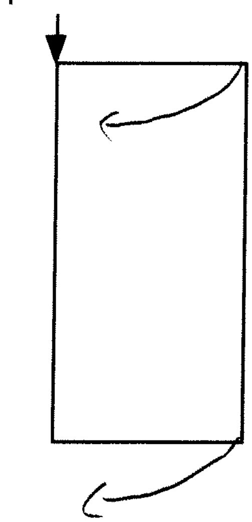
Physics 10164 - Exam 3B

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 rectangular loop of wire measuring 84 cm x 42 cm rests in the plane of the page, and it is pierced by a uniform magnetic field of 3.5 Tesla pointing out of the page. The left side of the loop is attached to the page and acts as the axis of rotation. The right side of the loop is grasped and pulled upward, rotating the loop until the loop is vertical, much like you would open the front cover of a book. This motion of the loop takes 0.55 seconds.

Assuming the loop has a resistance of 0.022 Ohms, what is the magnitude and direction of the average induced current during this time interval? Be sure to show/explain your steps in coming to the answer, especially regarding the direction.



$A = .84 \times .42 = 0.3528\ m^2$

$B = 3.5\ T$

$\Phi_i = BA\cos 0^\circ = 1.235\ T\cdot m^2$

$\Phi_f = BA\cos 90^\circ = 0$

$\mathcal{E}_{ind} = \frac{\Delta\Phi}{\Delta t} = \frac{1.235}{.55} = 2.25\ V$

$I_{ind} = \frac{2.25}{.022} = \boxed{102\ A}$

$\Phi_i = \odot$, decreases as angle goes from $0^\circ \to 90^\circ$

So $B_{ind} = \odot$

Thus, $I_{ind} = \boxed{CCW}$

2. (30 pts) A circuit contains a DC power source with a voltage of 12 Volts, a 25 Ohm resistor and a 3.0 mH inductor. A switch is closed at time t=0, connecting the voltage source to the rest of the circuit.

a) At what time, t, is the voltage drop across the resistor equal to 3.0 Volts?

b) What is the voltage drop across the inductor at this time?

c) How fast is the current changing ($\Delta I/\Delta t$) at this time?

a) $I = I_{max}(1 - e^{-t/\tau})$ $\quad \tau = \frac{L}{R} = 1.2\times10^{-4}\,s$

$IR = I_{max}R(1 - e^{-t/\tau})$

$\frac{3.0}{12} = 1 - e^{-t/\tau}$

$0.25 = 1 - e^{-t/\tau}$

$\ln 0.75 = -\frac{t}{\tau} \Rightarrow t = -(1.2\times10^{-4})\ln .75$

$= \boxed{3.5\times10^{-5}\,s}$

b) If $\Delta V_R = 3.0\,V$, ΔV_L must be $\boxed{9.0\text{ Volts}}$

due to the loop rule

c) $\mathcal{E}_L = L\frac{\Delta I}{\Delta t}$

$9.0 = .003\frac{\Delta I}{\Delta t}$ $\quad \boxed{\frac{\Delta I}{\Delta t} = 3000\,\frac{A}{s}}$

3. (40 pts) An AC adapter for an electronic game uses a transformer to reduce the incoming household voltage of 120 Volts (rms) to a voltage of 3.0 Volts for the game. The rms current delivered to the game is 250 mA.

a) If the primary input coil in the transformer has 160 turns, how many turns are there on the secondary output coil?

b) Assuming the transformer is ideal, how much power is delivered by the household outlet into the transformer?

c) The power supply used by the game therefore has an rms voltage of 3.0 Volts and a frequency of 60 Hz. Suppose this power supply is connected to a 23 Ohm resistor and a 36 mH inductor. When the current is at its maximum amplitude, what is the voltage drop across the resistor, inductor and power supply?

c) $\frac{\mathcal{E}_{pri}}{N_{pri}} = \frac{\mathcal{E}_{sec}}{N_{sec}} \Rightarrow \frac{120}{160} = \frac{3}{N_{sec}} \Rightarrow \boxed{N_{sec} = 4 \text{ turns}}$

b) $P_{in} = P_{out}$ since transformer is ideal

$P_{out} = I_{out} \Delta V_{out} = (.250)(3.0) = \boxed{0.750 \text{ Watts}}$

c) $X_L = 2\pi(60)(.036) = 13.6\ \Omega$

$Z = \sqrt{23^2 + 13.6^2} = 26.7\ \Omega$

$\mathcal{E}_{max} = 3\sqrt{2} = 4.24\text{V}$ $\quad I_{max} = \frac{\mathcal{E}_{max}}{Z} = 0.159\text{ A}$

When $I = I_{max}$

$\Delta V_R = \Delta V_{R,MAX} = I_{max} R = \boxed{3.65\text{ V}}$

When $I = I_{Max}$, $\frac{\Delta I}{\Delta t} = 0$, so

$\boxed{\Delta V_L = 0}$

Loop rule:

$\boxed{\Delta V_{\mathcal{E}} = 3.65\text{ V}}$