Name_____

Physics 111 Quiz #2, October 14, 2022

Please show all work, thoughts and/or reasoning in order to receive partial credit. The quiz is worth 10 points total.

I affirm that I have carried out my academic endeavors with full academic honesty.

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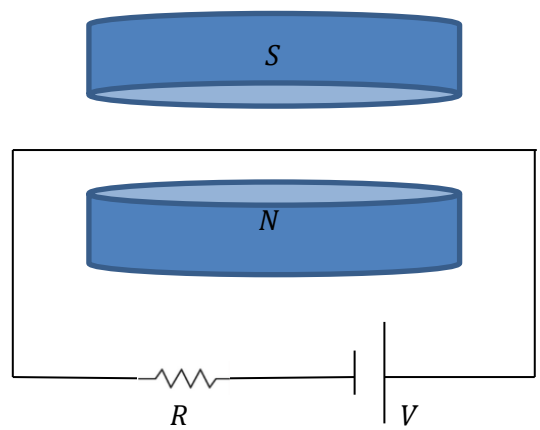
1. A gold wire (with dimeter $d_{wire} = 1mm$) is oriented parallel to the poles of a magnet of strength B, as shown below. The poles of the magnet are circular with a diameter $20cm$. Gold is known to have a density of $19300\frac{kg}{m^3}$, a molecular mass $197\frac{g}{mol}$ and donates one charge carrier per atom. If the wire is connected to a $100V$ battery and a 1000Ω resistor, what is the drift velocity of the charge carriers in the gold wire?

   $I = neAv_d \rightarrow v_d = \frac{I}{neA} = \frac{V}{RneA}$

   $$v_d = \frac{100V}{1000\Omega \times 5.9 \times 10^{28}m^{-3} \times 1.6 \times 10^{-19}C \times \pi(0.5 \times 10^{-3}m)^2} = 1.35 \times 10^{-5}\frac{m}{s}$$

   Where, $n = \frac{\rho_{Au}}{m_{Au}} \times N_A = \frac{19300\frac{kg}{m^3}}{0.197\frac{kg}{mol}} \times 6.02 \times 10^{23} = 5.9 \times 10^{28}m^{-3}$



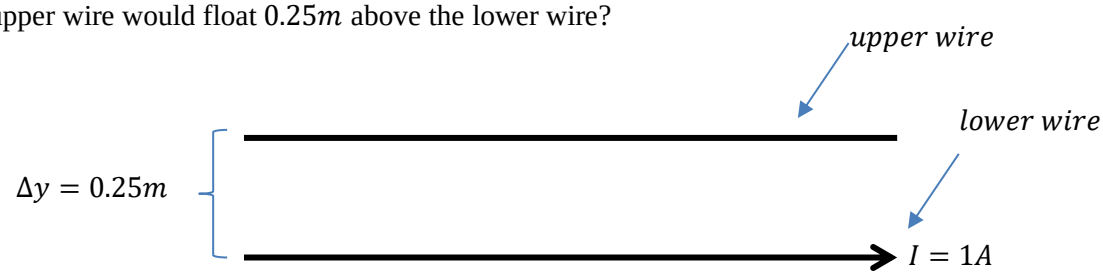
2. If the magnet has a field strength $B = 0.2T$, what Hall voltage would be measured across the diameter of the wire?

   $V_{Hall} = wv_dB = 1 \times 10^{-3}m \times 1.35 \times 10^{-5}\frac{m}{s} \times 0.2T = 2.7 \times 10^{-9}V$

3. What magnetic force would the wire experience in this magnetic field?

$F_B = ILB\sin\theta = 0.1A \times 0.2m \times 0.2T \times \sin 90 = 4 \times 10^{-3}N$ into the page.

4. Suppose you have two long straight wires shown below. The upper wire is parallel to the lower wire and has a mass per unit length of $0.02\frac{kg}{m}$. The lower wire has a current of flowing from left to right (to east). What is the direction of the current that would have to flow in the upper wire so that the upper wire would float $0.25m$ above the lower wire?



In order to levitate the upper wire, we need the magnetic force on the upper wire to be up the plane of the page. Since the magnetic field from the lower wire points out of the page at the upper wire and by the right-hand-rule the current needs to flow from the right to left across the page (or to the west) to levitate the wire.

5. What magnitude of current would have to flow in the upper wire so the upper wire will float $0.25m$ above the lower wire?

$$F_B - F_W = ma_y = 0 \rightarrow F_B = F_W \rightarrow ILB = mg \rightarrow I = \frac{mg}{LB} = \frac{0.02\frac{kg}{m}\times 9.8\frac{m}{s^2}}{8\times 10^{-7}T} = 2.45 \times 10^6 A$$

Where the magnetic field at the upper wire due to the lower wire is: $B = \frac{\mu_0 I}{2\pi r} = \frac{4\pi\times 10^{-7}\frac{Tm}{A}\times 1A}{2\pi\times 0.25m} = 8 \times 10^{-7}T$