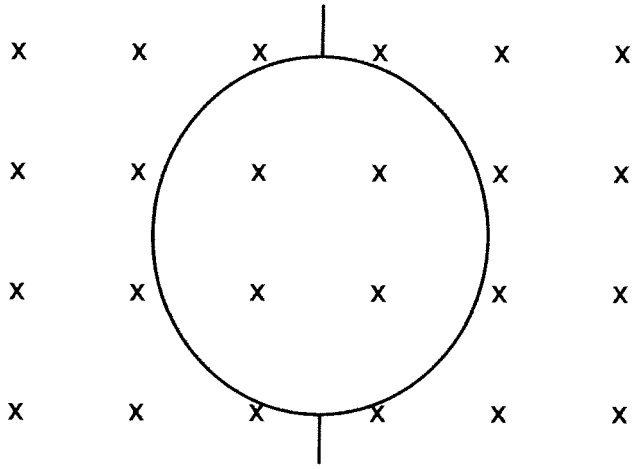
Physics 10164 - Exam 3D

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) A 55-turn circular loop with a resistance of 0.18 Ohms and a radius of 12 cm is aligned so its axis is parallel to a uniform 3.5 Tesla magnetic field pointing into the page. The loop rotates about a vertical axis so that the left side comes out of the page and the right side goes into the page. It takes 0.077 seconds for the loop to make its first quarter of a turn.

During that time interval, find the magnitude and direction of the induced current in the loop. For the direction of current, be sure to explain your reasoning fully.



$\Phi_i = BA\cos\theta$

$= (3.5)(\pi)(0.12)^2(1)$

$= 0.158$

$\Phi_f = 0$

$\mathcal{E} = N\frac{\Delta\Phi}{\Delta t}$

$= (55)\left(\frac{0.158}{.077}\right) = 113\,V$

a) $I_{ind} = \frac{\mathcal{E}_{ind}}{R} = \frac{113}{0.18} = \boxed{630\,A}$

b) $\Delta\Phi$ = x, decreasing

B_{ind} = x

$\boxed{I_{ind} = CW}$

2. (40 pts) An inductor has an inductive reactance of 32 Ohms in a circuit operated at a frequency of 120 Hz. The circuit also contains a 12 Ohm resistor and a 240 Volt rms source.

a) What is the power dissipated by the resistor in this circuit, when operated at 120 Hz?

b) If the frequency is changed to 180 Hz, what is the power dissipated by the resistor?

c) At a frequency of 180 Hz, what is the maximum voltage drop across the inductor?

d) At a frequency of 180 Hz, when the current is zero, what is the voltage drop across (i) the inductor and (ii) the voltage source? Explain both answers.

a) $Z = \sqrt{12^2 + 32^2} = 34.2\ \Omega$ $\quad L = \frac{32}{2\pi(120)}$

$I_{rms} = \frac{240}{34.2} = 7.02\ A$ $\quad = .0424$

$P_{lost} = I^2R = \boxed{590\ W}$

b) $X_L = 2\pi(180)(.0424) = 48\ \Omega$

$Z = \sqrt{12^2 + 48^2} = 49.5\ \Omega$

$I_{rms} = \frac{240}{49.5} = 4.85\ A$ $\quad P = I^2R = \boxed{280\ W}$

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

$I_{max} = \frac{4.85}{.707} = 6.86$ $\quad \boxed{\Delta V_{L,MAX} = 330\ V}$

d) When $I = 0$

$\frac{\Delta I}{\Delta t}$ is max, so $\boxed{\Delta V_L = \Delta V_{L,max} = 330\ V}$

When $I = 0$, $\boxed{\Delta V_R = IR = 0}$

By loop rule $\Delta V_\mathcal{E} = \Delta V_L + \Delta V_R = \boxed{330\ V}$

3. (30 pts) A series AC circuit contains a 3.3 Ohm resistor, a 650 mH inductor, a 240 μF capacitor and a 120 Volt rms voltage source.

a) What is the power supplied by this circuit when operated at the resonant frequency?

b) If the circuit is operated at a frequency 15% above the resonant frequency, what is the power supplied?

a) At resonance $Z = R = 3.3\ \Omega$

$$I_{rms} = \frac{120}{3.3} = 36.4\ A$$

$$P = I\mathcal{E} = \boxed{4400\ W}$$

b) $$f_0 = \frac{1}{2\pi\sqrt{LC}} = 12.7\ Hz$$

$$f_{new} = 14.7\ Hz$$

$$X_L = 2\pi f L = 59.8\ \Omega$$

$$X_C = \frac{1}{2\pi f C} = 45.1\ \Omega$$

$$Z = \sqrt{3.3^2 + (59.8 - 45.1)^2} = 15.1\ \Omega$$

$$I = \frac{120}{15.1} = 8.0\ A$$

$$P = I\mathcal{E} = \boxed{960\ W}$$