Physics 10164 - Exam 3C

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. (40 pts) An alternating current circuit has a voltage source with a peak voltage of 170 Volts and a frequency of 75 Hz. The resistor in the circuit has a resistance of 6.5 Ohms. A capacitor is also in the circuit. The rms current in the circuit is measured to be 12 Amps.

a) What is the capacitance of the capacitor?

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

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

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

a) $I_{rms} = \frac{\mathcal{E}_{rms}}{Z}$ $\quad \mathcal{E}_{rms} = \frac{\mathcal{E}_{max}}{\sqrt{2}} = 120$

$Z = \frac{120}{12} = 10.02 = \sqrt{R^2 + X_c^2}$

$100.35 = (6.5)^2 + X_c^2$

$58.1 = X_c^2$

$7.62 = X_c = \frac{1}{2\pi f C}$ $\quad C = \frac{1}{2\pi(75)(7.62)} = \boxed{2.8 \times 10^{-4} F}$

b) $\Delta V_{R,MAX} = I_{max} R$ $\quad I_{max} = \sqrt{2}\, I_{rms} = 16.97$

$= (16.97)(6.5) = \boxed{110 \text{ Volts}}$

c) $\Delta V_{C,MAX} = I_{max} X_c = (16.97)(7.62) = \boxed{130 \text{ Volts}}$

d) If $I = I_{max}$, $\Delta V_R = \Delta V_{R,MAX} = 110$ Volts

At I_{max}, C is uncharged, so $\Delta V_C = 0$ Volts

By loop rule, $\Delta V_{\mathcal{E}} = 110$ Volts

2. (30 pts) In the figure below, we are looking at a 25-turn circular loop of radius 33 cm in the plane of the page. The loop is immersed in a uniform, 45 Tesla magnetic field pointing into the page. The loop is rotated such that the left side of the loop comes out of the page, and the right side of the loop goes into the page. It is rotated 90 degrees in 0.15 seconds.

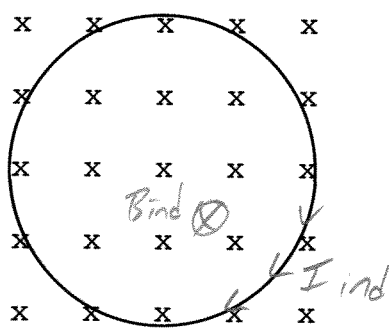
a) What is the initial direction of the flux in the loop? $\otimes$

b) How is the flux changing in the loop (increasing or decreasing)? $\cos\theta \rightarrow 1 \rightarrow 0$ decreasing

c) In what direction is the induced magnetic field in the loop? $\otimes$

d) What the magnitude of the induced EMF in the loop during this time interval?

e) What is the direction of the induced current in the loop during this time interval?



c) Since $\Phi_B = \otimes$, decreasing

Bind must be $\otimes$

d) $\mathcal{E} = N \frac{\Delta \Phi_B}{\Delta t}$

$= \frac{NBA\Delta\cos\theta}{\Delta t}$

$= \frac{(25)(45)(\pi)(.33)^2(1)}{0.15} = \boxed{2600 \text{ Volts}}$

e) Since Bind = $\otimes$, Iind = clockwise

3. (30 pts) A transformer at a power company steps up the voltage from 12,000 Volts (rms) to 240,000 Volts (rms) in order to transmit power along a power line with a resistance of 140 Ohms over many miles. The power company generator is providing 1.4 million Watts to the transformer.

a) What percentage of the power is lost in the power lines due to dissipation?

b) If the voltage were kept at its original level and the step-up transformer skipped over, what percentage of the power would be lost in the lines?

$I_s \Delta V_s = 1.4 \times 10^6 W$ $\quad$ $I_p \Delta V_p = 1.4 \times 10^6 W$

$I_s (12000) = 1.4 \times 10^6 W$ $\quad$ $I_p (240000) = 1.4 \times 10^6$

$I_s = 116.7 A$ $\quad$ $I_p = 5.83 A$

a) $P_{lost} = I_p^2 R = (5.83)^2 (140)$

$= 4763$

$\% \text{ loss} = \frac{4763}{1.4 \times 10^6} \times 100 = 0.34\%$

b) $P_{lost} = I_s^2 R = (116.7)^2 (140)$

$= 136\%$ or 100%

all power lost