Midterm Exam No. 03 (2023 Spring)

PHYS 205B: UNIVERSITY PHYSICS

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

Date: 2023 April 20

(Name) (Signature)

Instructions

1. Seating direction: Please be seated on seats with seat-numbers divisible by 5.
2. Total time = 75 minutes.
3. There are 4 conceptual questions and 3 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.**) A resistance R is connected to a battery V. Imagine an abstract Ampèrian loop c encircling the wires as described in Figure 1. Using Ampère's law evaluate

$$\oint_c \mathbf{B} \cdot d\mathbf{l} \tag{1}$$

along the closed curve c. Here $\mathbf{B}$ is the magnetic field.

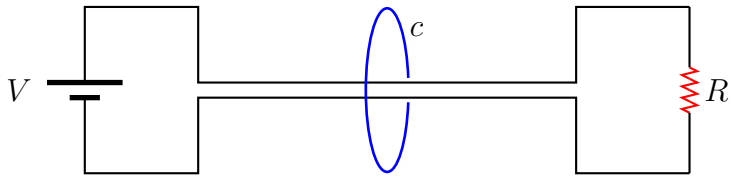

Figure 1: Problem 1

2. (**5 points.**) Figure 2 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. Determine the direction of the induced current in the loop.

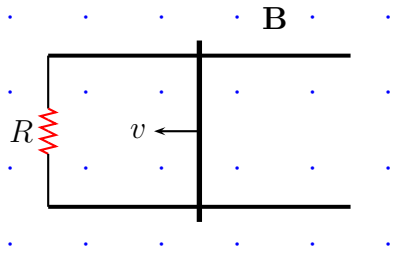

Figure 2: Problem 2

3. (**5 points.**) Figure 3 shows a battery of voltage V connected to an inductor L and resistor R in series. The potential drop across the inductor L is

$$L\frac{dI}{dt} \tag{2}$$

with I being the current passing through the inductor. In steady state, when the current passing through the inductor is constant, what is the potential drop across the inductor? In steady state, what is the potential drop across the resistor?

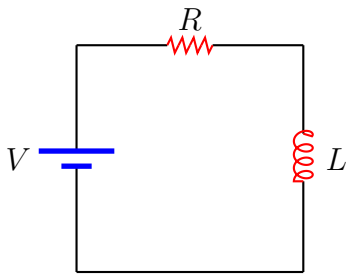

Figure 3: Problem 3

4. (**5 points.**) The wave nature stipulates the relation between wavelength λ, frequency f, and speed c of the wave,

$$c = \lambda f. \tag{3}$$

The time period $T = 1/f$, and the wavevector $k = 2\pi/\lambda$, are related quantities. A microwave oven passes electromagnetic (micro) wave at a frequency 2.45 GHz through food. Water is a good absorber of electromagnetic waves in this frequency range and heats the food in the process. Calculate the wavelength associated to 2.45 GHz.

5. (**10 points.**) Figure 4 shows two infinitely long current carrying wires. 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 $\times$, at the coordinate (x, y). Let $I_1 = 1.0\,\text{A}$, $I_2 = 2.0\,\text{A}$, $x = 8.0\,\text{cm}$, and $y = 6.0\,\text{cm}$.

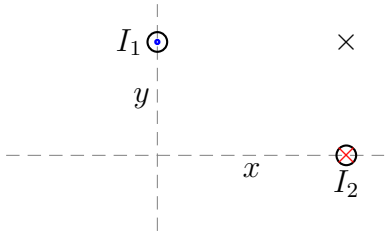

Figure 4: Problem 5

6. (**10 points.**) Figure 5 shows two infinitely long parallel current carrying wires coming out of the plane perpendicular to the wires. 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 force per unit length exerted by the wire carrying I_2 on the wire carrying current I_1. Given $I_1 = 1.0\,\text{A}$, $I_2 = 2.0\,\text{A}$, $x = 8.0\,\text{cm}$, and $y = 6.0\,\text{cm}$.

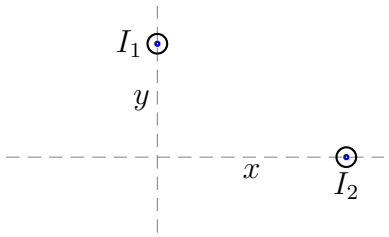

Figure 5: Problem 6

7. (**10 points.**) Using Kirchhoff's law write the differential equation for an LC circuit that governs an inductor L and a capacitor C in series. What is the dimension of the quantity

$$\frac{1}{\sqrt{LC}} \tag{4}$$

that characterizes an LC circuit. What does it represent?

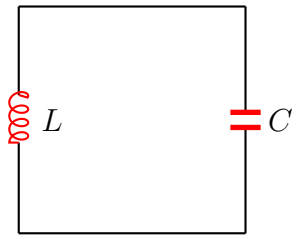

Figure 6: LC circuit.