Physics 10164 - 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. (40 pts) A circuit contains a 12-Volt battery, a 25,000 Ohm resistor and a capacitor, initially uncharged. A switch is closed at time t=0 closing the loop of the circuit. After 0.14 seconds has elapsed, the capacitor has charged to 75% 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?

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

$$0.75 = 1 - e^{-0.14/RC}$$

$$-0.25 = -e^{-0.14/RC}$$

$$\ln 0.25 = -\frac{0.14}{RC}$$

$$(25000)\,C = -\frac{0.14}{-1.39} \Rightarrow \boxed{C = 4.0\times10^{-6}\,F}$$

b) $I(t) = \frac{3\,V^{*}}{25000} = \boxed{1.2\times10^{-4}\,A}$

or $\frac{\varepsilon}{R} e^{-t/RC} = \frac{12}{25000} e^{-0.14/0.10}$

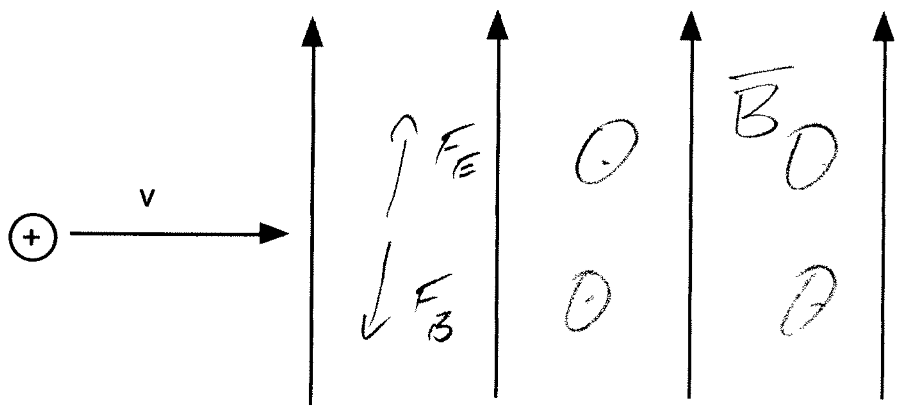
$$= 1.2\times10^{-4}$$

* We know $\Delta V_R = 3\,V$ since $\Delta V_C = 75\%$ of 12V or 9V.

2. (30 pts) A proton is accelerated from rest through a potential of 1200 Volts and, once it has achieved its final velocity, it moves at that velocity into a region shown below with a uniform electric field of magnitude 650 Volts/meter.

a) Assuming the proton's velocity (magnitude and direction) is constant while in the electric field, determine the magnitude and direction of the magnetic field that is also present in this region.

b) Suppose in this region, the magnitude of the electric field drops to 450 V/m but the magnetic field you calculated in part (a) remains present. What would be the direction of net force acting on the proton? Sketch the proton's path in this case.



B must point ⊙ to create F_B ↓

$$W_E = q\Delta V = \frac{1}{2}mv^2$$

$$(1.60\times10^{-19})(1200) = \frac{1}{2}(1.67\times10^{-27})v^2$$

$$v = 4.8\times10^{5}\ m/s$$

$$v = \frac{E}{B},\ \text{so}\ B = \frac{E}{v} = \frac{650}{4.8\times10^{5}} = \boxed{1.4\times10^{-3}\ T}$$

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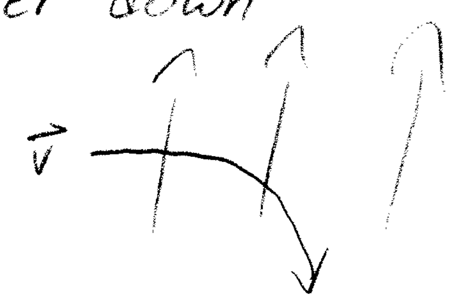
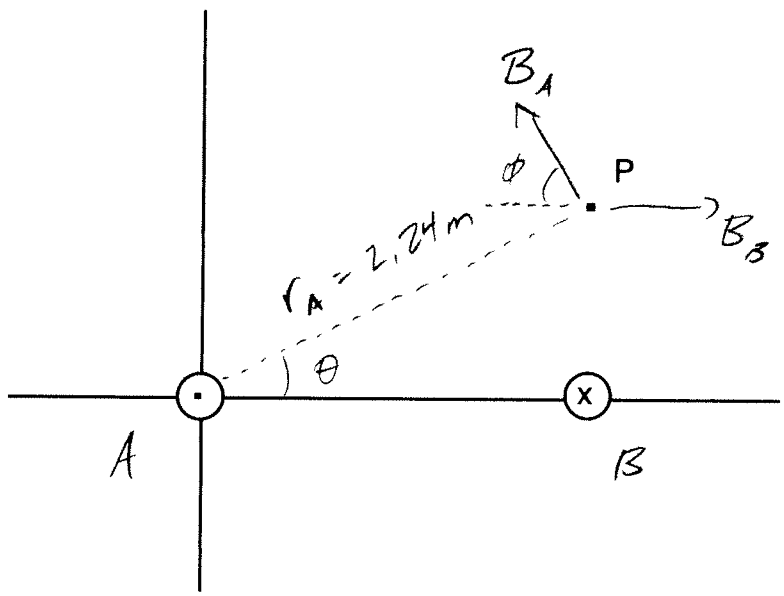
b) If F_E drops, ⊕ will veer down since F_B stronger

Net force is downward.



3. (30 pts) Wire A has a current of 3.0 Amps directed out of the page, and it passes through the origin perpendicular to the xy-plane as shown below. Wire B has a current of 2.0 Amps directed into the page, and it passes through the point (2.0,0.0) perpendicular to the xy-plane also.

What is the magnitude and direction of the magnetic field at point P, located at (2.0,1.0) in the xy-plane?



$\theta = \tan^{-1}\left(\frac{1}{2}\right)$

$= 26.6°$

so $\phi = 90 - 26.6°$

$= 63.4°$

$|B_A| = \dfrac{\mu_0 I_A}{2\pi r_A} = 2.68 \times 10^{-7}$, $63.4°$ above $-x$

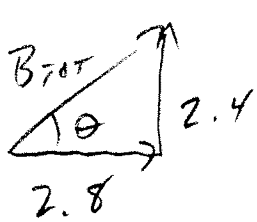
$|B_B| = \dfrac{\mu_0 I_B}{2\pi r_B} = 4.00 \times 10^{-7}$, $+x$

$B_{TOT,x} = 4.00 \times 10^{-7} - 2.68 \times 10^{-7} \cos 63.4°$

$= 2.8 \times 10^{-7}$

$B_{TOT,y} = 2.68 \times 10^{-7} \sin 63.4° = 2.4 \times 10^{-7}$

$B_{TOT} = \sqrt{2.8^2 + 2.4^2} = \boxed{3.7 \times 10^{-7}\ T}$



$\theta = \tan^{-1}\left(\frac{2.4}{2.8}\right) = \boxed{41° \text{ above } +x}$