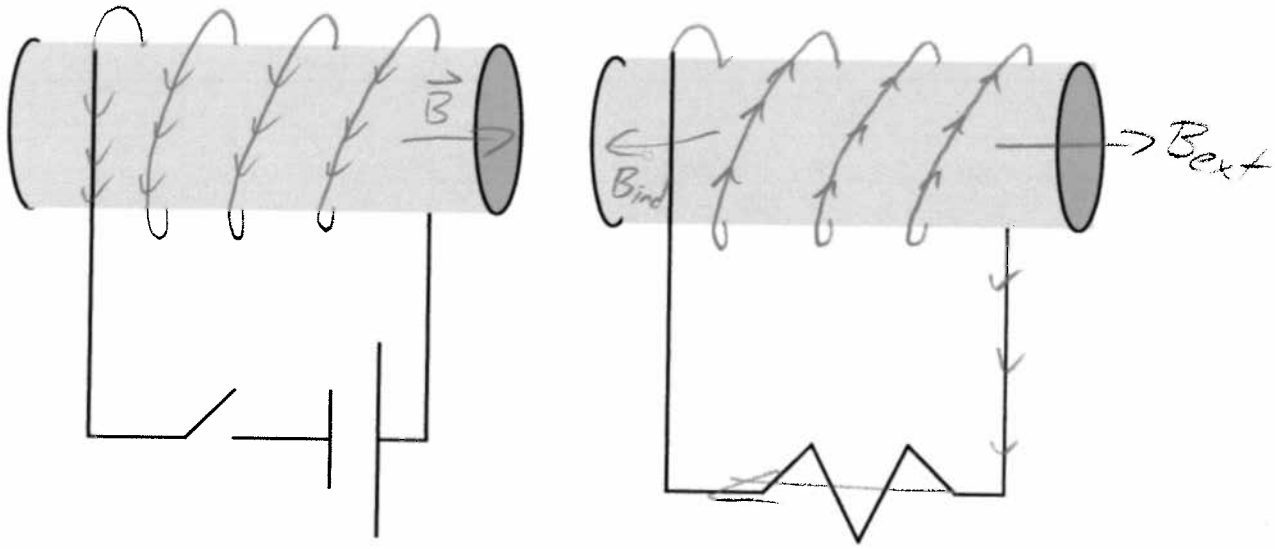
Physics 10164 - Exam 3A

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. (36 pts) Find the direction of induced current for each of the wire loops shown.



a) Describe the change in magnetic flux in the right coil after the switch is closed in the left circuit (state the direction of flux and whether it is increasing or decreasing).

→, increasing

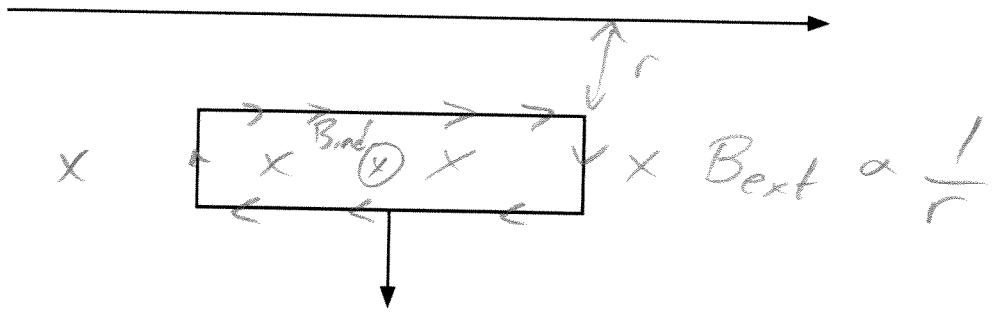
b) In what direction is the induced field in the right coil?

←

c) In what direction is the induced current in the resistor shown in the right coil?

←

1. (cont)



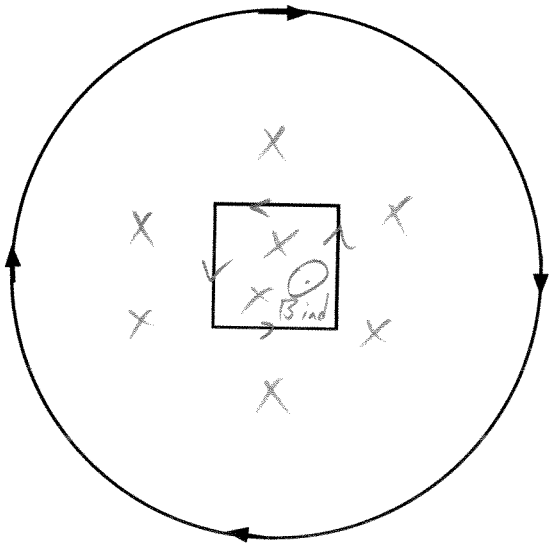
d) The long straight wire has a constant current pointing in the +x direction. The wire loop is moving away from the long straight wire as shown. Describe the change in magnetic flux in the wire loop.

