Physics 10164 - Summer 2019 - Exam #2A

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 7500 Ohm resistor and a capacitor, initially uncharged. A switch is closed at time t = 0, closing the loop of the circuit. After 0.17 seconds have elapsed, the capacitor is charged to 48% of its maximum possible charge.

a) What is the capacitance of the capacitor?

b) What is the current passing through the resistor at this time?

a) $0.48\,Q_{max} = Q_{max}(1 - e^{-t/\tau})$

$0.48 = 1 - e^{-t/RC}$

$0.52 = e^{-t/RC}$

$-0.654 = -\frac{0.17}{RC}$

$C = \frac{0.17}{(.654)(7500)}$

$= \boxed{35\ \mu F}$

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b) $I(t) = \frac{\mathcal{E}}{R} e^{-t/\tau}$ $\quad \tau = RC = 0.26\ s$

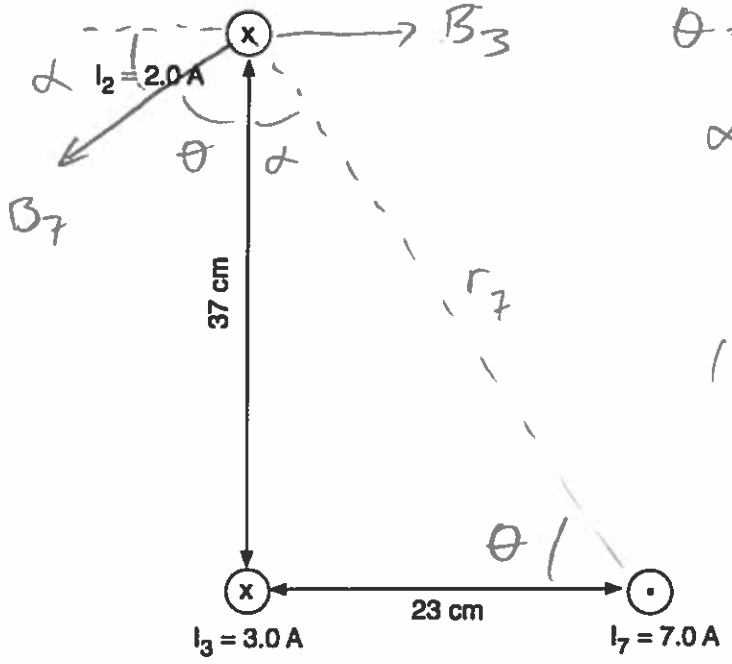
$= \frac{12}{7500} e^{-0.17/0.26}$

$= \frac{12}{7500}(0.52) = \boxed{8.3 \times 10^{-4}\ A}$

2. (40 pts) Three wires are arranged as shown below.

a) Find the magnitude and direction of the magnetic field at the location of wire I_2 due to the other two wires.

b) Find the magnitude and direction of the force per unit length acting on wire I_2 due to the other two wires.



$\theta = \tan^{-1}\left(\frac{37}{23}\right) = 58.13^\circ$

$\alpha = 90 - \theta = 31.87^\circ$

$r_7 = \sqrt{.37^2 + .23^2} = 0.436$ m

$|B_3| = \frac{\mu_0 I_3}{2\pi r_3} = \frac{\mu_0 (3.0)}{2\pi (.37)}$

$= 1.62\ \mu T$

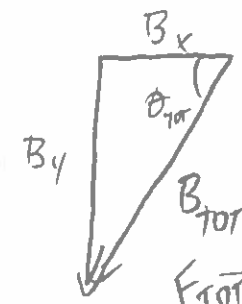
$|B_7| = \frac{\mu_0 (7.0)}{2\pi (.436)} = 3.21\ \mu T$

$B_{3x} = 1.62$ $\quad B_{3y} = 0$

$B_{7x} = -3.21 \cos 31.87^\circ$ $\quad B_{7y} = -3.21 \sin 31.87^\circ$

$= -2.73$ $\quad = -1.70$

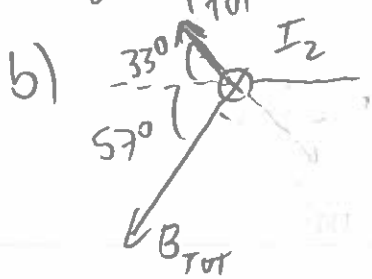
-1.11 $\quad -1.70$



$B_{TOT} = \sqrt{1.11^2 + 1.70^2} = \boxed{2.0 \times 10^{-6}\ T}$

$\theta_{TOT} = \tan^{-1}\left(\frac{1.70}{1.11}\right) = \boxed{57^\circ \text{ below } -x}$

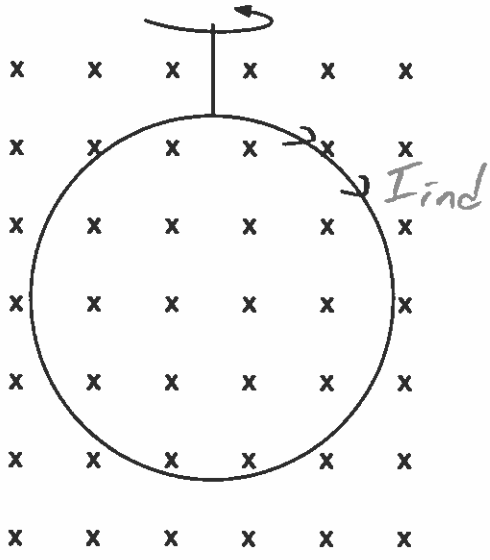
b)



$\frac{F_{TOT}}{\ell} = I_2 B_{TOT} \sin 90^\circ = \boxed{4.1 \times 10^{-6}\ N \text{ at } 33^\circ \text{ above } -x}$

#3. (30 pts) A circular wire loop with 344 turns, a resistance of 0.750 Ohms and a radius of 12.0 cm is located within a uniform magnetic field of 64.5 μT pointing into the page. Initially, the plane of the loop is perpendicular to the magnetic field as shown.

The loop initially rotates so that the left side comes out of the page toward you and the right side goes into the page. After 0.300 seconds, the loop has rotated 90.0°. During this time interval, what is the magnitude and direction of the average induced current observed in the loop?



$$\mathcal{E}_{ind} = N \frac{\Delta \Phi_B}{\Delta t}$$

$$= \frac{N B A \cos\theta}{\Delta t}$$

$$= \frac{(344)(64.5 \times 10^{-6})\pi (.12)^2 (1)}{.300}$$

$$= 3.346 \times 10^{-3} \text{ Volts}$$

$$I_{ind} = \mathcal{E}_{ind}/R = \boxed{4.46 \times 10^{-3} \text{ A}}$$

$\Phi_B = \otimes$, decreasing

$\Rightarrow B_{ind} = \otimes$

$\Rightarrow \boxed{I_{ind} = \text{clockwise}}$