# 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 and remember to include correct units and significant figures.

1. (30 pts) An RL circuit has a direct-current 12 Volt battery. The switch is initially open. At t=0, the switch is closed, completing the circuit The resistor in the circuit is 3.0 Ohms, and the inductor is 0.012 H.

a) What is the voltage drop across the inductor after one time constant has elapsed?

b) At what time is the current in the circuit equal to 85% of its maximum possible value?

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

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

a) $\Delta V_L = \mathcal{E} e^{-t/\tau}$

$= 12 e^{-\tau/\tau} = 12 e^{-1} =$ (4.4 Volts)

b) $I = \frac{\mathcal{E}}{R}(1 - e^{-t/\tau})$ $\tau = \frac{L}{R} = .004\,s$

$I = .85 \frac{\mathcal{E}}{R} = \frac{\mathcal{E}}{R}(1 - e^{-t/\tau})$

$-0.15 = -e^{-t/\tau}$

$\ln 0.15 = -\frac{t}{.004}$ (t = .0076 s)

c) $\Delta V_L = \mathcal{E} e^{-t/\tau} = 12 e^{-.0076/.004} =$ (1.8 Volts)

d) loop rule: $\Delta V_R + \Delta V_L = \mathcal{E}$

$\Delta V_R + 1.8 = 12$

($\Delta V_R = 10$ Volts)

2. (30 pts) An AC adapter for an electronic device uses a step-down transformer to reduce the input household voltage of 120 Volts (rms) to an output voltage of 2.0 Volts for the device. The rms current delivered to the transformer by the household outlet is 0.33 Amps.

a) If the primary input coil in the transformer has 180 turns, how many turns are there on the secondary output coil?

b) If the electronic device is connected to the transformer by a long extension cord with a resistance of ~~1.4~~ Ohms, how much power is dissipated by the resistance in the cord? → 0.014

c) What fraction of the power supplied to the device is lost due to resistance in the extension cord?

a) $\Delta V_p = 120$ Volts $\quad N_p = 180$

$\Delta V_s = 2.0$ Volts $\quad N_s = ?$

$$2.0 = \frac{N_s}{180}(120) \quad N_s = 3 \text{ turns}$$

b) $I_p \Delta V_p = (.33)(120) = 40$ Watts

$I_s \Delta V_s = 40$ Watts

$I_s(2) = 40$

$I_s = 20$

$P = I_s^2 R = (20)^2(0.014) = 5.6$ Watts

c) $\%\text{ loss} = \frac{(P_{lost})}{(P_{supplied})} = \frac{5.6}{40} = 0.14$

14%

3. (40 pts) An alternating current circuit has a voltage source with a peak voltage of 170 Volts and a frequency of 45 Hz. The resistor in the circuit has a resistance of 4.5 Ohms. An inductor is also in the circuit. The rms current in the circuit is measured to be ~~0.22~~ 22 Amps.

a) What is the inductance of the inductor?

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

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

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

a) $I_{max} = \sqrt{2}\, I_{rms} = 31.1 = \frac{\mathcal{E}_{max}}{Z}$

$$Z = \frac{170}{31.1} = 5.47\ \Omega$$

$$Z^2 = R^2 + X_L^2$$

$$(5.47)^2 = (4.5)^2 + X_L^2$$

$$X_L^2 = 9.63$$

$$X_L = 2\pi f L = 3.10$$

$$L = \frac{3.10}{2\pi f} = .011\ H$$

b) $\Delta V_{R,MAX} = I_{max} R = 140$ Volts

c) $\Delta V_{L,MAX} = I_{max} X_L = 96$ Volts

d) If $I = max$ $\Delta V_R = max = 140$ Volts

$\frac{\Delta I}{\Delta t} = 0$, so $\Delta V_L \propto \frac{\Delta I}{\Delta t} = 0$ Volts

loop rule: $\Delta V_R + \Delta V_L = \Delta V_\mathcal{E}$

$140 + 0 = 140$ Volts