire on the right (using the other right hand rule).

4. Using Newton's second law and the magnetic force law, derive the equation for the radius of the circular path of charge that moves perpendicular to a uniform magnetic field.

$$F_c = F_B$$

$$mv^2/r = qvB\sin\theta \quad (\text{if } \theta = 90^\circ, \text{ path is perpendicular to magnetic field, then } \sin\theta = 1)$$

$$r = (mv^2)/(qvB)$$

5. A long straight wire carries a current of 5.00 A. At one instant a proton, 4.00 mm from the wire, travels at  $1.50 \times 10^5$  m/s parallel to the wire and in the same direction as the current. Find (a) the magnitude and direction of the magnetic force that is acting on the proton because of the magnetic field produced by the wire.

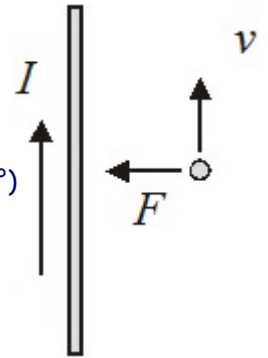
a. direction of force - see diagram

magnitude:

$$F_B = qvB\sin\theta = qv(\mu_0 I / 2\pi r)\sin\theta$$

$$= 1.60 \times 10^{-19} \text{ C} \cdot 1.50 \times 10^5 \text{ (} 4\pi \times 10^{-7} \text{ T}\cdot\text{m/A} \cdot 5.00 \text{ A) / (} 2\pi \cdot 0.00400 \text{ m) } \cdot \sin(90^\circ)$$

$$= \boxed{6.00 \times 10^{-18} \text{ N or } 6.00 \text{ aN}}$$



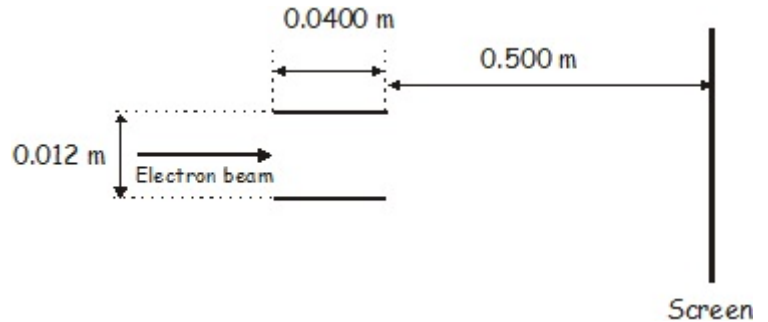
6. In a television set, electrons are accelerated from rest through a potential difference in an electron gun. They then pass through deflecting plates before striking the screen.
- a. Determine the potential difference through which the electrons must be accelerated in the electron gun in order to have a speed of  $6.0 \times 10^7$  m/s when they enter the deflecting plates.

a.  $\frac{1}{2}mv^2 = qV$

$$V = \frac{1}{2}mv^2/q = 0.5 \cdot 9.11 \times 10^{-31} \text{ kg} (6.0 \times 10^7 \text{ m/s})^2 / 1.60 \times 10^{-19} \text{ C}$$

$$= 10\,248.75 \text{ V} = \boxed{1.0 \times 10^4 \text{ V or } 10. \text{ kV}}$$

The pair of horizontal plates shown to the right is used to deflect electrons up or down in the television set by placing a potential difference across them. The plates have a length of 0.0400 m and a separation of 0.012 m, and the right edge of the plates is 0.500 m from the screen. A potential difference of 200.0 V is applied across the plates, and the electrons are deflected toward the top of the screen. Assume the electrons enter the plates with a speed of  $6.0 \times 10^7$  m/s and the fringing at the edges of the plates and gravity are negligible.



- b. Which plate in the pair must be at the higher potential (more positive) for the electrons to be deflected upward? Justify your answer.
- c. Considering only an electron's motion as it moves through the space between the plates, answer the following:
- The time for the electron to move through the plates.
  - The vertical displacement of the electron while it is between the plates.
  - Why it is reasonable to ignore gravity.
  - Describe the path of the electrons from when they leave the plate until they hit the screen. State a reason for your answer. (Feel free to use the back of this sheet.)
- b. To deflect the electrons upward, the upper plate must be more positive as opposite charges attract. And if the upper plate is positive, then the electric field between the plates would point from the top plate to the bottom plate, and electrons move in the direction opposite the electric field as they have a negative charge.

c. i.  $t = d/v = 0.0400 \text{ m} / 6.0 \times 10^7 \text{ m/s} = 6.66666667 \times 10^{-10} \text{ s} = \boxed{6.67 \times 10^{-10} \text{ s or } 0.667 \text{ ns}}$

ii.  $F = qE = ma$  so  $a = qE/m$

$$d = \frac{1}{2}at^2 = 0.5 \cdot (1.6 \times 10^{-19} \text{ C} \cdot (200.0 \text{ V} / 0.012 \text{ m}) / 9.11 \times 10^{-31} \text{ kg}) \cdot (6.67 \times 10^{-10} \text{ s})^2$$

$$= 6.50485832 \times 10^{-4} \text{ m} = \boxed{0.650 \times 10^{-3} \text{ m or } 0.650 \text{ mm}}$$

- iii. Gravity can be ignored because the acceleration due to the charged plates was on the order of  $10^{15} \text{ m/s}^2$  whereas gravity is only  $9.81 \text{ m/s}^2$ . In other words, gravity had very little effect on the electrons compared to the charged plates.
- iv. The electrons would travel in an almost straight line after leaving the plates until hitting the screen. There would be some very tiny effect due to gravity, but considering the electrons are traveling at  $6.0 \times 10^7$  m/s and only going a distance of half a meter, there won't be much time for gravity to pull the electrons downward.