Midterm Exam No. 03 (2016 Spring)

PHYS 205B: University Physics

Date: 2016 Apr 26

____________________ (Name) ____________________ (Signature)

Instructions

1. Seating direction: Please be seated on seats with seat-numbers divisible by 4.
2. Total time = 75 minutes.
3. There are 10 questions in this exam.
4. Equation sheet is provided separately.
5. To be considered for partial credit you need to show your work in detail and organize it clearly.
6. A simple calculator (with trigonometric functions) is allowed.
7. Use of mobile phones is strictly prohibited. It should stay out of reach during the exam.

1. (**10 points.**) An electron that has velocity $\vec{\mathbf{v}} = (2.1 \times 10^6\,\mathrm{m/s})\,\hat{\mathbf{i}} + (2.7 \times 10^6\,\mathrm{m/s})\,\hat{\mathbf{j}}$ moves through a magnetic field $\vec{\mathbf{B}} = (0.03\,\mathrm{T})\,\hat{\mathbf{i}} - (0.15\,\mathrm{T})\,\hat{\mathbf{j}}$. Find the force on the electron.

2. (**10 points.**) An electric field of 1.52 kV/m and a magnetic field of 0.375 T act on a moving proton to produce no net force. (Neglect the gravitational force on the proton.) If the fields are perpendicular to each other, and the velocity of the proton is perpendicular to the magnetic field, what is the proton's speed?

3. (**10 points.**) A loop in the shape of a right triangle, carrying a current I, is placed in a magnetic field $\vec{\mathbf{B}}$. (Choose $\hat{\mathbf{z}}$ to be out of the page.) Find the analytic expression for the magnetic force on side '2' of the loop in terms of I, B, x, y, and unit vectors $\vec{\mathbf{i}}$, $\vec{\mathbf{j}}$, $\vec{\mathbf{k}}$.

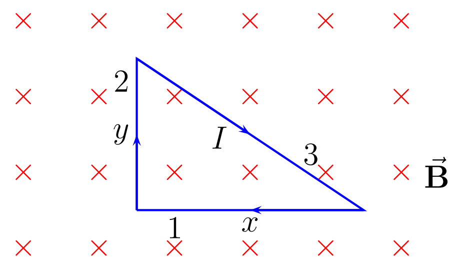

Figure 1: Problem 3.

4. (**10 points.**) Figure 2 shows two current carrying wires, separated by a distance $D = 10.0\,\mathrm{cm}$. The currents in the wires are $I_1 = 2.0\,\mathrm{A}$ and $I_2 = 6.0\,\mathrm{A}$, both coming out of the page. Determine the point $\times$ where the magnetic field is exactly zero.

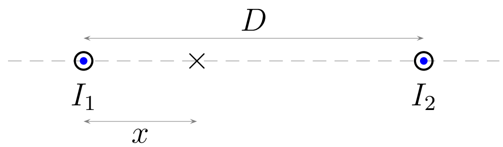

Figure 2: Problem 4.

5. (**10 points.**) Figure 3 shows two current carrying wires, in a plane. The directions of currents, either going into the page or coming out of the page, are shown in the figure. Determine the magnitude and direction of the magnetic field at the point $\times$, the origin. Let $I_1 = 3.0\,\mathrm{A}$, $I_2 = 2.0\,\mathrm{A}$, $x = 12\,\mathrm{cm}$, and $y = 8.0\,\mathrm{cm}$.

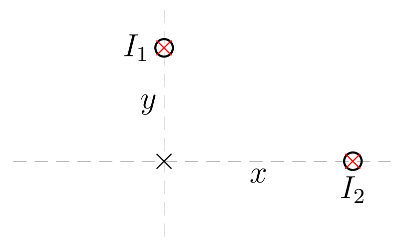

Figure 3: Problem 5.

6. (**10 points.**) A rectangular loop of wire carrying current $I_2 = 2.0\,\mathrm{A}$ is placed near an infinitely long wire carrying current $I_1 = 1.0\,\mathrm{A}$, such that two of the sides of the rectangle are parallel to the current I_1. See Figure 4. Let the distances be $a = 5.0\,\mathrm{cm}$, $b = 4.0\,\mathrm{cm}$, and $l = 10.0\,\mathrm{cm}$. Determine the magnitude and direction of the force on side '3' of the loop.

