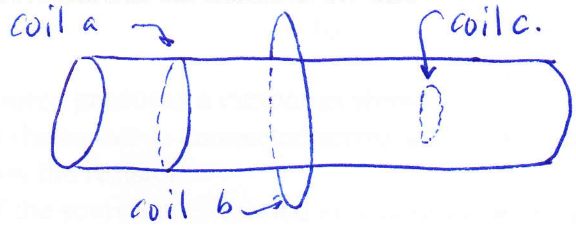
PHYS 51W - April 27-May 3

These problems are based on the material in Chapter 30, Inductance.

1. A solenoid is wrapped with wire such that n = 50,000 turns/m. The length of the solenoid is 10.0 cm and the radius is 1.0 cm.

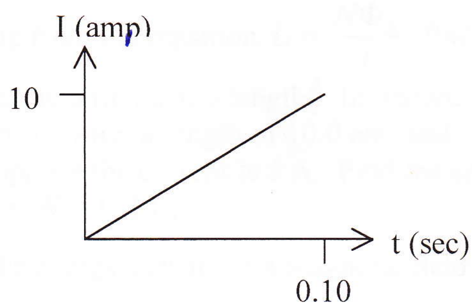


a. A coil consisting of 10 turns of wire are wrapped around the solenoid. If the current in the solenoid is I, what is the total flux through the coil? What is the mutual inductance between the solenoid and the coil? If the current in the solenoid goes from I = 0 to I = 5.0 A in 0.10 sec, what emf is induced in the coils?

b. A second coil, also with 10 turns of wire, has a radius of 2.0 cm and is coaxial with the solenoid. If the current in the solenoid is I, what is the total flux through the coil? What is the mutual inductance between the solenoid and the coil? If the current in the solenoid goes from I = 0 to I = 5.0 A in 0.10 sec, what emf is induced in the coils.

c. A third coil, also with 10 turns of wire, has a radius of 0.50 cm and is also coaxial with the solenoid. If the current in the solenoid is I, what is the total flux through the coil? What is the mutual inductance between the solenoid and the coil? If the current in the solenoid goes from
I = 0 to I = 5.0 A in 0.10 sec, what emf is induced in the coils.

2.

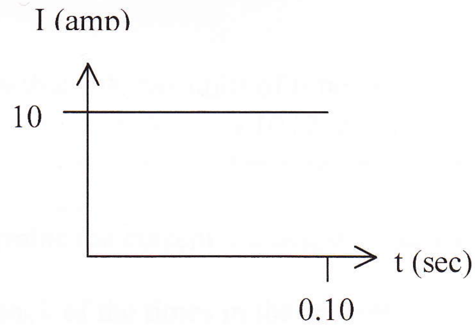


A voltage source produces a current as shown.

a. If the source is connected across a resistor, draw a graph representing the voltage across the resistor.

b. If the source is connected across an inductor, draw a graph representing the voltage across the inductor.

3.

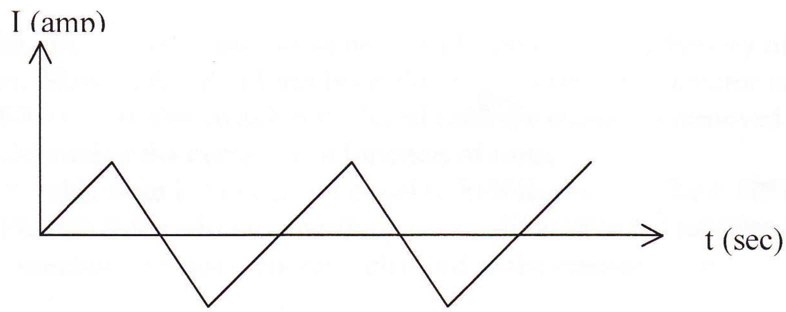


A voltage source produces a current as shown.

a. If the source is connected across a resistor, draw a graph representing the voltage across the resistor.

b. If the source is connected across an inductor, draw a graph representing the voltage across the inductor.

4.



The graph above represents the current passing through an inductor. Draw a graph representing the voltage across the inductor.

5. Starting from the equation $L = \frac{N\Phi_B}{I}$, find the inductance of an inductor with n turns of wire per m, a radius r, a length ℓ. In particular, find the inductance of an inductor with 5,000 turns of wire, a length of 10.0 cm; and a diameter of 1.0 cm.

a. Suppose the current is 5 A. Find the energy stored in the inductor using the expression $W = ½ LI^2$.

b. The energy density in a magnetic field is $\frac{1}{2\mu_o}B^2$. Use this expression to verify the energy you determined in part a.

6. It has been proposed to use large inductors to store electrical energy.

a. How much energy does it take to run a 100-W light bulb for 24 hours?

b. If the energy is stored in a magnetic field of 5.0 T, how large a volume is needed?

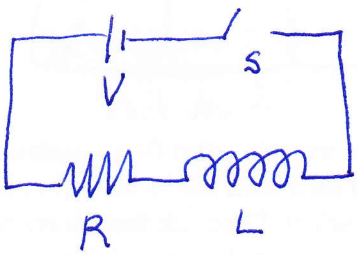
c. If the energy is stored in an inductor carrying 50 A of current, what is the inductance needed?

7. a. Show that L/R has units of time, when L is in Henrys and R is in ohms.

b. In the circuit below is a 10 Ω resistor, a 5.0 H inductor, and a 10 V battery. Initially there is no current. Find the current as a function of time starting when the switch S is closed.

c. Determine the current 0.0 sec, 0.5 sec, 1.0 sec, and 3600 sec after the switch is closed.

d. For each of the times in the previous problem, verify that the voltage across the resistor plus the voltage across the inductor = 10 V.



8. In the circuit shown are the same resistor, inductor, and battery of the previous problem. However, current has been flowing through the inductor and resistor for a long time. When t = 0, the switch S is closed (and the battery is removed from the circuit).

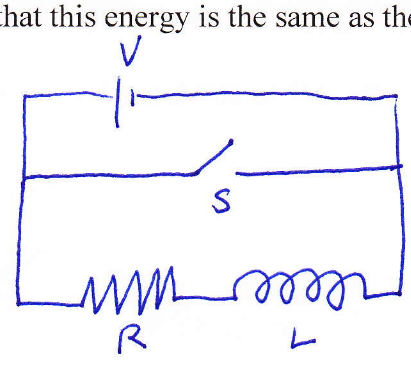
a. Determine the current as a function of time.

b. At what time is the current equal to half its initial value? 10% of its initial value?

c. Find an expression giving the power delivered to the resistor as a function of time.

d. Determine the total energy delivered to the resistor from

$energy = \int_0^\infty power\ dt$. Show that this energy is the same as the initial energy stored in the inductor.



9. In the circuit shown is a 2 μF capacitor and a 0.50 H inductor. Initially, the switch is open, and the charge on the capacitor is 10.0 V.

a. When the switch is closed, what is the frequency of oscillation?

b. What is the initial energy in the capacitor?

c. Find the energy of the inductor as a function of time. Find the maximum current in the inductor. Show that the maximum energy stored in the inductor equals the initial energy stored in the capacitor.