⊗, decreasing

e) In what direction is the induced field in the wire loop?

⊗

f) In what direction is the induced current in the loop? clockwise



g) The circular wire has a steadily increasing clockwise current. Describe the change in magnetic flux in the square loop.

⊗, increasing

h) In what direction is the induced field in the square loop?

⊙

i) In what direction is the induced current in the square?

CCW

2. (30 pts) An AC source operates at a frequency of 60.0 Hz with an rms voltage of 120 Volts. It is connected in series with a 55 Ohm resistor and a capacitor of unknown capacitance. The rms current is measured to be 0.87 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 equal to zero in the 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) $I_{rms} = \frac{\mathcal{E}_{rms}}{Z}$ $\quad Z = \frac{120}{0.87} = 138\ \Omega$

$Z^2 = R^2 + X_C^2$

$138^2 = 55^2 + X_C^2 \Rightarrow X_C^2 = 16000$

$X_C = 126\ \Omega = \frac{1}{2\pi(60)C}$

$C = 21\ \mu F$

b) $I_{max} = \sqrt{2}\, I_{rms} = 1.23\ A$

$\Delta V_{R,MAX} = I_{max} R =$ 68 Volts

c) $\Delta V_{C,MAX} = I_{max} X_C =$ 155 Volts

d) When $I = 0$, $\Delta V_R = 0$ (in phase with current)

$\Delta V_C = \Delta V_{C,MAX}$ since I is blocked $\Rightarrow \Delta V_C = 155\ V$

Loop rule $\Delta V_{\mathcal{E}} = \Delta V_R + \Delta V_C =$ 155 V

3. (20 pts) Consider a series RLC circuit with R = 6.5 Ohms, L = 350 mH and C = 120 μF. It has a maximum voltage of 85 Volts.

a) What is the resonant frequency of this circuit?

b) What is the rms value of the current at resonance?

c) If the frequency is reduced to 75% of the resonant frequency, what is the rms value of the current?

a) $f = \frac{1}{2\pi\sqrt{LC}} = 24.56\ Hz$ = (25 Hz)

b) $\mathcal{E}_{rms} = \frac{\mathcal{E}_{max}}{\sqrt{2}} = 60\ Volts$

$I_{rms} = \frac{\mathcal{E}_{rms}}{Z}$ At resonance, $Z = R$

So $I_{rms} = \frac{60}{6.5}$ = (9.2 A)

c) $f = 0.75 f_0 = 18.42\ Hz$

$X_L = 2\pi f L = 40.5\ \Omega$

$X_C = \frac{1}{2\pi f C} = 72.0\ \Omega$

$Z = \sqrt{6.5^2 + (72.0 - 40.5)^2} = 32.2\ \Omega$

$I_{rms} = \frac{60}{32.2}$ = (1.9 A)

4. (18 pts) Consider an RL circuit with a DC power source of 24 Volts. R = 24 Ohms and L = 0.45 H. When a switch is closed at t = 0, the circuit is completed.

a) What is the voltage drop across the resistor at t = 0?

b) What is the voltage drop across the inductor at t = 0?

c) At what time t is the voltage drop across the inductor equal to 25% of its maximum possible value?

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

a) At $t = 0$, $\frac{\Delta I}{\Delta t}$ is very large so $\Delta V_L = \mathcal{E}$

$\Delta V_R = 0$ since $I = 0$

b) $\Delta V_L = \mathcal{E} =$ 24 Volts

c) $\Delta V_L = \mathcal{E} e^{-t/\tau}$ $\tau = \frac{L}{R} = .01875$

$6 = 24 e^{-t/.01875}$

$0.25 = e^{-t/.01875}$

$-1.386 = -\frac{t}{.01875}$

$t = .026\ s$

d) If $\Delta V_L = 6$, then $\Delta V_R = 18$ Volts due to loop rule