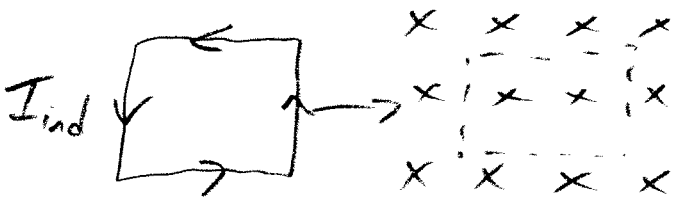
Physics 10164 - Exam #3B

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. If you give more than one answer without indicating which is correct, you will definitely lose points, even if one answer is correct.

1. (40 pts) A 250-turn square loop 45 cm on a side is next to a region with a 5.6 Tesla magnetic field pointing into the page, perpendicular to the plane of the loop as shown. The loop has a resistance of 0.14 Ohms.

The loop slowly moves to the right, entering the region of the magnetic field until the loop is completely within the field in a time interval of 1.5 seconds.

What is the magnitude and direction (cw or ccw) of the induced current in the loop during this time interval?



$\Phi = 0$

$\Delta\Phi = \times$, increasing

$B_{ind} = \odot$ to oppose $\Delta\Phi$

I_{ind} = ccw 

$$|\mathcal{E}_{ind}| = N\frac{\Delta\Phi}{\Delta t} = \frac{N\Delta B A\cos\theta}{\Delta t}$$

$$= \frac{(250)(5.6)(.45)^2\cos 0^\circ}{1.5} = 189$$

$$I_{ind} = \frac{\mathcal{E}_{ind}}{R} = \frac{189}{.14} = \boxed{1350\ A} \text{ or } 1400\ A$$

2. (30 pts) A circuit contains a 4.5 Ohm resistor, a 0.15 H inductor, an open switch and a 9.0 Volt battery. At t = 0, the switch is closed, completing the circuit.

a) What is the maximum possible value of the current?

b) At what time, t, is the current 33% of its maximum value?

c) At this time, what is the voltage drop across the resistor?

d) At this time, what is the voltage drop across the inductor?

a) $I_{max} = \frac{\mathcal{E}_{max}}{R} = \frac{9}{4.5} = \boxed{2.0\ A}$

b) $I(t) = 0.33\, I_{max}$

$\tau = \frac{L}{R} = .0333$

$0.33\, I_{max} = I_{max}\left(1 - e^{-t/\tau}\right)$

$0.33 = 1 - e^{-t/.0333}$

$\ln 0.67 = -\frac{t}{.0333}$

$\boxed{t = 0.013\ s}$

c) $\Delta V_R = IR$

($\mathcal{E}$ of battery)

Since $I = \frac{1}{3} I_{max}$, $\Delta V_R = \frac{1}{3} \Delta V_{R,MAX}$

$\Delta V_R = \frac{1}{3}(9) = \boxed{3.0\ Volts}$

d) $\boxed{\Delta V_L = 6.0\ Volts}$ (loop rule)

3. (30 pts) An RLC circuit contains a 4.2 Ohm resistor, a 48 mH inductor, a 2.1 μF capacitor and a 120 Volt rms alternating voltage source.

a) If this circuit is operated at a frequency of 320 Hz, what is the average power dissipated in the circuit?

b) What is the resonant frequency of this circuit?

c) If the circuit is operated at the resonant frequency, what will be the average power dissipated in the circuit?

a) $X_L = 2\pi f L = 2\pi(320)(.048) = 96.5\ \Omega$

$X_C = \frac{1}{2\pi f C} = \frac{1}{2\pi(320)(2.1\times10^{-6})} = 236.8\ \Omega$

$Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{4.2^2 + (96.5 - 236.8)^2}$

$= 140\ \Omega$

$I_{rms} = \frac{\mathcal{E}_{rms}}{Z} = \frac{120}{140} = 0.855$

$P_{avg} = I_{rms}^2 R = (.855)^2(4.2) = \boxed{3.1\ W}$

b) $f_{res} = \frac{1}{2\pi\sqrt{LC}} = \boxed{501\ Hz}$ or $500\ Hz$

c) $I_{rms} = \frac{\mathcal{E}_{rms}}{Z}$ $Z = R$ at resonance, so...

$I_{rms} = \frac{120}{4.2} = 28.6$

$P_{avg} = (28.6)^2(4.2) = \boxed{3400\ W}$