Homework No. 07 (Fall 2021)

PHYS 205B: University Physics

Due date: Tuesday, 2021 Oct 26, 9:30 AM, on D2L

Instructions

- Describe your thought process in detail and organize it clearly. Make sure your answer has the correct units and the right number of significant digits.

- After completion, scan the pages as a single PDF file, and submit the file on D2L (under Assessments → Assignments).

Problems

1. (**10 points.**) The magnetic field at a distance R from a wire of infinite extent carrying a steady current I is given by

$$\mathbf{B} = \frac{\mu_0}{4\pi} \frac{2I}{R} \hat{\phi}, \tag{1}$$

where the direction of $\hat{\phi}$ is given by the right-hand rule. Find the magnetic field at point o in Fig. 1 in terms of distances a and b and current I. That is, express R in terms of a and b.
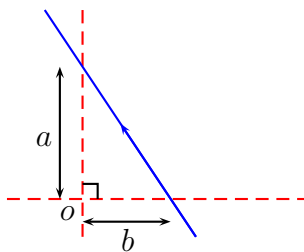

Figure 1: Problem 1

2. (**10 points.**) A steady current I flows through a wire shown in Fig. 2. Determine the magnitude and direction of magnetic field at point P in terms of I and a.

   (a) Determine the magnitude and direction of the magnetic field for $I = 1.0\,\text{A}$ and $a = 10.0\,\text{cm}$.
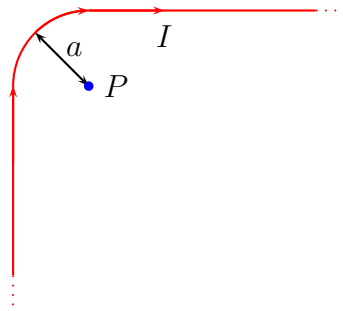
Figure 2: Problem 2

(b) Determine the magnitude and direction of the magnetic force on a proton moving with velocity $v = 2.0 \times 10^6$ m/s, to the right, while it is passing the point P.

Solution

3. (**10 points.**) A steady current I flows through a wire in the shape of a square of side L, shown in Fig. 3. Determine the magnitude and direction of the magnetic field at the center of the square, P.
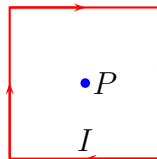

Figure 3: Problem 3

Solution

4. (**10 points.**) Figure 4 shows two current carrying wires, separated by a distance D. The directions of currents, either going into the page or coming out of the page, are shown in the figure. Determine the point × where the magnetic field is exactly zero.
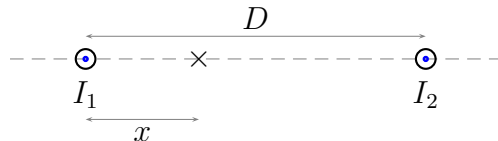

Figure 4: Problem 4

Solution

2

5. (**10 points.**) Figure 5 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 $I_1 = 1.0\,\text{A}$, $I_2 = 2.0\,\text{A}$, $x = 12\,\text{cm}$, and $y = 8.0\,\text{cm}$.
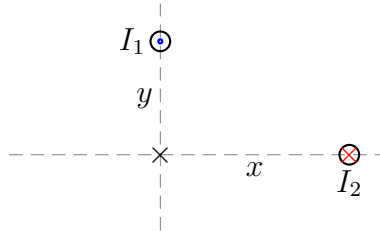

Figure 5: Problem 5

Solution

6. (**10 points.**) A rectangular loop of wire carrying current $I_2 = 2.0\,\text{A}$ is placed near an infinitely long wire carrying current $I_1 = 1.0\,\text{A}$, such that two of the sides of the rectangle are parallel to the current I_1. Let the distances be $a = 5.0\,\text{cm}$, $b = 4.0\,\text{cm}$, and $l = 10.0\,\text{cm}$.
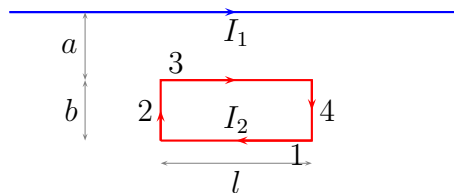

Figure 6: Problem 6

(a) Determine the force on side '1' of the loop.

(b) Determine the force on side '3' of the loop.

(c) Show that the combined force on side '2' and '4' is zero.

(d) Determine the magnitude and direction of the total force on the loop.

Solution

7. (**10 points.**) Using Ampère's law show that the magnetic field due to a solenoid carrying a current I is given by,

$$\vec{\mathbf{B}} = \begin{cases} \hat{\mathbf{z}}\,\mu_0 I n, & \text{inside the solenoid,} \\ 0, & \text{outside the solenoid,} \end{cases} \tag{2}$$

where n is the number of turns per unit length.

Solution