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. (40 pts) A circuit contains a 12 Volt battery, a switch, a resistor, and a 4.0 μF capacitor. When the switch is closed, the initially uncharged capacitor begins to charge up. After 5.2 milliseconds, the voltage drop across the resistor is equal to the voltage drop across the capacitor.

a) What is the resistance of the resistor?

b) At what time is the capacitor 75% charged?

If $\Delta V_R = \Delta V_C$, then both must be 6 Volts.

a) $\Delta V_R = 6 = IR$

$6 = \left(\frac{\varepsilon}{R} e^{-t/RC}\right)(R)$

$6 = 12 e^{-t/RC}$

$0.5 = e^{-t/RC}$

$\ln 0.5 = -\frac{t}{RC}$

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

$R = \frac{t}{.693C} = \frac{5.2\times10^{-3}}{.693(4\times10^{-6})}$

$= 1900\ \Omega$

b) $Q = Q_{max}(1 - e^{-t/RC})$

$RC = .0075\ s$

$0.75\, Q_{max} = Q_{max}(1 - e^{-t/RC})$

$0.75 = 1 - e^{-t/RC}$

$0.25 = e^{-t/RC}$

$\ln .25 = -\frac{t}{.0075}$

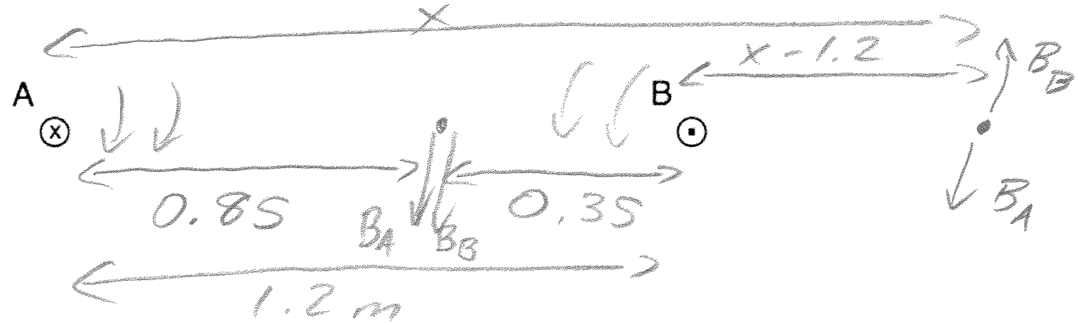
$t = -.0075 \ln .25$

$t = .010\ s$

2. (30 pts) Wire A passes through the origin and carries a current of 3.0 Amps. Wire B passes through the x-axis at x = 1.2 meters and carries a current of 1.2 Amps.

a) What is the magnitude and direction of the magnetic field at the coordinate x = 85 cm?

b) At what x-coordinate (other than infinity) is the total magnetic field due to the two wires equal to zero?



a) B_A + B_B both point ↓ at x = .85, so we will add them together.

$$|B_A| = \frac{\mu_0(3)}{2\pi(.85)} = 7.06 \times 10^{-7}\ T$$

$$|B_B| = \frac{\mu_0(1.2)}{2\pi(.35)} = 6.86 \times 10^{-7}\ T$$

$1.4 \times 10^{-6}\ T$, ↓

b) Must be closer to smaller current, I_B

Need $|B_A| = |B_B|$

$$\frac{\mu_0(3)}{2\pi x} = \frac{\mu_0(1.2)}{2\pi(x-1.2)}$$

$$\frac{3}{x} = \frac{1.2}{x-1.2}$$

$$3x - 3.6 = 1.2x$$

$$3.6 = 1.8x$$

$x = 2.0\ m$

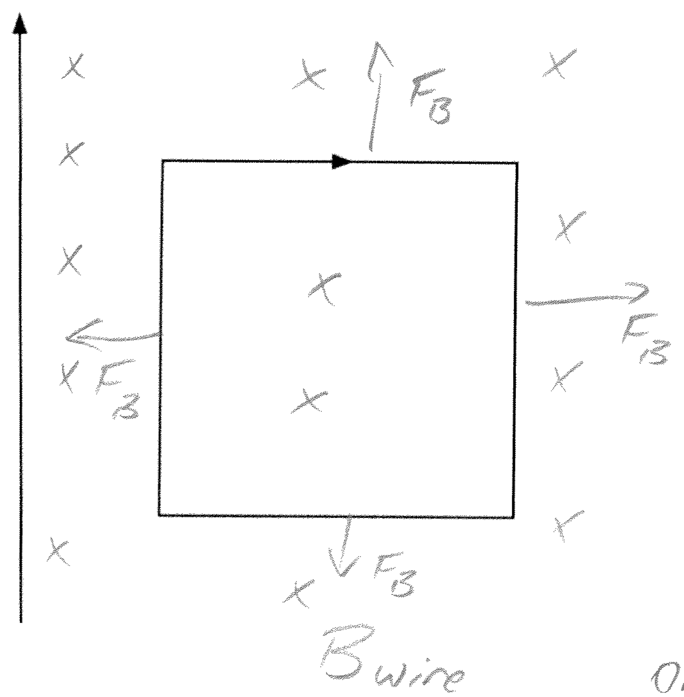
#3. (30 pts) A single-turn square wire loop 25 cm on a side carries a clockwise current of 2.2 Amps. The square is placed so that its left side is 8.0 cm away from a long straight wire carrying a 4.0 Amp current as shown below.

a) Determine the magnitude <u>and direction</u> of the total magnetic force on the loop due to the long straight wire.

b) What is the magnitude of the magnetic torque acting on the loop?

(P) (t) (f)

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



F_B on top + bottom is equal + opposite + sums to zero.

On left:

$B_{wire} = \frac{\mu_0 (4)}{2\pi(.08)} = 10\ \mu T$

On right:

$B_{wire} = \frac{\mu_0 (4)}{2\pi(.33)} = 2.4\ \mu T$

$F_{left} = (.25)(2.2)(10\times10^{-6})\sin 90 = 5.5\ \mu N, \leftarrow$

$F_{right} = (.25)(2.2)(2.4\times10^{-6})\sin 90 = 1.3\ \mu N, \rightarrow$

$F_{TOT} = -5.5 + 1.3 = -4.2$

so $4.2\times10^{-6}\ N, \leftarrow$

θ = ∡ between B_{loop} + B_{ext}

b) $\vec{B}_{loop} \parallel \vec{B}_{wire}$, so $\vec{\tau} = 0$ since $\sin\theta = 0$