Physics 10164 - Exam 2D

Partial credit will be given provided you show all work and are solving parts of the problem correctly. Points will be deducted if you don't show your work even if you get the right answer. Clearly indicate your answer with a circle or a box and remember to include correct units and significant figures.

1. (30 pts) A circuit contains a 12-Volt battery, a 3.0 Ohm resistor and an unknown capacitor. A switch is closed at t = 0 to allow current to flow and begin charging the capacitor.

a) At a time of 1.1 x 10-5 seconds, the voltage drop across the capacitor is observed to be equal to the voltage drop across the resistor. What is the capacitance of the capacitor?

b) At what time is the current in the circuit equal to 1.0% of its initial value immediately after the switch is closed?

a) $\Delta V_R = \Delta V_C$ when both are 6.0 Volts

$$\Delta V_R = \mathcal{E} e^{-t/RC}$$

$$6.0 = 12 e^{-t/RC}$$

$$\ln\left(\frac{6}{12}\right) = -\frac{t}{RC}$$

$$-0.693 = -\frac{1.1\times10^{-5}}{3.0\,C}$$

$$C = -\frac{1.1\times10^{-5}}{-(.693)(3.0)}$$

$$= 5.3\times10^{-6}\,F$$

or $5.3\,\mu F$

b) $I = I_{max}\, e^{-t/RC}$

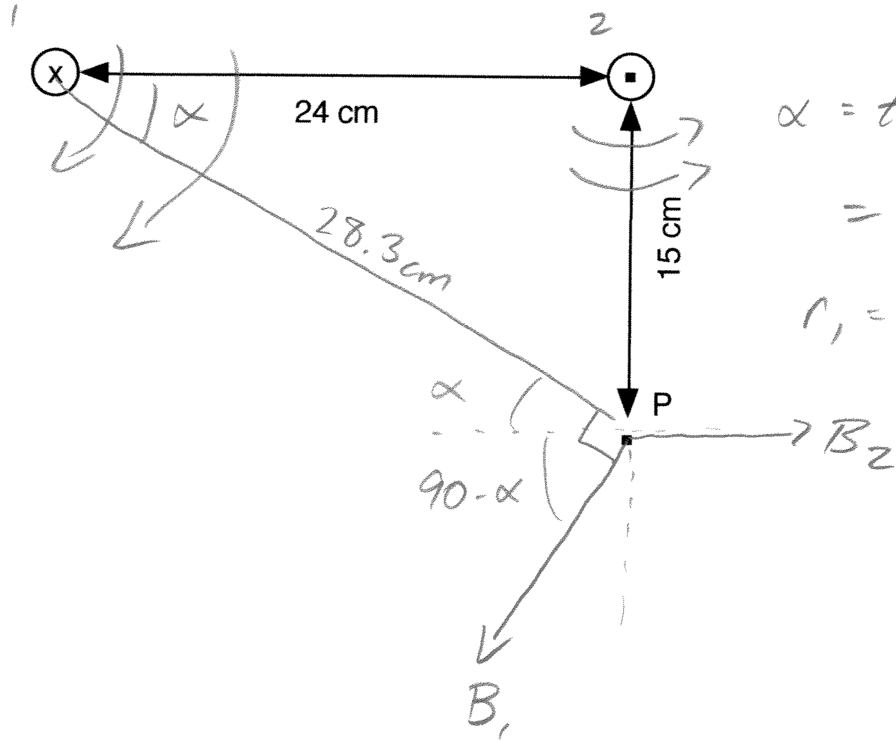
$$.01 = e^{-t/RC}$$

$$\ln(.01) = -\frac{t}{RC}$$

$$-4.605 = -\frac{t}{(3.0)(5.3\times10^{-6})}$$

$$t = 7.3\times10^{-5}\,s$$

2. (40 pts) Wire 1 has a 9.0 Amp current pointing into the page, and wire 2 has a 3.0 Amp current pointing out of the page. The wires are arranged as shown below. What is the magnitude and direction of the total magnetic field at point P?



