Midterm 2

PHYS 2020, spring 2016, Michelle Arnold

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Seat:

Instructions

Multiple choice: There is only one correct answer to each multiple choice questions. Circle the letter of the answer you choose, and make sure if you change your mind it is clear which of the two answers you want as your actual answer.

Problems: Show all of your work for full credit.

Total points possible: 30
Multiple Choice (6 x 1.5 = 9 points)

1. A charged particle is moving with velocity v, and enters a region that contains a magnetic field. In general, which of the following is NOT a possible path that a charged particle might travel within a magnetic field?

   a. a straight line
   b. a circular curve
   c. a helical curve
   d. all of the above are possible paths for a charged particle to travel within a magnetic field

2. A transformer consists of 50 turns in the primary coil and 400 turns in the secondary coil. If the current in the primary coil is 12 A, what is the current in the secondary coil?

   a. 0.67 A
   b. 1.5 A
   c. 96 A
   d. 600 A
   e. none of the above

3. A charged object enters a region which has a magnetic field pointing out of the page, and follows the path shown below. What is the charge on the object?

   a. the object is positively charged
   b. the object is negatively charged
   c. the object may be positively charged or negatively charged
   d. the object does not have a charge

4. Current is flowing through a square loop wire, which is located in a magnetic field as shown below. The loop is free to rotate about the axis indicated. As viewed from above, which statement is true in regards to the rotation of the loop?

   a. the loop will rotate clockwise as viewed from above
   b. the loop will rotate counterclockwise as viewed from above
   c. the loop will remain stationary, it will not rotate
   d. not enough information is given to determine whether or not the loop rotates
5. A loop of wire is next to a long straight wire which originally has a current of 5 A running through it. The current in the long straight wire is then reduced from 5 A to 2 A. While the current is being decreased, is a current induced in the nearby coil, and if so in which direction?

**Diagram:**
- A loop of wire with a current of 5 A running through it.
- A long straight wire with a current of 2 A, decreasing to 0.

**Options:**
- a. a clockwise current is induced in the coil
- b. a counter clockwise current is induced in the coil
- c. the magnetic field inside the coil changes but no current is induced
- d. the magnetic field inside the coil does not change and no current is produced

**Answer:** a clockwise current is induced in the coil

6. If the magnetic field in the center of the two loops drawn below is zero, what can you say about the relationship between the two currents?

**Diagram:**
- Two loops with currents labeled as $I_1$ and $I_2$.

**Options:**
- a. $I_1$ is larger than $I_2$ and they are both in the same direction
- b. $I_1$ is larger than $I_2$ and they are in opposite directions (one clockwise and one counterclockwise)
- c. $I_1$ is smaller than $I_2$ and they are both in the same direction
- d. $I_1$ is smaller than $I_2$ and they are in opposite directions (one clockwise and one counterclockwise)
- e. no relationship between the two currents can be determined

**Answer:** b. $I_1$ is larger than $I_2$ and they are in opposite directions (one clockwise and one counterclockwise)

Problems

7. [2 points] We spent about two thirds of a class discussing RLC circuits, connected to an AC voltage source. What is the importance of RLC circuits (AC)? That is, what practical application are they used for?

**Answer:**

RLC circuits only allow current to flow for a resonant frequency of the circuit.

This is used to tune or select a specific frequency, such as for radio transmitting and receiving.
8. A light bulb with resistance of 288 Ω is connected to an AC power supply that has the maximum (peak) voltage set to 340 V.

   a. [3 points] What will be the average power output of the light bulb?

   \[ P = \frac{V^2}{R} \]

   \[ V = 340 \text{ V peak} \]

   \[ V_{\text{rms}} = \frac{1}{\sqrt{2}} V \]

   \[ V_{\text{rms}} = \frac{1}{\sqrt{2}} (340) \]

   \[ V_{\text{rms}} = 240 \text{ V} \]

   \[ P_{\text{avg}} = \frac{V_{\text{rms}}^2}{R} = \frac{(240)^2}{288} = 199.8 \text{ watts} \]

   b. [3 points] What will be the maximum power output of the light bulb?

   \[ P_{\text{max}} = V_{\text{max}} I_{\text{rms}} = \sqrt{2} V_{\text{rms}} I_{\text{rms}} = 2V_{\text{rms}} I_{\text{rms}} = 2P_{\text{avg}} \]

   \[ P_{\text{max}} = 2(199.8) = 400 \text{ watts} \]

9. a. [4 points] A (positively charged) helium ion in a region with a 0.8 T magnetic field, directed perpendicular to the direction of its velocity. The helium ion travels in a circle of radius 25 cm, completing 14 million revolutions per second (as drawn below). How many electrons is the helium ion missing?

   \[ \text{speed} = \frac{\text{distance}}{\text{time}} = \frac{61,000,000 \text{ cm}}{1 \text{ s}} = 9.6 \times 10^7 \text{ m/s} \]

   \[ r = \frac{mv}{qB} \]

   \[ q = \frac{mv}{rB} \]

   \[ q = \frac{(6.65 \times 10^{-8} \text{ kg})(9.6 \times 10^7 \text{ m/s})}{(0.025 \text{ m})(0.8 \text{ T})} \]

   \[ q = 3.2 \times 10^{-19} \text{ C} \]

   \[ q = 1 \text{ missing electron} \]

   b. [1 point] What direction is the magnetic field that produces this motion?

   Out of the page
10. a. [3 points] What is the magnitude and the direction of the magnetic field at point A in the figure, below the two long straight wires?

\[ B = B_1 + B_2 \]
\[ B = \frac{N_1 I_1}{2\pi r_1} + \frac{N_2 I_2}{2\pi r_2} \]
\[ B = \frac{(447 \times 10^{-6})(2A)}{2\pi (0.11m)} \hat{\theta} + \frac{(447 \times 10^{-6})(5A)}{2\pi (0.03m)} \hat{\theta} \]
\[ B = 3.6 \times 10^{-6} \hat{\theta} + 3.3 \times 10^{-5} \hat{\theta} \]
\[ B = 2.97 \times 10^{-5} \hat{\theta} \]
\[ = 30 \mu T \]

b. [1 point] What is the direction of the force that wire 1 exerts on wire 2? repelled down

11. a. [3 points] Electricity is a way of transferring energy from one location to another. Explain how the mechanical energy of blowing wind or running water can be used to create an AC current of electricity (and thus carry the wind/water energy to far away locations).

See notes describing a generator

As the loop rotates within a magnetic field, the magnetic flux (amount of magnetism) enclosed by the loop changes. A change in magnetic flux induces a current.

b. [1 point] What is the name of this device that converts wind/water energy to electrical energy? generator