Midterm Exam No. 03 (2023 Fall)

PHYS 205B: UNIVERSITY PHYSICS

School of Physics and Applied Physics, Southern Illinois University–Carbondale

Date: 2023 Nov 14

(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 4 short questions and 3 homework-style problems in this exam.
4. Equation sheet is provided separately.
5. To be considered for partial credit you need to present your work in detail and organize it clearly.
6. A simple calculator (with trigonometric functions) is allowed.
7. Use of smart devices, including smart watches, is strictly prohibited. They should stay out of reach during the exam.
8. Restroom breaks are allowed. Under questionable circumstances this might lead up to a Makeup Exam.
9. Academic misconduct will lead to a failing grade in the course.

1. (**5 points.**) Figure 1 shows two current carrying wires, separated by a distance $D = 9.0\,\text{cm}$. The directions of currents, either going into the page or coming out of the page, are shown in the figure. Let $I_1 = 1.0\,\text{A}$ and $I_2 = 2.0\,\text{A}$. Determine the distance x of the point $\times$ where the magnetic field is exactly zero.

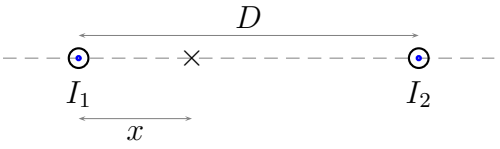

Figure 1: Problem 1

2. (**5 points.**) A rectangular loop of wire carrying current I_2 is placed near an infinitely long wire carrying current I_1, such that two of the sides of the rectangle are parallel to the current I_1. Let the distances be a, b, and l. Determine the direction of the force acting on side '2' of the loop.

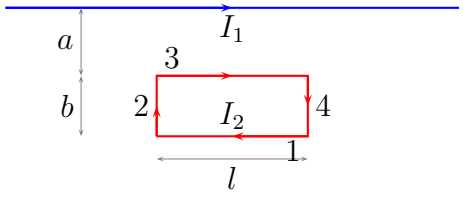

Figure 2: Problem 2

3. (**5 points.**) Figure 3 shows a snapshot of a rectangular coil being pushed through a uniform magnetic field directed into the page. Determine the direction of induced current in the loop at the instance shown in the figure. Given $L = 10.0\,\text{cm}$, $v = 5.0\,\text{m/s}$, and $B = 1.2\,\text{T}$,

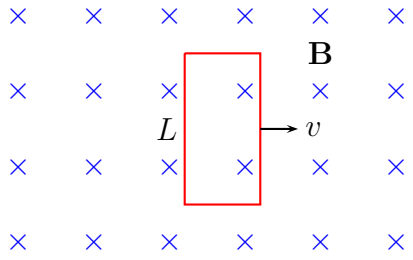

Figure 3: Problem 3.

4. (**5 points.**) What is the dimension of

$$\frac{1}{\sqrt{\mu_0 \varepsilon_0}}, \tag{1}$$

where ε_0 is the electric permittivity of vacuum and μ_0 is the magnetic permeability of vacuum.

5. (**10 points.**) A steady current I flows through a wire in the shape of a rectangle of breadth L and length $2L$, shown in Fig. 4. Determine the magnitude and direction of the magnetic field at the center of the rectangle, P.

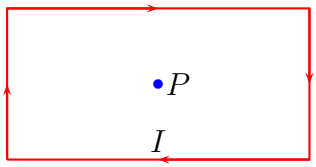

Figure 4: Problem 5

6. (**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 $L = 5.0\,\text{cm}$, $v = 4.0\,\text{m/s}$, $B = 0.12\,\text{T}$, and $R = 0.30\,\Omega$. Determine the magnitude and direction of the induced current in the loop.

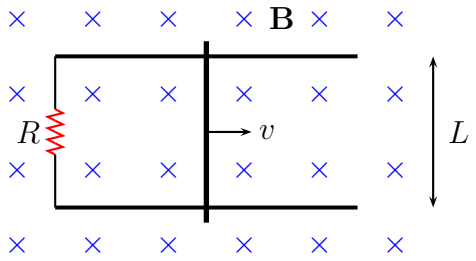

Figure 5: Problem 6

7. (**10 points.**) The expression for the current in a RL circuit for the initial condition $I(0) = 0$ is given by

$$I(t) = \frac{V}{R}\left[1 - e^{-\frac{t}{(L/R)}}\right]. \tag{2}$$

How much time does it take to attain half of the maximum current in the circuit? Given $L = 1.0\,\text{mH}$, $R = 1.0\,\text{M}\Omega$, and $V = 110.0\,\text{V}$.

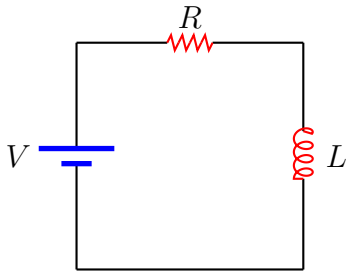

Figure 6: A series RL circuit.