Physics 10164 - Exam 3A

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) An alternating current circuit has a voltage source with a peak voltage of 170 Volts and a frequency of 75 Hz. The resistor in the circuit has a resistance of 6.5 Ohms. A capacitor is also in the circuit. The rms current in the circuit is measured to be ~~0.22~~ 12 Amps.

a) What is the capacitance of the capacitor?

b) What is the maximum voltage drop possible across the resistor?

c) What is the maximum voltage drop possible across the capacitor?

d) When the current is maximized, what is the voltage drop across (i) the resistor, (ii) capacitor and (iii) voltage source?

$$I_{rms} = \frac{\mathcal{E}_{rms}}{Z} \qquad \mathcal{E}_{rms} = \frac{\mathcal{E}_{max}}{\sqrt{2}} = 120$$

$$Z = \frac{120}{12} = 10.02 = \sqrt{R^2 + X_c^2}$$

$$100.35 = (6.5)^2 + X_c^2$$

$$58.1 = X_c^2$$

$$7.62 = X_c = \frac{1}{2\pi f C}$$

$$C = \frac{1}{2\pi(75)(7.62)} = \boxed{2.8 \times 10^{-4}\ F}$$

b) $\Delta V_{R,MAX} = I_{max} R \qquad I_{max} = \sqrt{2}\, I_{rms} = 16.97$

$= (16.97)(6.5) = 110$ Volts

c) $\Delta V_{c,MAX} = I_{max} X_c$

$= (16.97)(7.62) = 130$ Volts

d) If $I = I_{max}$, $\Delta V_R = \Delta V_{R,MAX} = 110$ Volts

By loop rule

At I_{max}, C is uncharged, so $\Delta V_c = 0$ Volts

$\Delta V_{\mathcal{E}} = 110$ Volts

2. (30 pts) In the figure below, we are looking end-on along the axis of a 500 turn, 25-cm long solenoid. There is a 2.1 Ampere current in the solenoid flowing in a clockwise direction. Inside the solenoid is a 2.2 cm x 2.2 cm square loop oriented with its plane perpendicular to the axis of the solenoid.

Now assume that the current in the solenoid drops to zero in a time interval of 0.15 seconds.

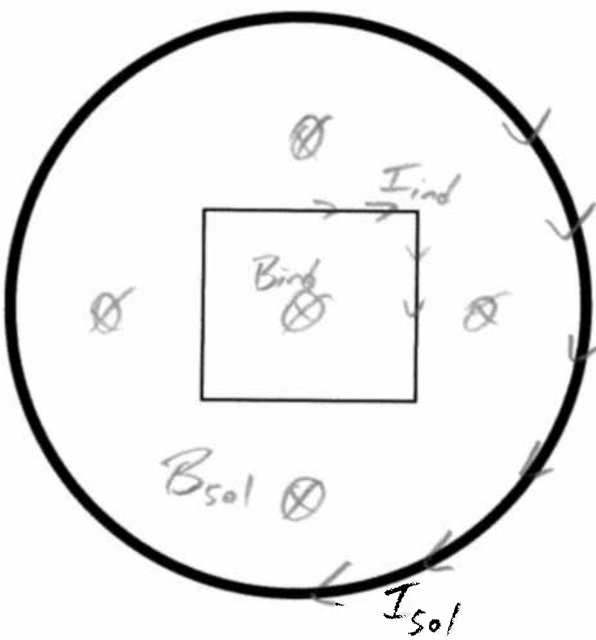
a) What is the initial direction of the flux in the square loop? $\otimes$

b) How is the flux changing in the square loop (increasing or decreasing)? decreasing since $I_{sol} \Rightarrow 0$

c) In what direction is the induced magnetic field in the square loop? $\otimes$

d) What the magnitude of the induced EMF in the square loop during this time interval?

e) What is the direction of the induced current in the square loop during this time interval?



$$\vec{B}_i = \frac{\mu_0 N I}{L} = \frac{(1.26\times10^{-6})(500)(2.1)}{0.25} = .00529\ T$$

$$\vec{B}_f = 0$$

c) Since $\Phi_{loop} = \otimes$, decreasing

$B_{ind} = \otimes$

d) $$\mathcal{E}_{ind} = N\frac{\Delta \Phi_B}{\Delta t} = \frac{N \Delta B A \cos\theta}{\Delta t}$$

$$= \frac{(1)(.00529)(.022)^2(1)}{0.15} = 1.7\times10^{-5}\ \text{Volts}$$

e) Since $B_{ind} = \otimes$, $I_{ind} = CW$

3. (30 pts) A series circuit contains a 12 Volt battery, a 3.5 Ohm resistor, and a 0.045 H inductor. A switch is closed at t=0, connecting the (direct current) circuit.

a) What is the voltage drop across the inductor just after the switch is closed?

b) At what time is the voltage drop across the inductor equal to 2.0 Volts?

c) At the time when the current in the circuit is 2.0 Amps, what is the voltage drop across the inductor?

a) At $t=0$ $\Delta V_L = \Delta V_{max} = \mathcal{E} = 12$ Volts

I changing fastest, so $\frac{\Delta I}{\Delta t}$ largest,

so $\Delta V_L \propto \frac{\Delta I}{\Delta t} = max$

b) $2.0 = 12e^{-t/\tau}$ $\tau = \frac{L}{R} = .01286$

$\frac{2}{12} = e^{-t/\tau}$

$\ln\left(\frac{2}{12}\right) = -\frac{t}{.01286}$

$-1.792 = -\frac{t}{.01286}$ $\Rightarrow$ $t = 0.023$ s

c) If $I = 2.0$ A

$\Delta V_R = IR = 7.0$ Volts

loop rule: $\Delta V_L = 5.0$ Volts

so that $\Delta V_R + \Delta V_L = \mathcal{E}$

$7 + 5 = 12$