GRADES: 100
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# PHYS 223 University Physics III
# Exam 4

November 5, 2014

Name V.C. Daly

1. Determine the voltage across the 10 ohm resistor in Figure 1.

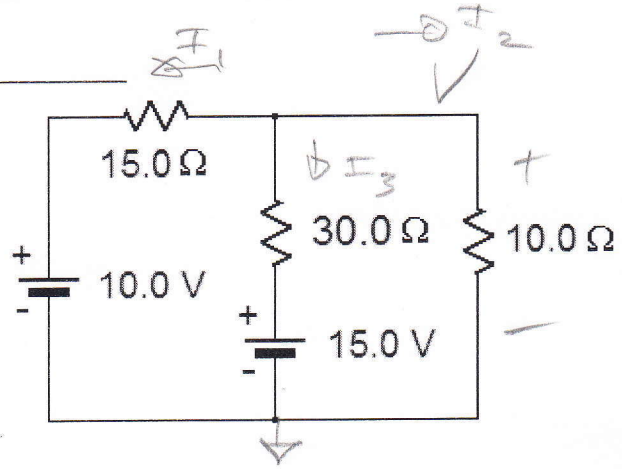


Figure 1

$I_1 + I_2 + I_3 = 0$

$I_1 = \frac{V-10}{15}$

$I_2 = \frac{V}{10}$

$I_3 = \frac{V-15}{30}$

$\frac{V-10}{15} + \frac{V}{10} + \frac{V-15}{30} = 0$

$V\left\{\frac{1}{15} + \frac{1}{10} + \frac{1}{30}\right\} = \frac{10}{15} + \frac{15}{30}$

$V\left\{\frac{2+3+1}{30}\right\} = \frac{20+15}{30}$

$V\left\{\frac{6}{30}\right\} = \frac{35}{30}$

$V \times 6 = 35$

$V = 5.83$

$I_1 = \frac{5.83-10}{15} = -0.278$

$I_2 = 0.583$

$I_3 = \frac{5.83-15}{30}$

$I_3 = -0.3056$

$-0.278 + 0.583 - 0.3056 = 0$

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2. A 2 Ampere current flows down the wire then around the circular section then out the horizontal wire as shown in Figure 2. The circular section has a 2 cm radius.

   Find the magnetic field at point, *P*, the center of curvature of the circular section of the wire.

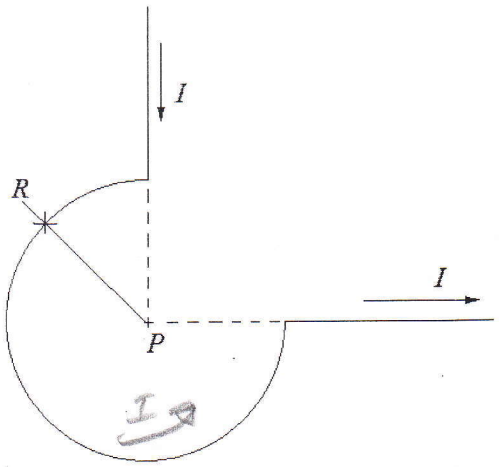


Figure 2

$$\vec{dB} = \frac{\mu_0}{4\pi}\frac{I\vec{dl}\times\hat{r}}{r^2}$$

$I\vec{dl}\times\hat{r} = 0$ for the STRAIGHT Sections since $\sin\theta = 0$

For the circular section

$dl = r\,d\theta$

$\vec{I dl}\times\hat{r} = I dl = I r\,d\theta$

$$dB = \frac{\mu_0}{4\pi}\frac{I r\,d\theta}{r^2} = \frac{\mu_0 I}{4\pi r}d\theta$$

$$B = \frac{\mu_0 I}{4\pi R}\int_0^{\frac{3}{4}\times 2\pi} d\theta = \frac{\mu_0 I}{4\pi R}\,3\pi/2$$

$$\boxed{B = \frac{3\mu_0 I}{8R}}$$

out of the paper by the Right Hand Rule

$$B = \frac{3\times 4\pi\times 10^{-7}\times 2}{8\times .02} = \frac{3\pi\times 10^{-7}}{.02} = \boxed{4.71\times 10^{-5}\ T}$$

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3. A current, $I_1$, flows in the long straight wire.