$\alpha = \tan^{-1}\left(\frac{15}{24}\right)$

$= 32^\circ$

$r_1 = \sqrt{15^2 + 24^2}$

$= 28.3 \text{ cm}$

$\vec{B}_1 = \frac{\mu_0 I_1}{2\pi r_1} = \frac{(4\pi \times 10^{-7})(9.0)}{2\pi(.283)} = 6.36\,\mu T,\ 58^\circ \text{ below } -x$

$\vec{B}_2 = \frac{\mu_0 I_2}{2\pi r_2} = \frac{(4\pi \times 10^{-7})(3.0)}{2\pi(.15)} = 4.00\,\mu T,\ +x$

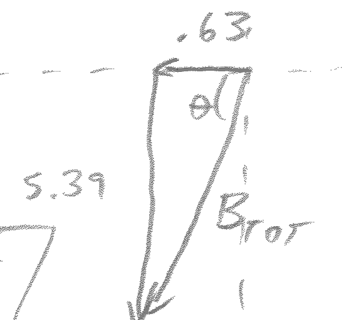
$B_{1x} = -6.36 \cos 58^\circ = -3.37 \qquad B_{2x} = 4.00$

$B_{1y} = -6.36 \sin 58^\circ = -5.39 \qquad B_{2y} = 0$

$B_{TOT,x} = -0.63\,\mu T$

$B_{TOT,y} = -5.39\,\mu T$

$|B_{TOT}| = \sqrt{.63^2 + 5.39^2} = 5.4\,\mu T$



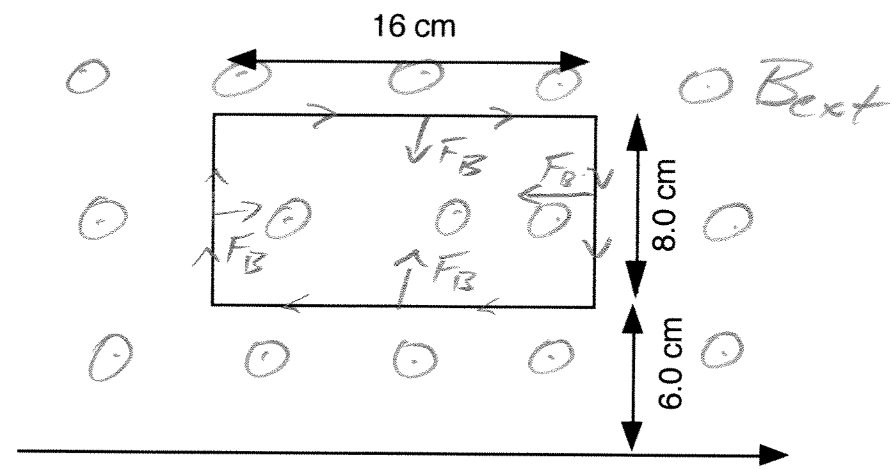
$\theta = \tan^{-1}\left(\frac{5.39}{.63}\right) = 83^\circ \text{ below } -x$

3. (30 pts) A rectangular wire loop with a 0.35 Amp current flowing clockwise around it is in the vicinity of a long straight wire with a 5.0 Amp current flowing in the +x direction as shown below.

a) Indicate the direction of magnetic force on each of the four sides of the loop (or zero if there is no force).

b) Determine the net magnetic force on the loop (magnitude and direction) due to the long straight wire.

a)



b) $F_{B,left} = F_{B,right}$, equal + opposite, so they cancel.

$$F_{B,bot} = l I_{loop} B_{wire} \sin 90^\circ$$

$$= (0.16)(0.35)\frac{(4\pi \times 10^{-7})(5.0)}{2\pi(.06)} = 9.3 \times 10^{-7}\ N,\ +y$$

$$F_{B,top} = l I_{loop} B_{wire} \sin 90^\circ$$

$$= (0.16)(0.35)\frac{(4\pi \times 10^{-7})(5.0)}{2\pi(.14)} = 4.0 \times 10^{-7}\ N,\ -y$$

$$F_{TOT} = +9.3 - 4.0 = \boxed{5.3 \times 10^{-7}\ N,\ +y}$$