Physics 10164 - Exam 3D

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 RLC circuit contains a 4.2 Ohm resistor, a 42 mH inductor and a 22 μF capacitor. It is powered by a 120 Volt (rms) alternating current source.

a) What is the resonant frequency of this circuit?

b) If operated at resonance, what is the power dissipated by the circuit?

c) If operated at one-half the resonant frequency, what is the power dissipated by the circuit?

a) $f_0 = \frac{1}{2\pi\sqrt{LC}} = 165.6\ Hz$ or (170 Hz)

b) At resonance, $Z = R$

$$I_{rms} = \frac{\mathcal{E}_{rms}}{Z} = \frac{120}{4.2} = 28.57\ A$$

$$P_{lost} = I_{rms}^2 R = (28.57)^2(4.2) = (3400\ W)$$

c) $f = 82.8\ Hz$

$$X_L = 2\pi f L = 21.85$$

$$X_C = \frac{1}{2\pi f C} = 87.37$$

$$Z = \sqrt{4.2^2 + (87.37 - 21.85)^2}$$

$$= 65.7\ \Omega$$

$$I_{rms} = \frac{120}{65.7} = 1.83\ A$$

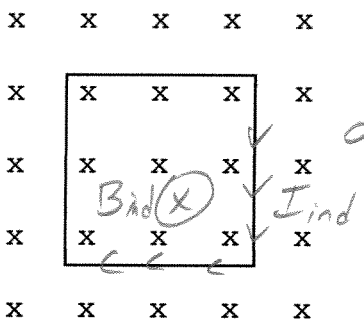
$$P_{lost} = (1.83)^2(4.2) = (14\ W)$$

2. (30 pts) A square loop, 25 cm on a side, is initially oriented with the plane of the loop perpendicular to a uniform, external 35 Tesla magnetic field as shown below. The magnetic field is changed over 0.15 seconds to be 22 Tesla pointing out of the page.

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

b) What is the direction of the magnetic field that is induced in the square loop during this time interval?

c) What is the direction of the induced current in the square loop?



a) $\mathcal{E}_{ind} = N\frac{\Delta \Phi_B}{\Delta t}$

$= \frac{N \Delta B A \cos\theta}{\Delta t}$

$= \frac{(1)(35-(-22))(.25)^2(1)}{0.15}$

$= 23.75 = (24\ V)$

b) Since $\Phi_B = (\times)$, decreasing

$B_{ind} = (\times)$

c) I_{ind} = clockwise to be consistent with B_{ind}

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

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

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

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

$$X_L^2 = 9.63$$

$$X_L = 3.10 = 2\pi f L \Rightarrow L = \frac{3.10}{2\pi(45)} = .011\ H$$

b) $\Delta V_{R,MAX} = I_{max} R = (31.1)(4.5) = 140\ Volts$

c) $\Delta V_{L,MAX} = I_{max} X_L = (31.1)(3.10) = 96\ Volts$

d) If $I = max$, $\Delta V_R = \Delta V_{R,MAX} = 140\ Volts$

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

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

$$140 + 0 = 140\ Volts$$