Physics 10164 - Exam 2B

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. (40 pts) A circuit contains a 12 Volt battery, a switch, a 0.24 Ohm resistor, and a capacitor, which is initially uncharged. The switch is closed to complete the circuit at time t = 0. After 0.55 seconds have elapsed, the voltage drop across the resistor is measured to be 3.5 Volts.

a) At this time, what is the voltage drop across the capacitor?

b) What is the capacitance of the capacitor?

c) After 3.0 time constants have elapsed, what will be the voltage drop across the resistor?

a) If $\Delta V_R + \Delta V_C = 12$ (loop rule)

$3.5 + \Delta V_C = 12$

$\boxed{\Delta V_C = 8.5 \text{ Volts}}$

b) $\Delta V_C = \frac{Q}{C} = \mathcal{E}(1 - e^{-t/RC})$

$8.5 = 12(1 - e^{-0.55/RC})$

$.7083 = 1 - e^{-.55/RC}$

$.2917 = e^{-.55/RC}$

$\ln(.2917) = -\frac{0.55}{RC}$

$-1.23 = -\frac{0.55}{0.24\,C}$

$C = \frac{.55}{(.24)(1.23)} = \boxed{1.86\text{ F}}$

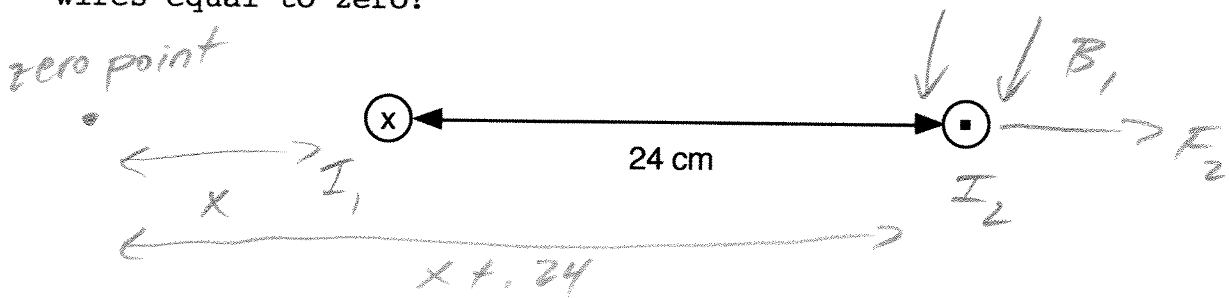
c) $\Delta V_R = IR = \left(\frac{\mathcal{E}}{R} e^{-t/RC}\right)R$

$= \mathcal{E} e^{-t/\tau} = 12 e^{-3} = \boxed{0.60 \text{ Volts}}$

2. (30 pts) Wire 1 carries a current of 5.0 Amps into the page, and wire 2 carries a current of 8.0 Amps out of the page.

a) What is the <u>magnitude and direction</u> of the magnetic force that wire 2 feels as a result of wire 1?

b) Aside from infinity, and assuming wire 1 is located at x = 0, at what x-coordinate is the total magnetic field due to these two wires equal to zero?



a) F_2 points +x due to RHR

$$|F_2| = I_2 B_1 \sin\theta = I_2 \frac{\mu_0 I_1}{2\pi r} \sin 90°$$

$$= \frac{(4\pi \times 10^{-7})(5.0)(8.0)}{2\pi(.24)} = \boxed{33\ \mu N,\ +x}$$

b) zero point must be left of I_1 to be closer to I_1 than I_2

$$|\vec{B}_1| = |\vec{B}_2|$$

$$\frac{\mu_0 I_1}{2\pi x} = \frac{\mu_0 I_2}{2\pi(x+.24)}$$

$$\frac{I_1}{I_2} = \frac{x}{x+.24}$$

$$\frac{5}{8} = \frac{x}{x+.24}$$

$$.625(x+.24) = x$$

$$0.375x = 0.15$$

$$x = \frac{.15}{.375} = 0.40\ m$$

x-coord = −0.40 m

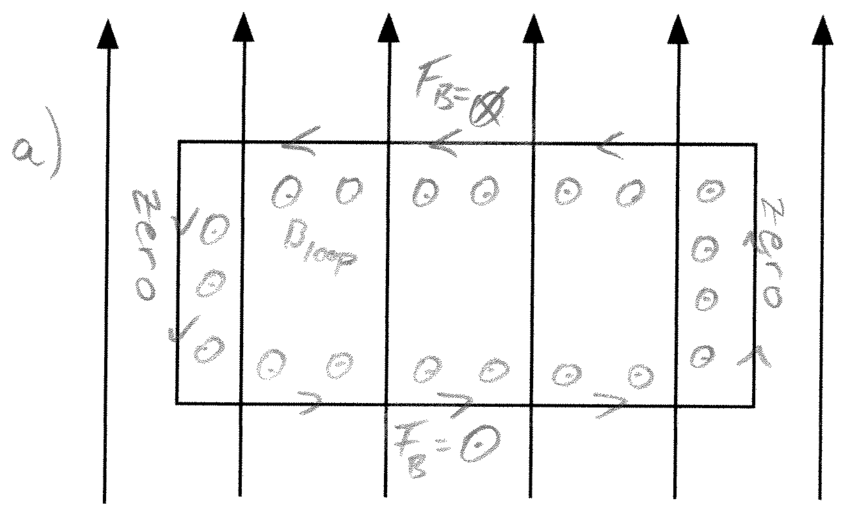
3. (30 pts) A single-turn rectangular wire loop measuring 12 cm x 24 cm is immersed in a 3.5 Tesla uniform magnetic field as shown below. A 0.22 Amp current runs counterclockwise in the wire loop.

a) On the diagram, clearly indicate the direction of the magnetic force felt by each of the four sides of the loop (or zero if it feels no force).

b) What is the magnitude of the torque on the loop due to the external magnetic field?

c) In what direction does the loop's magnetic field point in the center of the loop?

d) In order for the torque to be minimized, in what direction must the loop's magnetic field point?



$F_B = 0$ on left and right wires since $\vec{I}$ is parallel to $\vec{B}_{ext}$ so $\sin\theta = 0$.

b) $|\vec{\tau}| = NIAB \sin\theta$

$= (1)(.22)(.12 \times .24)(3.5) \sin 90°$

$= \boxed{.022\ N\cdot m}$

c) RHR curl says $\boxed{B_{loop} = \odot}$

d) τ is minimized when $\theta = 0°$

so $\vec{B}_{loop}$ must point in same direction as $\vec{B}_{ext}$. $\boxed{B_{loop} = \uparrow}$