Physics 10164 - Spring 2019 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.

(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 complete the circuit, and the capacitor begins to charge. At t = 3.6 μs, the voltage drop across the capacitor is 4.5 Volts.

a) What is the capacitance of the capacitor?
b) At that time, what is the voltage drop across the resistor?
c) At what time is the voltage drop across the capacitor equal to the voltage drop across the resistor?

a) $4.5 = 12(1 - e^{-t/RC})$

$0.375 = 1 - e^{-t/RC}$

$0.625 = e^{-t/RC}$

$-4.7 = -\frac{t}{RC}$

$C = \frac{t}{R(4.7)}$

$= \frac{3.6 \times 10^{-6}}{(3.0)(4.7)}$

$= \boxed{2.6 \times 10^{-6}\ F}$

b) Loop rule: $\Delta V_R + \overset{(4.5)}{\Delta V_C} = \overset{(12)}{\mathcal{E}}$

$\rightarrow \boxed{\Delta V_R = 7.5 \text{ Volts}}$

c) When $\Delta V_R = \Delta V_C$, both must equal 6.0 Volts in order to sum to 12 Volts.

$6.0 = 12(1 - e^{-t/RC})$

$0.50 = 1 - e^{-t/RC}$

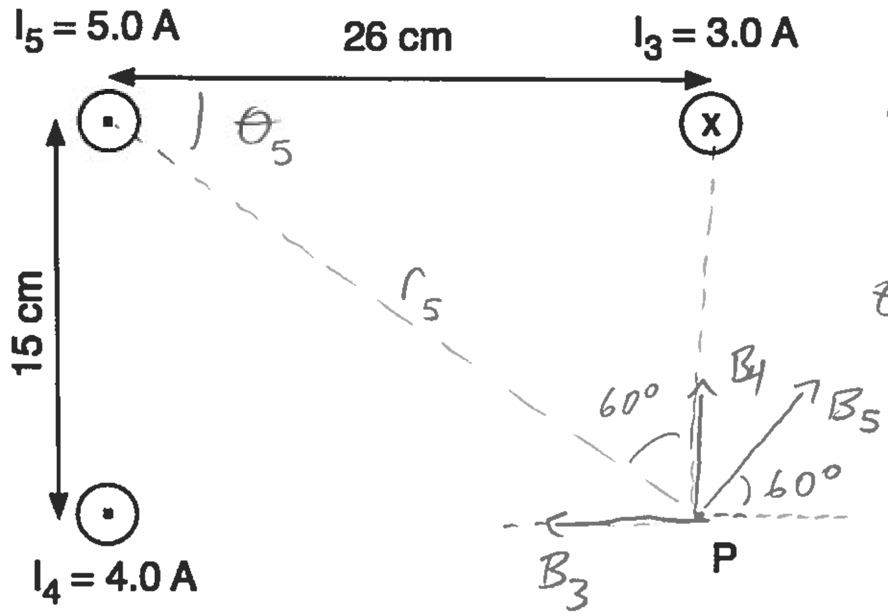
$0.50 = e^{-t/RC}$

$0.693 = \frac{t}{RC}$

$t = 0.693\ RC$

$= \boxed{5.4 \times 10^{-6}\ s}$

2. (40 pts) Three wires are arranged to form three corners of a rectangle as shown below. The currents in the wires are all perpendicular to the plane of the rectangle and the page. Point P is in the 4th corner of the rectangle. Find the magnitude and direction of the magnetic field at point P due to the 3 wires.



$r_5 = \sqrt{.26^2 + .15^2}$

$= 0.30 m$

$\theta_5 = \tan^{-1}\left(\frac{.15}{.26}\right)$

$= 30.0°$

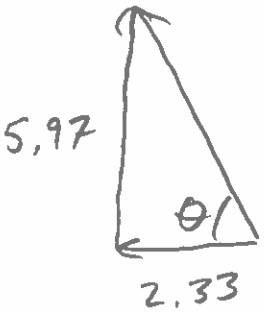
$|B_3| = \frac{\mu_0 I_3}{2\pi(.15)} = 4.0 \mu T$, ← $B_{3x} = -4.0$ $B_{3y} = 0$

$|B_4| = \frac{\mu_0 I_4}{2\pi(.26)} = 3.08 \mu T$, ↑ $B_{4x} = 0$ $B_{4y} = +3.08$

$|B_5| = \frac{\mu_0 I_5}{2\pi(.30)} = 3.33 \mu T$, 60° above +x

$B_{5x} = 1.67$ $B_{5y} = 2.89$

-2.33 5.97



$B_{TOT} = \sqrt{2.33^2 + 5.97^2} = \boxed{6.4 \mu T}$

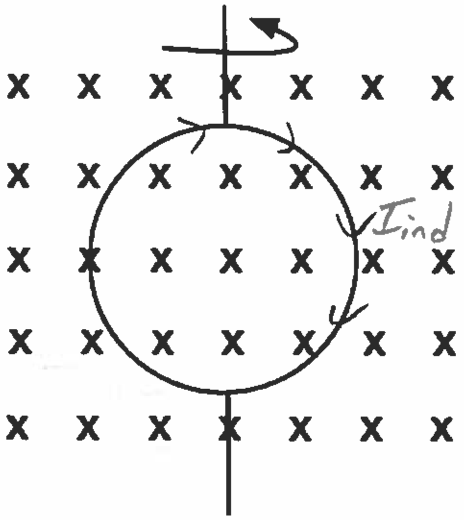
$\theta = \tan^{-1}\left(\frac{5.97}{2.33}\right) = \boxed{69° \text{ above } -x}$

3. (30 pts) A 75-turn wire loop of radius 35 cm and resistance 2.1 Ohms is initially oriented in the plane of the page and immersed in a 42 μT magnetic field pointing into the page. The loop is rotated as shown, with the left side of the loop coming out of the page, by 90 degrees in 1.2 seconds. During this time interval…

a) What is the magnitude of the induced EMF in the loop?
b) What is the magnitude and direction of the induced current in the loop?
c) Once the loop has completed its 90 degree turn, what is the magnitude of the torque acting on the loop?

$\cos 0° - \cos 90°$

$|\Delta \cos\theta| = 1$



a) $\mathcal{E}_{ind} = \dfrac{NBA\,\Delta\cos\theta}{\Delta t}$

$= \dfrac{(75)(42\times10^{-6})\pi(.35)^2(1)}{1.2}$

$= \boxed{1.0\times10^{-3}\text{ Volts}}$

b) $I_{ind} = \dfrac{\mathcal{E}_{ind}}{Res} = \dfrac{1.0\times10^{-3}}{2.1} = \boxed{4.8\times10^{-4}\text{ A}}$

$\Delta\Phi_B = \otimes$, decrease $\Rightarrow B_{ind} = \otimes \Rightarrow \boxed{I_{ind} = cw}$

c) After turn ∡ between μ + B $= 90°$

$|\tau| = NIAB\sin 90°$

$= (75)(4.8\times10^{-4})\pi(.35)^2(42\times10^{-6})(1)$

$= \boxed{5.8\times10^{-7}\text{ N}\cdot\text{m}}$