`Massachusetts Institute of Technology *Spring Term 2005*

8.02X Electricity and Magnetism

Practice-Quiz #4b

Problem 1 (25 points)

In the HVPS experiment, you built a "transformer" by winding 6 loops of wire around a tightly wound red coil.

(a) Which side of the transformer was the primary side in this setup?

(b) Assume that in your setup the inner (red) coil had length L_1, number of windings N_1 and radius R_1. The outer coil (wire loops) had length L_2, number of windings N_2 and radius R_2. Derive an expression for the mutual inductance of the two coils. Show work!

(c) Based on the known output voltages of LVPS and HVPS, estimate (within a factor of 2) a numerical value for the number of windings of the red coil (ignore the different length for primary and secondary coil).

(d) Assume a current $I_2(t) = I_0 * \cos(\omega t)$ was flowing through the outer coil. What would the voltage across the red coil $\Delta V_1(t)$ be?

Problem 2 (25 points)

Shown below is a circuit that is connected to a DC power supply with an output voltage V_0. For times $t < 0$, the switch is in position 1 and a current is flowing through the inductor (inductance L), the resistor (resistance R) and the power supply. Assume the switch has been closed for a very long time and the resistance of the inductor is negligible. Assume also that for $t < 0$, the capacitor (Capacity C) is discharged (Q=0).

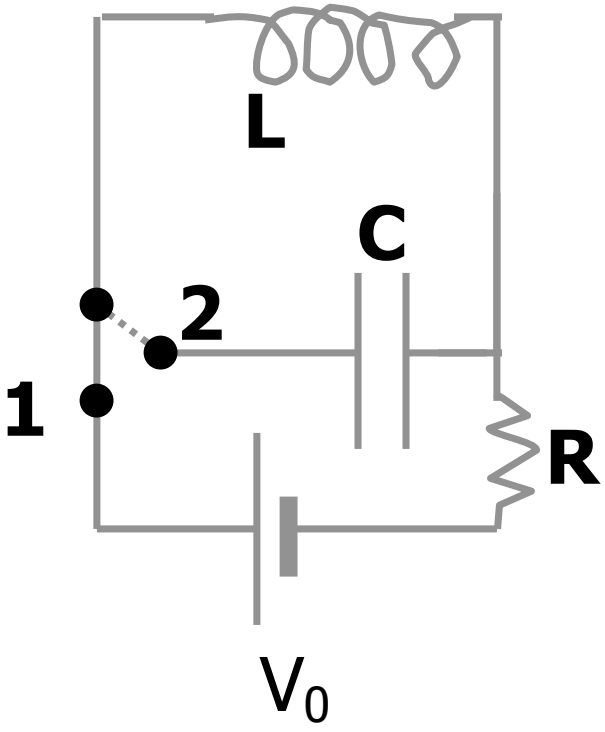
At t=0, the switch is moved to position 2 and the power supply and resistor are therefore removed from the circuit.

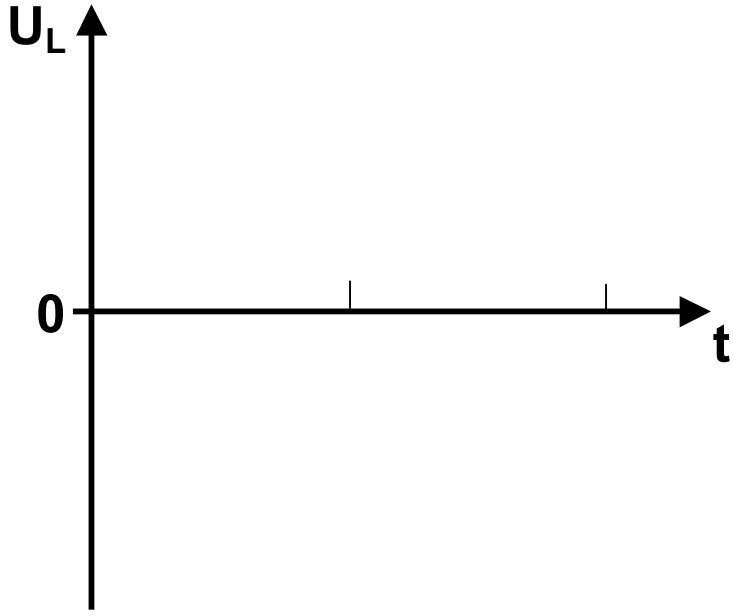
(a) At t=0, what is the total energy stored in the circuit formed by capacitor and inductor?

(b) Give an example (sketch) of a mechanical system that corresponds to the circuit formed by the inductor and capacitor (after t=0). Identify which elements in the mechanical system correspond to which circuit elements.

(c) How will the charge Q(t) on the capacitor vary with time? Give an equation in terms of the quantities defined above.

(d) On the graph below, sketch how the energy in the inductor varies with time after t=0.


L
C
2
1
R
V_0


U_L
0
t

Problem 3 (25 points)

Consider a plane wave with an amplitude that is described by the following equations:

$$A_x = 0$$
$$A_y = 0$$
$$A_z = A_0 \cos(\omega t - (2\pi / 3m)\, x)$$

(a) Which direction is the wave traveling in?

(b) How big is the wave length of the wave?

(c) Could these equations describe a sound wave? Explain your answer.

(d) If the wave was electromagnetic, what would the frequency f be?

Problem 4 (25 points) AMP experiment

(a) What is the purpose of the AMP experiment? (1-2 sentences)

(b) How did you calibrate the AMP setup? What does the calibration curve tell you? (2-3 sentences)

(c) Shown below is a calibration circuit like that on the AMP experiment. All voltages a measured relative to the common line C, which is defined as 0V. What is the voltage at point X when the slider of the potentiometer is 1/2 way between the extreme positions?

(d) What are the maximum and minimum voltages at point D relative to C, when the slider is moved from one extreme position to the other?