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

1. (30 pts) A RL circuit contains a 15 Ohm resistor, a 33 mH inductor, an open switch and a 24 Volt battery. At t = 0, the switch is closed, connecting the circuit.

a) What is the voltage drop across the resistor after 1 time constant has elapsed?

b) What is the voltage drop across the inductor at this time?

c) At what time t is the voltage drop across the inductor equal to 5.0% of its maximum possible value?

a) $I_{max} = \frac{\mathcal{E}_{max}}{R} = \frac{24}{15} = 1.6\ A$

$I(t) = I_{max}(1 - e^{-t/\tau}) = 1.6(1 - e^{-1})$

$= 1.0$

$\Delta V_R = (1.0)(15) =$ **15 Volts**

b) **$\Delta V_L = 9.0$ Volts** (loop rule)

c) $\Delta V_L = \Delta V_{L,MAX}\, e^{-t/\tau}$

$\frac{\Delta V_L}{\Delta V_{L,MAX}} = 0.05 = e^{-t/\tau}$ $\quad \tau = \frac{L}{R} = .0022$

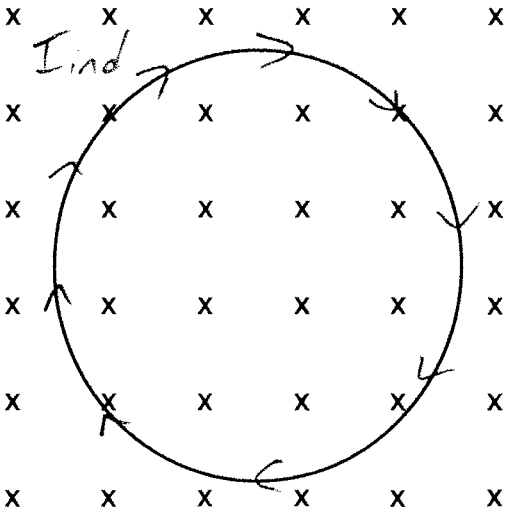
$\ln 0.05 = -\frac{t}{.0022}$

$t = .0066$ or 6.6×10^{-3} s

2. (30 pts) A single-turn, circular wire loop of radius 3.5 cm is placed in an external magnetic field of 5.0 Tesla pointing into the page and perpendicular to the plane of the loop. The loop has a resistance of 0.045 Ohms.

The magnetic field is changed over a time interval of 1.2 seconds so that it now has a magnitude of 5.0 Tesla pointing out of the page.

During this time interval, what is the magnitude and direction (cw or ccw) of the induced current in the loop?



$\Phi = x$

$\Delta\Phi$ = decreasing or 0 increase (same either way)

$B_{ind} = x$ to oppose change

so I_{ind} is clockwise

$$|\mathcal{E}_{ind}| = N\frac{\Delta\Phi}{\Delta t} = (1)\frac{\Delta B A\cos\theta}{\Delta t}$$

$$= \frac{(1)(10)(\pi)(.035)^2\cos 0^\circ}{1.2} = 0.032 \text{ Volts}$$

$$I_{ind} = \frac{\mathcal{E}_{ind}}{R} = \frac{.032}{.045} = \boxed{0.71\ A}$$

3. (40 pts) An RLC circuit contains a 2.2 Ohm resistor, a 74 mH inductor, a 1.1 μF capacitor and a 120 Volt rms alternating voltage source.

a) At the resonant frequency, what is the rms current in the circuit?

b) At the resonant frequency, what the the maximum amplitude of the current in the circuit?

c) At the resonant frequency, what is the power dissipated in the circuit?

d) If the frequency is reduced by 15%, what is the power dissipated in the circuit?

a) At res, $Z = R = 2.2$

$$I_{rms} = \frac{\mathcal{E}_{rms}}{Z} = \frac{120}{2.2} = \boxed{54.5\ A} \text{ or } 55A$$

b) $I_{max} = \frac{I_{rms}}{.707} = \boxed{77\ A}$

c) $P = I_{rms}^2 R = (54.5)^2(2.2) = \boxed{6500\ W}$

d) $f_0 = \frac{1}{2\pi\sqrt{LC}} = 557.8\ Hz$

$f_{new} = 0.85 f_0 = 474\ Hz$

$X_L = 2\pi f L = 2\pi(474)(.074) = 220.5$

$X_C = \frac{1}{2\pi f C} = \frac{1}{2\pi(474)(1.1\times10^{-6})} = 305.2$

$Z = \sqrt{2.2^2 + (220.5 - 305.2)^2} = 84.8$

$I_{new} = \frac{120}{84.8} = 1.4 \quad P = (1.4)^2(2.2) = \boxed{4.4\ W}$