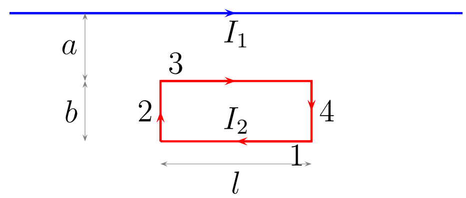

Figure 4: Problem 6.

7. (**10 points.**) A square loop of wire consisting of a single turn is perpendicular to a uniform magnetic field. The square loop is then re-formed into a circular loop and is also perpendicular to the same magnetic field. Determine the ratio of the flux through the square loop to the flux through the circular loop.

8. (**10 points.**) Figure 5 shows a conducting rod being pulled along horizontal, frictionless, conducting rails at a constant speed v. A uniform magnetic field $\mathbf{B}$ fills the region in which the rod moves. Assume $L = 10.0\,\mathrm{cm}$, $v = 5.0\,\mathrm{m/s}$, $B = 1.2\,\mathrm{T}$, and $R = 0.40\,\Omega$.

   (a) Is the magnetic flux in the loop increasing or decreasing?

   (b) What is the direction of the induced current in the loop?

   (c) Determine the magnitude of the induced current in the loop.

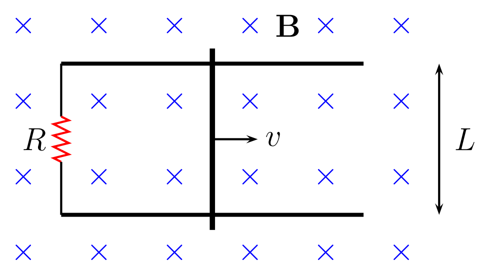

Figure 5: Problem 8

9. (**10 points.**) Consider the area enclosed by the loop formed in the configuration shown in Figure 6. The rotation described in the figure effectively changes the area enclosed by the loop periodically. Determine the maximum induced voltage for magnetic field $B = 0.10\,\mathrm{T}$ and radius $a = 10.0\,\mathrm{cm}$, when the loop is rotated at a uniform angular speed of 600 revolutions per minute.

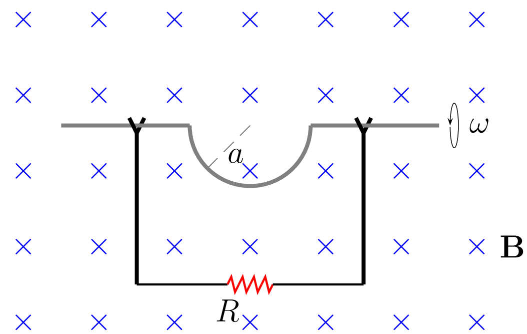

Figure 6: Problem 9.

10. (**10 points.**) Figure 7 shows five snapshots of a rectangular coil being pushed across the dotted region where there is a uniform magnetic field directed into the page. Outside of this region the magnetic field is zero. Determine the direction of induced current in the loop at each of the five instances in the figure.

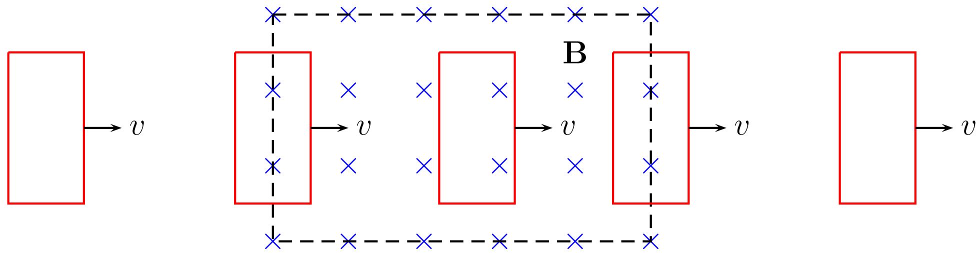

Figure 7: Problem 10