Midterm Exam No. 03 (2024 Spring)

PHYS 205B: UNIVERSITY PHYSICS

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

Date: 2024 Apr 23

(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.**) Two infinitely long straight wires parallel to each other carry steady currents I in each of them in the same direction as shown in Figure 1. What is the magnitude and direction of the magnetic field at the point P midway between the wires?

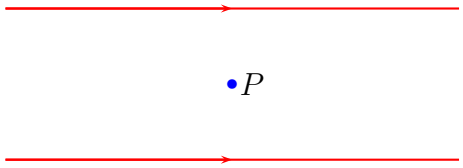

Figure 1: Problem 1

2. (**5 points.**) A battery of voltage V is connected to an inductor L and resistor R in series. The potential drop across the inductor L is

$$L\frac{dI}{dt} \tag{1}$$

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?

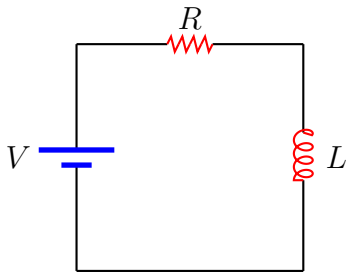

Figure 2: A series RL circuit.

3. (**5 points.**) Can an electromagnetic wave impart momentum to an object? That is, can you move an object by shining light on it in empty space.

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

$$c = \lambda f. \tag{2}$$

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 electromagnetic waves in this frequency range and heats the food in the process. Calculate the wavelength associated to 2.45 GHz.

5. (**10 points.**) A steady current I flows through a wire in the shape of an equilateral triangle of side L shown in Fig. 3. Express the magnitude of the magnetic field at the center of the triangle, P, in the form

$$B = \frac{\mu_0}{4\pi}\frac{I}{L}a. \tag{3}$$

Thus, determine the number a.

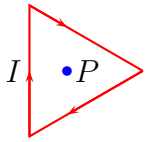

Figure 3: Problem 5

6. (**10 points.**) Figure 4 shows two current carrying wires, separated by a distance $D = 3.0\,\text{cm}$. The directions of currents, either going into the page or coming out of the page, are shown in the figure. Determine the point $\times$ on the line, (which need not be in between the wires,) where the magnetic field is exactly zero. Given $I_1 = 1.0\,\text{A}$ and $I_2 = 4.0\,\text{A}$.

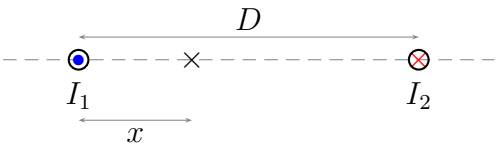

Figure 4: Problem 6

7. (**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 $L = 10.0\,\text{cm}$, $v = 5.0\,\text{m/s}$, $B = 1.2\,\text{T}$, 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.

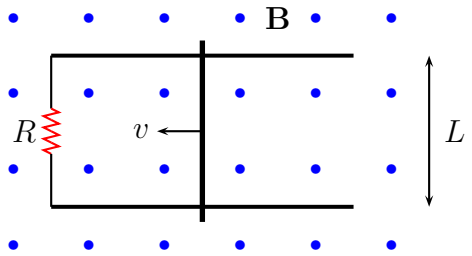

Figure 5: Problem 7