Physics 10164 - Spring 2019 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.

(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 resistor is 4.5 Volts.

a) What is the capacitance of the capacitor?
b) At that time, what is the voltage drop across the capacitor?
c) At what time is the capacitor 75% charged?

a) $I = \frac{\Delta V_R}{R} = \frac{4.5}{3} = 1.5\,A \qquad I_{max} = \frac{12}{3} = 4\,A$

$I(t) = I_{max} e^{-t/RC}$

$1.5 = 4.0 e^{-t/RC}$

$0.375 = e^{-t/RC}$

$-0.981 = -\frac{t}{RC}$

$C = \frac{t}{(.981)R} = \frac{3.6\times10^{-6}}{(.981)(3)} = \boxed{1.2\,\mu F}$

b) Loop rule says $\underset{(4.5)}{\Delta V_R} + \Delta V_c = \underset{(12)}{\mathcal{E}}$

$\Rightarrow \boxed{\Delta V_c = 7.5\text{ Volts}}$

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

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

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

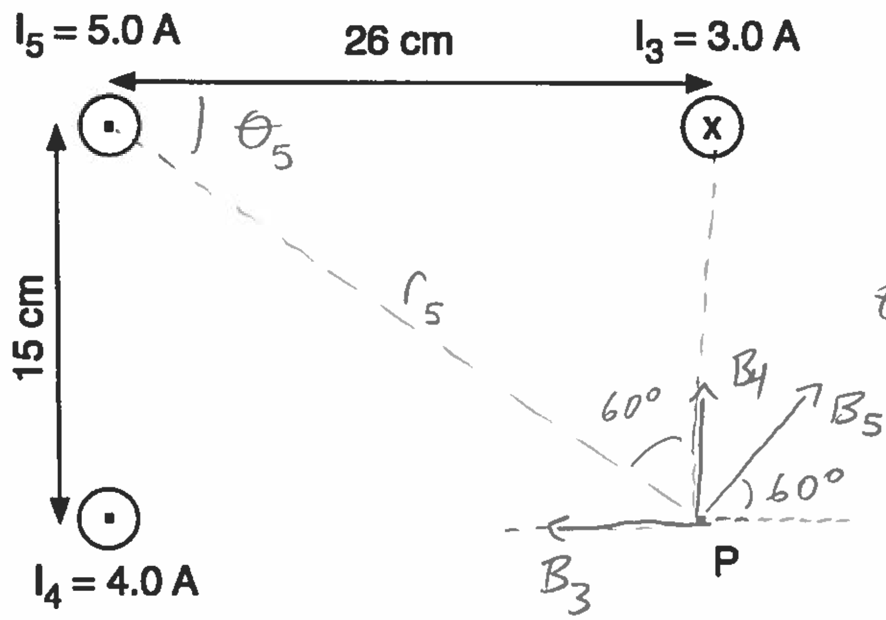
$0.25 = e^{-t/RC}$

$-1.386 = -\frac{t}{RC}$

$t = 1.386(3.0)(1.2\times10^{-6})$

$= \boxed{5.0\times10^{-6}\,s}$

2. (40 pts) Three wires are arranged to form three corners of a rectangle as shown below. The currents in the wires are all perpendicular to the plane of the rectangle and the page. Point P is in the 4th corner of the rectangle. Find the magnitude and direction of the magnetic field at point P due to the 3 wires.



$r_5 = \sqrt{.26^2 + .15^2}$

$= 0.30\,m$

$\theta_5 = \tan^{-1}\left(\frac{.15}{.26}\right)$

$= 30.0°$

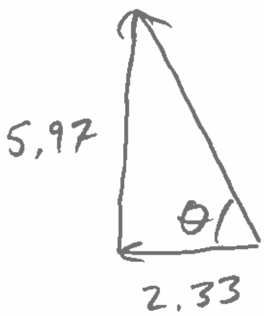
$|B_3| = \frac{\mu_0 I_3}{2\pi(.15)} = 4.0\,\mu T, \leftarrow$ $\qquad B_{3x} = -4.0 \quad B_{3y} = 0$

$|B_4| = \frac{\mu_0 I_4}{2\pi(.26)} = 3.08\,\mu T, \uparrow$ $\qquad B_{4x} = 0 \quad B_{4y} = +3.08$

$|B_5| = \frac{\mu_0 I_5}{2\pi(.30)} = 3.33\,\mu T$, 60° above +x

$B_{5x} = 1.67 \quad B_{5y} = 2.89$

$-2.33 \qquad 5.97$

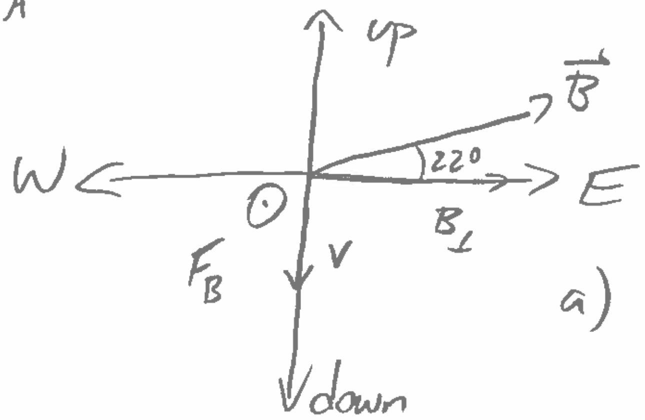


$B_{TOT} = \sqrt{2.33^2 + 5.97^2} = 6.4\,\mu T$

$\theta = \tan^{-1}\left(\frac{5.97}{2.33}\right) = 69°$ above $-x$

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 (0.25 A) 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?



$B_\perp = 75 \cos 22° = 69.5\ \mu T$

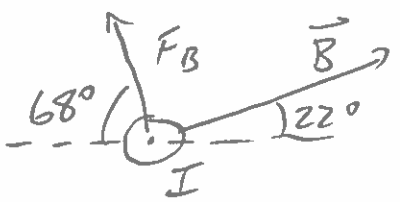
a) $\mathcal{E}_{ind} = B_\perp l v = (69.5\times10^{-6})(.75)(45) = \boxed{2.3\times10^{-3}\ \text{Volts}}$

b) F_B points ⊙ (South) from RHR #1

so + charges gather in **South end**

c) P t f

$F_B = l\vec{I}\times\vec{B} = (.75)(0.25)(75\times10^{-6})\sin 90°$



$= \boxed{1.4\times10^{-5}\ N}$ 68° vert. above West