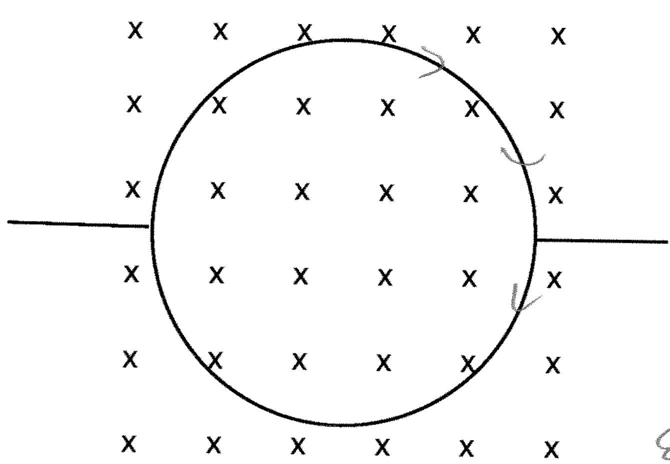
Physics 10164 - Exam 3C

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. (25 pts) A circular loop of radius 7.5 cm is oriented as shown so that the plane of the loop is perpendicular to the uniform external magnetic field of 3.5 Tesla it is immersed in. The resistance in the loop is 0.11 Ohms. If the loop rotates around the horizontal axis shown by 180° in 0.22 seconds, determine the magnitude and direction of the induced current in the loop as it begins its motion. Show work, including your reasoning for the direction of the induced current.



$A = \pi(.075)^2 = .01767\ m^2$

$\Delta\Phi_B = BA\,\Delta\cos\theta$ $\quad |\cos 0° - \cos 180°|$ or $|\cos 180° - \cos 0°|$

$= (3.5)(.01767)(2)$

$= 0.124$

$\mathcal{E}_{ind} = \frac{\Delta\Phi_B}{\Delta t} = 0.56\ \text{Volts}$

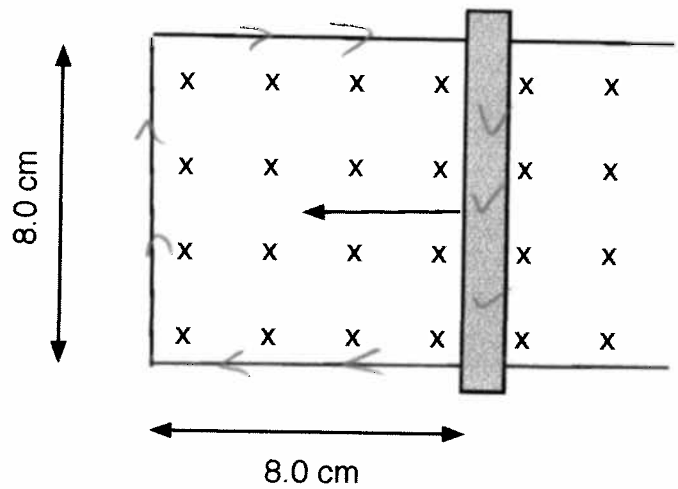
$I_{ind} = \frac{\mathcal{E}_{ind}}{R} = \boxed{5.1\ A}$

$\Delta\Phi_B = \otimes$, decreasing

$\Rightarrow B_{ind} = \otimes$

$\Rightarrow$ I_{ind} = clockwise

2. (25 pts) A U-shaped wire is immersed in an external magnetic field of magnitude 24 Tesla. A conducting rod connects the two sides of the wire as shown below, and it moves left by 2.0 cm in 0.12 seconds. If the resistance in the loop is 1.7 Ohms, determine the magnitude and direction of the induced current in the loop. Again, show work, including your reasoning for the direction of the induced current.



$$\Delta \Phi_B = B \Delta A \cos\theta$$

$$= (24)(.02)(.08)(1) = .0384$$

$$\mathcal{E}_{ind} = N \frac{\Delta \Phi_B}{\Delta t} = \frac{.0384}{.12} = 0.32 \text{ Volts}$$

$$I_{ind} = \frac{\mathcal{E}_{ind}}{R} = \frac{0.32}{1.7} = 0.19 \text{ A}$$

$\Delta \Phi_B = \otimes$, decreasing

$B_{ind} = \otimes$

I_{ind} = clockwise

3. (30 pts) An AC source operates at a frequency of 60.0 Hz with an rms voltage of 85 Volts. It is connected in series with a 65 Ohm resistor and an unknown capacitor. The rms current is measured to be 0.64 Amps.

a) What is the value of the capacitance?

b) What is the maximum value of the voltage drop across the resistor?

c) What is the maximum value of the voltage drop across the capacitor?

d) When the current is maximized in this circuit, what is the voltage drop across the resistor, the capacitor and the power source? Briefly explain and/or mathematically justify each of your three answers.

a) $I_{rms} = \frac{\mathcal{E}_{rms}}{Z} \Rightarrow Z = \frac{\mathcal{E}_{rms}}{I_{rms}} = \frac{85}{.64} = 132.8\,\Omega$

$(132.8)^2 = R^2 + X_c^2$

$X_c = 116\,\Omega = \frac{1}{2\pi f C}$

$C = \frac{1}{2\pi(60)(116)} \Rightarrow C = 2.3\times10^{-5}\,F$

or $23\,\mu F$

b) $I_{max} = \sqrt{2}\, I_{rms} = 0.905\,A$

$\Delta V_{R,MAX} = I_{max} R = 59$ Volts

c) $\Delta V_{C,MAX} = I_{max} X_c = 105$ Volts

d) I = max means capacitor is uncharged

Since R in phase with current $\Delta V_R = \Delta V_{R,MAX} = 59\,V$

Since C not charged, $\Delta V_c = 0$

Loop rule $\Delta V_{\mathcal{E}} = \Delta V_R + \Delta V_c = 59\,V$

4. (20 pts) An AC generator at a power plant produces 140 Amps at a voltage of 20,000 Volts. The voltage is then stepped up to 240,000 Volts by an ideal transformer, and this energy is then transmitted along a power line with a resistance of 95 Ohms.

a) What percentage of the power supplied is dissipated as heat in the power line?

b) If the power were not sent through the transformer first, what would be the percentage of power supplied that is dissipated by heat?

$$I_p \Delta V_p = I_s \Delta V_s$$

$$I_p (240{,}000) = (140)(20{,}000) = 2.8 \times 10^6 \, W$$

$$I_p = 11.7 \, A$$

a) $P_{lost} = I_p^2 R = 13000 W$

$$\% \text{ lost} = 100 \times \frac{13000}{2.8 \times 10^6} = 0.46\%$$

b) $P_{lost} = I_s^2 R = \frac{1.86 \times 10^6}{2.8 \times 10^6} \times 100 = 67\%$