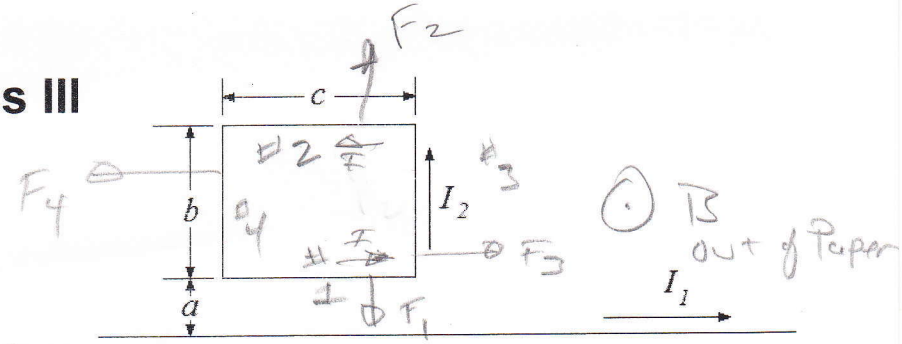


Figure 3

a. Find an expression for the force on the loop carrying the current, $I_2$, as shown in Figure 3. $\frac{\mu_0 I_1 I_2 c}{2\pi}\left(\frac{1}{a}-\frac{1}{a+b}\right)$

b. What is the direction of the force? down (Toward the STRAIGHT wire)

$F = ILB$ for a Length of wire in a B field where B is uniform over the Length of the wire

$B = \frac{\mu_0 I_1}{2\pi r}$ out of the paper — THIS is the B field due to current $I_1$

$d\vec{F} = \vec{I}\,d\vec{\ell} \times \vec{B}$

The Forces on the Vertical Sections add to Zero since the current is in opposite directions in the 2 Vertical Sections

$F_3 + F_4 = 0$

$F_1 = I_2 L B = \frac{I_2 c \mu_0 I_1}{2\pi a} = \frac{\mu_0 I_1 I_2 c}{2\pi a}$

$F_2 = I_2 L B = \frac{\mu_0 I_1 I_2 c}{2\pi (a+b)}$

$F = F_1 - F_2 = \frac{\mu_0 I_1 I_2 c}{2\pi}\left(\frac{1}{a}-\frac{1}{a+b}\right) = \frac{\mu_0 I_1 I_2 c}{2\pi}\left(\frac{b}{a(a+b)}\right)$

## Physical Constants

| Constant | Symbol | Magnitude |
|---|---|---|
| Avogadro's Number | $N_A$ | $6.022 \times 10^{23}$ molecules/mole |
| Boltzmann's constant | k | $1.38 \times 10^{-23}$ J/K = $8.62 \times 10^{-5}$ eV/K |
| Stefan-Boltzmann constant | $\sigma$ | $5.67 \times 10^{-8}$ J/(s*m$^2$*K$^4$) |
| Electronic charge | q | $1.6 \times 10^{-19}$ C |
| Electronvolt | eV | $1.6 \times 10^{-19}$ J |
| Planks constant | h | $6.625 \times 10^{-34}$ J-s |
| Thermal voltage, kT, at 300 °K | $V_t$ | 25.8 mV |
| Velocity of light | c | $3 \times 10^8$ m/s |
| Permeability of free space | $u_o$ | $1.257 \times 10^{-6}$ H/m |
| Permittivity of free space | $\varepsilon_o$ | $8.854 \times 10^{-12}$ F/m |
| Free-electron mass | m | $9.1 \times 10^{-31}$ kg |

## Atomic Masses

| Element | Symbol | Atomic Mass | Atomic Number |
|---|---|---|---|
| Hydrogen | H | 1.00794 u | 1 |
| Helium | He | 4.00260 u | 2 |
| Lithium | Li | 6.941 u | 3 |
| Beryllium | Be | 9.0122 u | 4 |
| Boron | B | 10.811 u | 5 |
| Carbon | C | 12.0107 u | 6 |
| Nitrogen | N | 14.0067 u | 7 |
| Oxygen | O | 15.9994 u | 8 |
| Fluorine | F | 18.9984 u | 9 |
| Neon | N | 20.1797 u | 10 |
| Sodium | Na | 22.9897 u | 11 |
| Magnesium | Mg | 24.305 u | 12 |
| Aluminum | Al | 26.9815 u | 13 |
| Silicon | Si | 28.0855 u | 14 |
| Phosphorus | P | 30.9738 u | 15 |

## Thermal properties of Water