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. (35 pts) A circuit contains a 24.0 Volt battery, a 325 Ohm resistor, a capacitor and a switch. The capacitor is initially uncharged when the switch is closed at t = 0 to complete the circuit. At t = 0.240 seconds, the voltage drop across the resistor is 11.2 Volts.

a) At t = 0.240 seconds, what is the voltage drop across the capacitor?

b) What is the capacitance of the capacitor?

c) At what time will the capacitor be 85.0% charged?

a) Loop rule $\mathcal{E} - \Delta V_R - \Delta V_C = 0$

$24.0 - 11.2 - \Delta V_C = 0$

$\Delta V_C = 12.8 \text{ Volts}$

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

$\frac{11.2}{24} = e^{-t/RC}$

$0.467 = e^{-t/RC}$

$-0.762 = -\frac{.240}{325C}$

$C = -\frac{.240}{325(-.762)}$

$= 9.7 \times 10^{-4} F$

c) $\tau = RC$

$= (325)(9.7 \times 10^{-4})$

$= 0.315 s$

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

$0.85 = 1 - e^{-t/\tau}$

$\ln 0.15 = e^{-t/.315}$

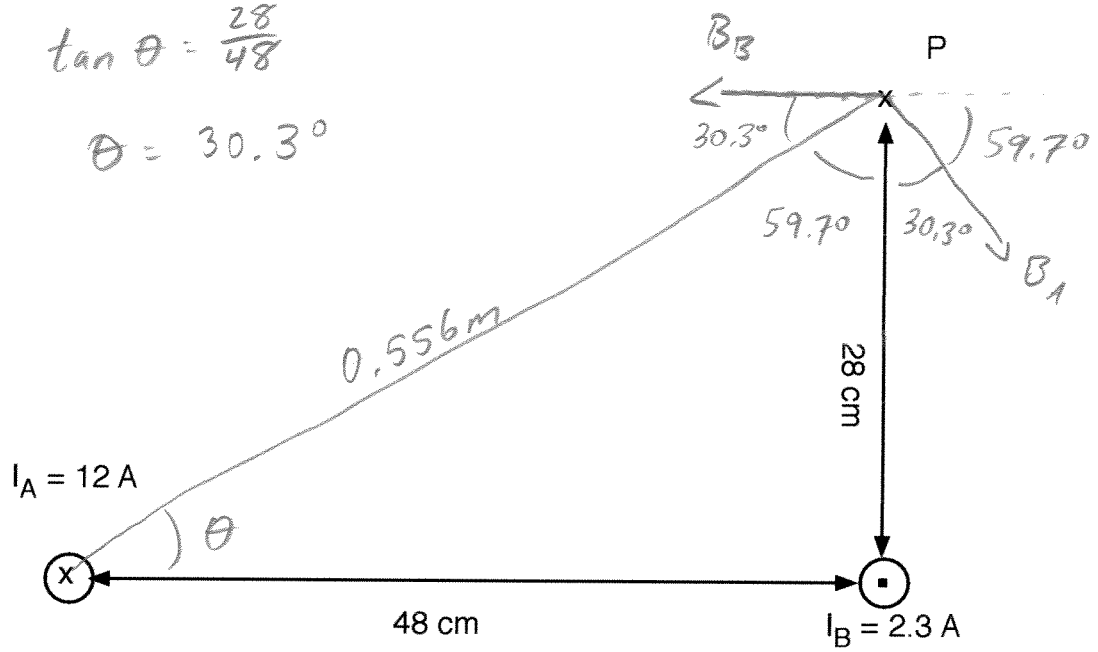
$-1.90 = -\frac{t}{.315}$

$t = 0.60 s$

2. (35 pts) Two parallel wires carry currents in opposite directions, as shown below. Wire A carries current into the page, wire B carries current out of the page. Wire A crosses through the origin. Wire B crosses through the x-axis 48 cm from the origin. Find the magnitude and direction of the total magnetic field due to the two wires at point P which has coordinates (x = 48 cm, y = 28 cm).

$\tan\theta = \frac{28}{48}$

$\theta = 30.3°$



$|B_A| = \frac{\mu_0(12)}{2\pi(.556)} = 4.32 \times 10^{-6}\ T$, 59.7° below $+x$

$|B_B| = \frac{\mu_0(2.3)}{2\pi(.28)} = 1.64 \times 10^{-6}\ T$, $-x$

$B_{Ax} = 4.32 \cos 59.7° = 2.18$

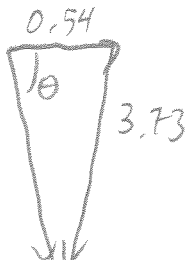
$B_{Ay} = -4.32 \sin 59.7° = -3.73$

$B_{Bx} = -1.64$

$B_{By} = 0$

$B_{TOT,x} = 0.54$

$B_{TOT,y} = -3.73$

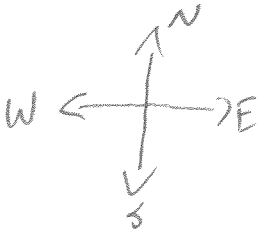


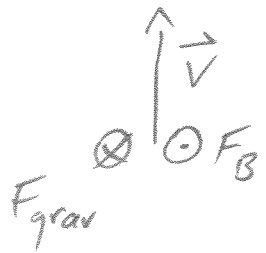
$B_{TOT} = \sqrt{.54^2 + (3.73)^2} = 3.8 \times 10^{-6}\ T$

$\theta = \tan^{-1}\left(\frac{3.73}{.54}\right) =$ 82° below $+x$

3. (30 pts) A proton is moving north with a speed of 32,000 meters/sec through a uniform magnetic field. The proton moves parallel to the surface of the Earth because the magnetic force it feels cancels out the gravitational force. Assume that the only forces in this problem are gravity and the magnetic force.

a) What is the magnitude and direction of the magnetic field through which the proton moves?





According to RHR, $\vec{B}$ must point ←, which is West

Need $|F_{grav}| = |F_B|$

$$mg = qvB$$

$$B = \frac{mg}{qv} = \frac{(1.67\times10^{-27})(9.8)}{(1.60\times10^{-19})(32{,}000)} = \boxed{3.2\times10^{-12}\ T,\ \text{West}}$$

b) A square loop carries a current in a clockwise direction and is immersed in a uniform, external magnetic field pointing in the +x direction as shown. For each straight segment of the loop, indicate the direction of the magnetic force on the wire (or write "zero" if there is no force).