Physics 10164 - Spring 2019 Exam 2F

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

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

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

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

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

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

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

$t = 0.693\,RC = \boxed{5.4 \times 10^{-6}\ s}$

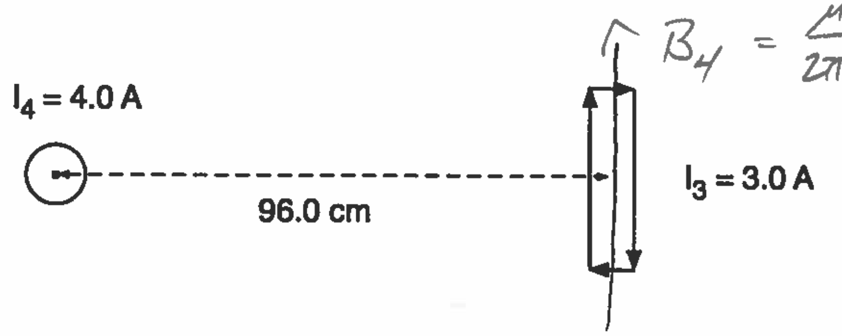
2. (40 pts) A long straight wire with current I_4 pointing out of the page generates a magnetic field in the vicinity of the rectangular loop shown. Assume the magnetic field in that loop is uniform and equal to the magnitude and direction of the field at the geometric center of the loop, located 96.0 cm away from wire I_4. The 5.0 cm x 18 cm single-turn rectangular loop is in the plane of the page and contains a clockwise current I_3.

a) Determine the magnitude and direction of the magnetic force on (i) the left wire of the loop and (ii) the top wire of the loop.

b) Determine the magnitude of the torque acting on the loop.

c) Describe how the loop will rotate in response to the torque.

$B_4 = \frac{\mu_0 I_4}{2\pi(.96)} = 8.33 \times 10^{-7}\ T$



a) On left wire I_3 is parallel to B_4, so $F_B = 0$

On top wire $\vec{F}_B = \ell \vec{I}_3 \times \vec{B}_4$

$= (.05)(3.0)(8.33 \times 10^{-7}) = \boxed{1.3 \times 10^{-7}\ N}$

RHR #1 says $\vec{F}_B$ points ⊙ $\boxed{⊙}$

b) μ points ⊗, so $\theta = 90°$

$\tau = N I_3 A B_4 \sin 90°$

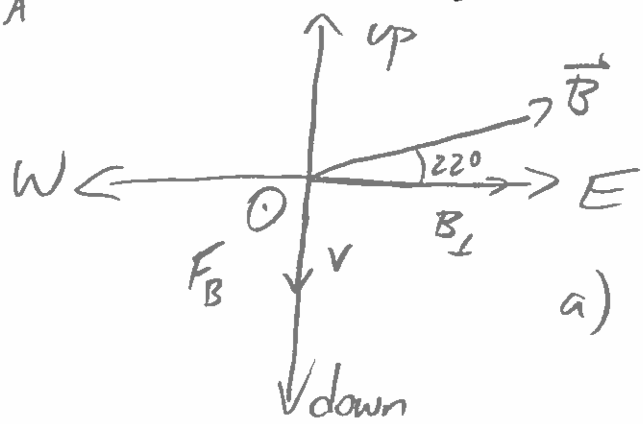
$= (1)(3.0)(.05)(.18)(8.33 \times 10^{-7})(1)$

$= \boxed{2.2 \times 10^{-8}\ N \cdot m}$

c) Top side comes out of page,
bottom side goes into page (so $\vec{\mu}$ aligns with $\vec{B}$)

3. (30 pts) A 75-cm long thin conducting rod is oriented North-South and is falling vertically downward with a speed of 45 m/s through a 75 μT magnetic field that points 22° vertically above due East.

a) What is the magnitude of the induced EMF in the rod?
b) Which end of the rod is positive, North or South?
c) If current flows through the rod in the direction that positive charges are forced, what is the magnitude and direction of the magnetic force on the rod? 0.25 A

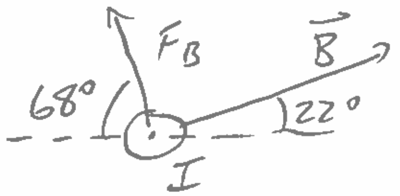


$B_\perp = 75 \cos 22°$
$= 69.5\ \mu T$

a) $\mathcal{E}_{ind} = B_\perp l v$
$= (69.5 \times 10^{-6})(.75)(45)$
$= \boxed{2.3 \times 10^{-3}\ \text{Volts}}$

b) F_B points ⊙ (South) from RHR #1
so + charges gather in $\boxed{\text{South end}}$

c) $\vec{F}_B = l\,\vec{I} \times \vec{B} = (.75)(0.25)(75 \times 10^{-6}) \sin 90°$
(p, t, f)



$= \boxed{1.4 \times 10^{-5}\ N \quad 68° \text{ vert. above West}}$