1. Current in a wire loop or coil creates a magnetic field. In the "Tangent Galvanometer" experiment on pages 120 & 121 you discovered how this magnetic field's strength is related to the coil current ("I") and the number of turns ("N"). You recorded that relation on the Chapter XIV review sheet.
   a. Copy it here, *in proportion form:* ____________
   b. Sketch a magnetic field map describing the coil's field. (Copy it from a book.)

2. By definition, the magnetic flux surrounded by each loop of the coil is _____.
   * a. Write that definition as an equation. Include *all* of the relevant variables. (Use 1a.)
   * b. Define each symbol in your equation, including the one representing the proportionality constant.
   c. Do you expect that constant to be "universal"? ___
   * d. Does its value depend on the size and shape of the coil and magnetic properties of its core?

3. Michael Faraday tells us that the emf induced in each turn of a coil is related to that flux in a very simple way: **emf per turn =** ______. (Copy from #4 on RS XV.)

4. All of the coil's turns are connected in series. How must the coil's emf be related to the flux and the number of turns? **Coil emf =** _________

5. Use #2 to eliminate the flux from equation 4. (Also use #1 to eliminate "B".) The resulting equation, relating the coil's emf to I and N is called the **"INDUCTANCE LAW"**. Write it here with all of the *constants* grouped together in parentheses: **Coil emf =** (_____)_____

6. Compare the inductance law with the "capacitor law" in chapter XI. Then invent a definition for the **"Inductance"** of a coil. *Do not look for it in a book until you have recorded your own idea.*

7. The symbol commonly used for inductance is the letter "L". (It's the first letter in "coil" if you spell it backwards.) Using that symbol, the inductance law says: **emf =** _____
   a. How must inductance depend on N? **L** ______
   b. How must inductance depend on the cross-sectional area of the core? ______
   c. List all other factors which L might depend on: (Use 2c & 5.) _____
   d. Does any part of #7 contradict #5? ___ -The inductance law has been copied into # __ on RS___

8. The standard unit of inductance is called a "henry": **One henry = one ____ per____.**

9. Summarize the three voltage & current laws that you have learned. Also define your symbols.
   For RESISTORS, **V =** ____. For CAPACITORS, **I =** ____. For INDUCTORS, **V =** ____.

10. Transformers: Imagine a coil of insulated wire wound around an iron core. For simplicity, let's pretend that the wire has no resistance. Let "N_1" represent the number of turns in the coil.
   a. How is the magnetic field strength in the iron related to the current in the wire? _____
   b. How must the flux in the iron be related to the current? _____
   c. Now let's wind a second insulated wire around the same core. Call it the "secondary winding".
   -Does it surround any magnetic flux? ____
   d. Is there any emf in the secondary winding when the core flux is steady? ____
   e. Is there any emf in the secondary winding when the flux is *changing?* ____
   f. Let "N_2" represent the number of turns in the secondary coil. Use Faraday's Law to show how the secondary emf can be calculated from N_2 and the rate at which the flux is changing: _____
   g. Use the same reasoning to write a formula for the voltage across the primary winding.___
   h. For *alternating* currents, how must the voltage ratio (V_2/V_1) be related to the transformer's "turns ratio", N_2/N_1? ______ = ______ *That result has been saved in #___ on RS* ___.
   i. Does the core flux depend on the primary current *only?* ___ Does the core flux also depend on the current in the secondary winding? _____ *Give a reason for your answer.*
   j. Do those two fluxes reinforce each other?___ -Do they oppose each other? ___
   (Use "Lenz's law" which you discovered on page 131 and recorded in # ___ on RS XIV.)

* 11. Imagine a transformer with its primary coil connected to a source of alternating current. The secondary winding is connected through a switch to a resistive load. By magic we have arranged for the primary current amplitude to be unaffected by operation of the switch:
   a. Will the core flux amplitude be greater when the switch is open, or when it is closed?
   b. In which case must the primary voltage amplitude be greater? *Explain your answers.*

1. How much voltage is required to maintain a steady current in a coil of ideal wire no resistance? ____

2. Suppose the ideal coil carries a steadily increasing current, so that its current vs time graph is a straight line through the origin.
   a. Sketch the coil's voltage vs time graph. (Use “Faraday's law”, on RS XV.)
   b. Sketch a graph of stored energy vs time for the coil. (See page 91)

3. The coil current is increasing at 100 amp per sec, and the inductance of the coil is 50 millihenries.
   a. Calculate the inductor voltage in SI units. (Show how you do it.)
   b. Calculate the energy delivered during the first 0.01 second of this process.
   c. Calculate the energy stored after 0.02 sec, and show how you do it.
   d. If these results do not agree with #2, correct the mistake or explain why you don’t care.

4. Now suppose the current vs time graph resembles a sine curve:
   a. What must the voltage vs time graph look like? ______ (Use the inductor law.)
   b. How will the voltage amplitude be affected if we double the frequency without changing the current amplitude? _____ Did you use the inductor law in 4b, or did you guess? ___

5. The definition of "inductive reactance" is similar to the definition of "capacitive" reactance on RS XII.
   a. Write the definition: $\mathbf{X_L}$ **=** ______________
   b. According to #4, how must inductive reactance depend on frequency? ______
   c. According to 3a, how must inductive reactance depend on inductance? ______

   * d. Combine 5a and 5b into a single equation. Show how the proportionality constant in the reactance formula can be found by using a calculator or clever mathematics. For ideas see p. 110C or RS VIII.

   e. The definition of "reactance" *and* the complete reactance formula have been recorded on this sheet *and* on RS __ for future reference.

6. Imagine a capacitor and an inductor in series, carrying a sinusoidally alternating current:
   a. Sketch the two voltage vs. time graphs. Label them clearly. (Use 4a.)
   b. Suppose one amplitude is 3 volts and the other is 2 volts. Calculate the amplitude of the voltage across the combination. (Use 6a.) ________
   c. Is it possible for the amplitude of the voltage across the inductor or the capacitor to be greater than the amplitude of the generator voltage? _____
   d. At one special frequency the capacitor voltage amplitude will be equal to the inductor voltage amplitude. Create a formula for predicting that "resonance" frequency.
   e. Sketch a graph of impedance vs frequency for this combination.
   f. What will the current amplitude vs frequency graph look like if the generator voltage amplitude is independent of frequency? (Sketch it.)

7. A model train transformer is used to "step down" 110-volt AC to 6 volts. The train uses about one amp RMS. We find that the secondary winding has about 100 turns.
   a. How many turns must there be in the primary winding? _____ (Use 9b on RS XV.)
   b. If the transformer is efficient, how much current is there in its primary coil? ______

   * c. Use the definition on RS XII to calculate this transformer’s input and output impedances.

   * d. How must the ratio of those two impedances depend on the transformer's "turns ratio"?

8. Now we place a second train on the tracks, so that the transformer must feed power to both trains in parallel. Exactly how will each of the following quantities be affected if the transformer is efficient and the trains are identical?
   a. Output power
   b. Input power
   c. Output emf
   d. Output current
   e. Input current
   f. Output impedance
   g. Input impedance