

**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

**The Turbo Inductant 1500... Hair Dryer? (50,000 pts.)**

1.) (a) A hair dryer generates 1500 W of heat from its coiled heating element at 115 V D.C. The coil consists of 225 turns, with a cross-sectional area of  $0.000314 \text{ m}^2$  and a length of 0.150 m. Find the inductance  $L$  of this coil.

(b) Use the inductance  $L$  found in (a) to find the magnetic flux  $\Phi_B$  from the current  $I$  that is going through the coil. *If you didn't get an answer to (a), use  $L = 1.00 \text{ mH}$ .*

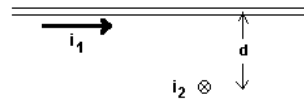
(c) The 1500 W comes from the Joule heating of the high resistance wire, so this hair dryer has an  $R$  and an  $L$ . Find the time constant of this LR circuit. *If you didn't get an answer to (a), use  $L = 1.00 \text{ mH}$ .*

(d) If the hair dryer was run on AC at 115.  $V_{\text{rms}}$  60.0 Hz ( $\omega = 377 \text{ rad/s}$ ), find the impedance  $Z$  of the hair dryer. *If you didn't get an answer to (a), use  $L = 1.00 \text{ mH}$ .*

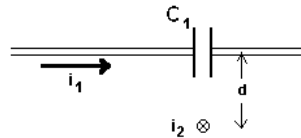
(e) Which will have a bigger effect on  $I_{\text{rms}}$  when compared to the hair dryer in (d): (1) Doubling the voltage, so the AC runs at 230.  $V_{\text{rms}}$  60.0 Hz OR (2) Lowering the frequency, so the AC runs at 115.  $V_{\text{rms}}$  25.0 Hz? *An answer without some sort of supporting work is called a "guess", and doesn't count.*

**Staring at Star Problems (50,000 points)**

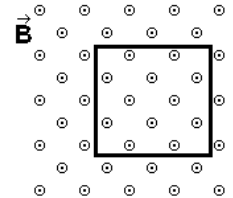
2.) ☆(a) Two wires, marked 1 and 2 as shown below, each 2.50 m long, are separated by a distance  $d = 0.110$  m. They carry currents  $i_1 = 3.00$  A and  $i_2 = 3.50$  A. Use Ampère's Law to find the magnitude of  $\vec{B}_1$  at the point where wire 2 is located directly below wire 1. Do the integration properly if you want full credit.



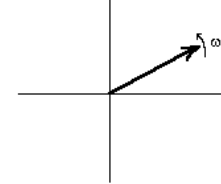
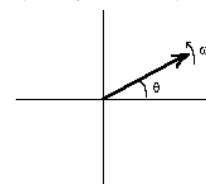
☆(b) A section of wire 1 in (a) is replaced with a capacitor  $C_1$ . Find the electric flux  $\Phi_E$  that would generate the same  $B$ -field magnitude of  $\vec{B}_1$  at the point where wire 2 is located directly below wire 1 using the Maxwell displacement current.



☆(c) Consider a square in the  $xy$ -plane with sides of length  $a$  and a magnetic field,  $\vec{B} = (B_0 + Cy)\hat{k}$  where  $B_0$  and  $C$  are constants. Find the magnetic flux  $\Phi_B = \int \vec{B} \cdot d\vec{A}$ . The lower left corner of the square is at the origin,  $x=y=0$ .



(d) An A.C. circuit has a resistive nature and an capacitive nature. If the vector in the phasor diagram on the left represents  $I_R$ , sketch in  $V_R$ ,  $V_C$  and show the relevant instantaneous components,  $i_R$ ,  $v_R$  and  $v_C$ . If the vector in the phasor diagram on the right represents  $V_C$ , sketch in  $I_R$ ,  $V_R$  and show the relevant instantaneous components,  $i_R$ ,  $v_R$  and  $v_C$ . Starting from  $\theta = 0$  at  $t = 0$ , which diagram happens first, LEFT or RIGHT (circle your answer)?



☆(e) Show whether the current as a function of time,  $I = -\omega Q_0 \cos(\omega t)$ , is a solution to the differential equation for an ideal LC circuit is  $\frac{d^2 Q}{dt^2} = -\frac{1}{LC} Q$ .