Name____

Physics 121 Quiz #6 November 4, 2022

Please show all work, thoughts and/or reasoning in order to receive partial credit. The quiz is worth 10 points total.

I affirm that I have carried out my academic endeavors with full academic honesty.

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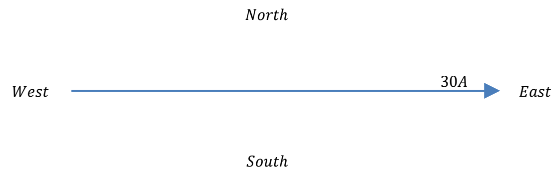
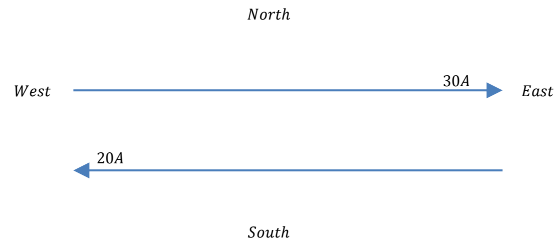
Consider the long straight wire shown below in which a $30A$ current is flowing from west to east.



1. At a point $0.5m$ to the south of this wire, what is the magnitude and direction of the magnetic field produced by the current flowing?

$B = |\vec{B}| = \frac{\mu_0 I}{2\pi r} = \frac{4\pi \times 10^{-7}\frac{Tm}{A} \times 30A}{2\pi \times 0.5m} = 1.2 \times 10^{-5}T$ directed into the plane of the paper by the right-hand rule.

2. Suppose that at a distance of $0.5m$ south of the wire, another wire was placed. This second wire is parallel to the first wire and has a $20A$ current flowing east to west. What is the magnitude and direction of the force on a $1m$ length of this second wire?

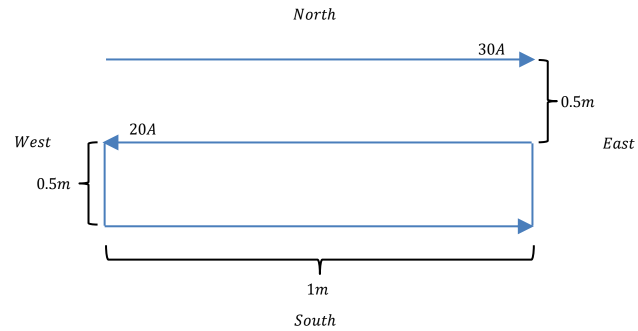


$F_B = |\vec{F}_B| = ILB \sin\theta = 20A \times 1m \times 1.2 \times 10^{-5}T \times \sin 90 = 2.4 \times 10^{-4}N$ down the page to the south by the right-had rule.

Or we can evaluate the vector cross product:

$$\vec{F}_B = \vec{IL} \times \vec{B} = \begin{vmatrix} \hat{x} & \hat{y} & \hat{z} \\ -IL & 0 & 0 \\ 0 & 0 & -B \end{vmatrix} = (0)\hat{x} - (ILB)\hat{y} + (0)\hat{k} = \langle 0, -2.4, 0 \rangle \times 10^{-4}N$$

3. Suppose that this lower wire is part of a larger circuit shown below. Over a $1mm$ segment of wire located at the midpoint of the left-hand side of the rectangular wire loop, what is the magnitude and direction of the force at this point? Additionally, over a $1mm$ segment of wire located at the midpoint of the right-hand side of the rectangular wire loop, what is the magnitude and direction of the force at this point?



On the left-hand side:

$F_B = |\vec{F}_B| = ILB \sin\theta = IL\left(\frac{\mu_0 I}{2\pi r}\right) =$

$20A \times 1 \times 10^{-3} m \times \left(\frac{4\pi \times 10^{-7} \frac{Tm}{A} \times 30A}{2\pi \times 0.25m}\right) = 1.6 \times 10^{-7} N$ to the east by the right-had rule.

On the right-hand side:

$F_B = |\vec{F}_B| = IL\left(\frac{\mu_0 I}{2\pi r}\right) = 20A \times 1 \times 10^{-3} m \times \left(\frac{4\pi \times 10^{-7} \frac{Tm}{A} \times 30A}{2\pi \times 0.25m}\right) = 1.6 \times 10^{-7} N$ to the west by the right-had rule.

4. What is the net force on the bottom segment of the rectangular wire loop if the bottom part has a length of $1m$?

$F_{B,1} = |\vec{F}_B| = ILB \sin\theta = IL\left(\frac{\mu_0 I}{2\pi r}\right) = 20A \times 1m \times \left(\frac{4\pi \times 10^{-7} \frac{Tm}{A} \times 30A}{2\pi \times 1m}\right) \times \sin 90 = 1.2 \times 10^{-4} N$ up the page to the north by the right-had rule.

$F_{B,2} = |\vec{F}_B| = ILB \sin\theta = IL\left(\frac{\mu_0 I}{2\pi r}\right) = 20A \times 1m \times \left(\frac{4\pi \times 10^{-7} \frac{Tm}{A} \times 20A}{2\pi \times 0.5m}\right) \times \sin 90 = 1.6 \times 10^{-4} N$ down the page to the south by the right-had rule.

$F_B = F_{B,1} - F_{B,2} = 1.2 \times 10^{-4} N - 1.6 \times 10^{-4} N = -4 \times 10^{-5} N$ or $4 \times 10^{-5} N$ down the page.

5. What is the net force on the wire loop in magnitude and direction?

$\vec{F}_{net} = \vec{F}_{top} + \vec{F}_{bottom} + \vec{F}_{left} + \vec{F}_{right}$

$\vec{F}_{net} = \langle 0, -2.4, 0 \rangle \times 10^{-4} N + \langle 0, -4, 0 \rangle \times 10^{-5} T + \langle 1.6, 0, 0 \rangle \times 10^{-7} N + \langle -1.6, 0, 0 \rangle \times 10^{-7} N$

$\vec{F}_{net} = \langle 0, -1.20, 0 \rangle \times 10^{-4} N$

or $F_{net,y} = F_{top} - F_{bottom} = -2.4 \times 10^{-4} N - 4 \times 10^{-5} N = -2 \times 10^{-4} N$ or $2 \times 10^{-4} N$ to the south by the right-hand rule, where the left and right forces sum to zero.