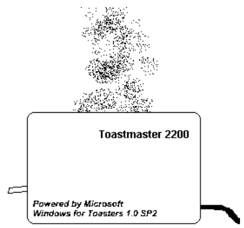
PHYS-207 (3) (Kaldon-10776) **Name ____________________________________**
WMU - Summer 2000
Exam 3 - 100,000 points + 20,000 ☆ points

08/03/2000•Rev.5

State Any Assumptions You Need To Make – Show All Work – Circle Any Final Answers
Use Your Time Wisely – Work on What You Can – Be Sure to Write Down Equations
Feel Free to Ask Any Questions ☐☆2a ☐☆2b ☐☆2c ☐☆2e

"Care For Some Toast?" ***THE TOASTER IN THE BBC TV SHOW RED DWARF*** **(35,000 pts.)**

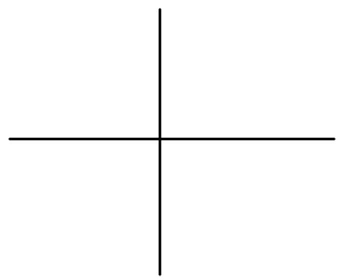
1.) (a) A toaster generates Joule heating at a rate of 855 W when plugged into a 125 volt D.C. power source. This results in a current of $I = 6.84\ A$. The nichrome wire used in the heating element is a high resistance wire, but still the entire heating element only has a resistance of $R = 18.3\ \Omega$. The heating element can be unfolded to be a single coil 0.500 cm in diameter and 45.0 cm long, with 480. turns. Find the inductance, L, of this coil.
NOTE: *If you do not get an answer to (a), use L = 252 mH in parts (b) - (e).*



(b) If this toaster into an AC wall outlet, with $V_{rms} = 125$ *volts* and $f = 60.0$ *Hz*, find the inductive reactance, X_L, of the heating element.

(c) Sketch a single phasor diagram showing v_R, v_L, and the current, i.

	"In Use" Equation	"By Geometry" Equation
R	$V = I R$	$R = \frac{\rho L}{A}$
C	$Q = CV$	$C = \varepsilon_0 \frac{A}{d}$ (Parallel Plate Capacitor)
L	$L = \frac{N\Phi_B}{I}$	$L = \frac{\mu_0 N^2 A}{l}$ (Air-Core Solenoid)

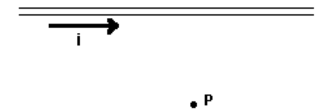


(d) The heater element can be thought of as being a resistor and an inductor in series. What is the time constant of this RL circuit?

(e) Use the impedance to find I_{max} for the toaster. There is no capacitive nature to this circuit.

Star Problems in Flight… Afternoon Delight! **(30,000 points)**

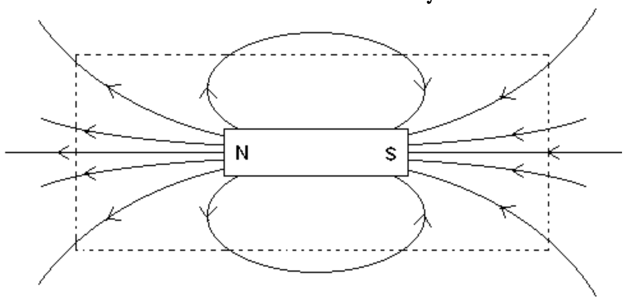
2.) ☆(a) A current of 4.35 A flows in a long straight wire. Use Ampere's Law to find $\vec{B}$ at point P which is 15.0 cm (0.150 m) directly below the long straight wire. *This is a Star Problem – "Show Me The Integral!"*



☆(b) The differential equation for an ideal LC circuit is $\frac{d^2Q}{dt^2} = -\frac{1}{LC} Q$, whose solutions are mathematically the same as the Simple Harmonic Oscillator in PHYS-205. Create this equation by starting with the knowledge that the change in the total energy stored in both the inductor and the capacitor is zero, $\frac{dU}{dt} = \frac{d}{dt}\left(\frac{Q^2}{2C} + \frac{1}{2} LI^2\right) = 0$ and remembering that $I = \frac{dQ}{dt}$.

☆(c) Starting from the equation for an inductor with N turns, $L = \frac{N\Phi_B}{I}$, show that the right-hand equality of the self-induced emf equation for a coil in a magnetic field $\mathcal{E}_L = -N\frac{d\Phi_B}{dt} = -L\frac{dI}{dt}$, is true.

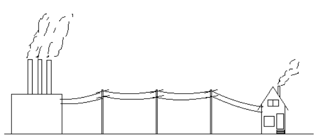
(d) Although we don't want to calculate all the little bits and pieces (we don't really have the equations), consider a permanent magnet inside a Gaussian surface of some symmetric shape. What can you say about the magnetic flux, Φ_B, such that Gauss' Law for Magnetism, $\oint \vec{B} \cdot d\vec{A} = 0$, holds true?



☆(e) A 15 turn coil of cross-sectional area 0.00785 m² and length 0.0500 m, experiences a uniform magnetic field directly down its length of magnitude $B(t) = 5.00T + (5.00T/\text{sec})\,t - (5.00T/\text{sec}^2)\,t^2$. Find the induced current, if any, in the coil at the time $t = 5.00$ *seconds*.

Power to the People! (35,000 points)

3.) (a) Two parallel power lines each carry 480. A of current in the same direction. If the cables between two power poles are 85.0 m long and are separated by a distance of 3.50 meters, find the magnetic force between the two power lines, and indicate whether they are attracted or repelled. *For simplicity's sake, treat this as D.C. in this part, even though we know that the power lines are really A.C.*



(b) At the house of a mad scientist, Dr. Fyl, the 480. A is used at 118 V A.C. to power his cathedral of Micron Millennia Pentium computers. The power plant is 25.0 km away, and 50.0 km of wires (*to* and *from*) has a total resistance of 22.5 Ω . If 480. A runs through the wires, find the efficiency of this power distribution system.

(c) If instead, the electricity is set at 118,000 V A.C. on the power lines, find the new efficiency of the power distribution system.

(d) The voltage is changed by a step-down transformer from 118,000 volts to 118 volts. The secondary coil has $N_2 = 1000.$ *turns*. How many turns does the primary loop have?

(e) Our transformer is sketched below – note that both sides have the same number of turns so as not to suggest an answer for (d)! If at some time t_0 that the primary current I_1 is <u>increasing</u> and going to the right as shown, then explain whether the induced current of the secondary, I_2, goes to the LEFT or to the RIGHT.