Reminders 11-19-07

-Exam 3 Average 73%.
-POW 9 Due Monday the 19th at 5PM.
-Next Homework Due Thursday 11/26.
-Inductance conceptual questions due 11/28.
-POW 10 Due 12/3.
-EXAM 4 December 3 or 5.

Objectives:
-Self Inductance
-RL Circuits
-Magnetic Energy

What is the inductance of a uniformly *wound solenoid with N turns and length l? Assume that l is long compared with* the radius and that the core of the solenoid is air.

$$L = \frac{N\Phi_B}{I} \; ; \; \Phi_{solenoid} = \int \vec{B}\cdot\hat{n}\,dA$$

$$B_{solenoid} = n\mu_0 I$$

$$\Phi_B = \mu_0 n I \pi r_s^2$$

$$L = \frac{N\mu_0 n I \pi r_s^2}{I} = N\mu_0 n \pi r_s^2$$

$$L = \frac{N}{L}\mu_0 n \pi r_s^2 L = \mu_0 n^2 \pi r_s^2 L$$

$$= \mu_0 n^2 V_{solenoid}$$

1. You are given a wire to wind into a coil. How can you wind the coil to minimize its self-inductance?
2. Why can't self-inductance be less than zero?

The self-induced emf in a solenoid of length 25 cm and radius 1.5 cm is 1.6 mV when the current is 3.0 A and increasing at the rate of 200 A/s. What is the number of turns in the solenoid?

$$L = \frac{\mathcal{E}}{dI/dt} = \mu_0 n^2 \pi r_s^2 \ell$$

$$= \frac{\mathcal{E}}{\frac{dI}{dt}} = \mu_0 \left(\frac{N}{\ell}\right)^2 \pi r_s^2 \ell$$

$$\therefore \frac{\mathcal{E}}{\frac{dI}{dt}} \frac{\ell^2}{\mu_0 \pi r_s^2 \ell} = N^2$$

$$N = \sqrt{\frac{\mathcal{E}}{\frac{dI}{dt}} \frac{\ell}{\mu_0 \pi r_s^2}} = \sqrt{\frac{.0016}{200} \frac{.25\,m}{\mu_0 \pi (.015)^2}}$$

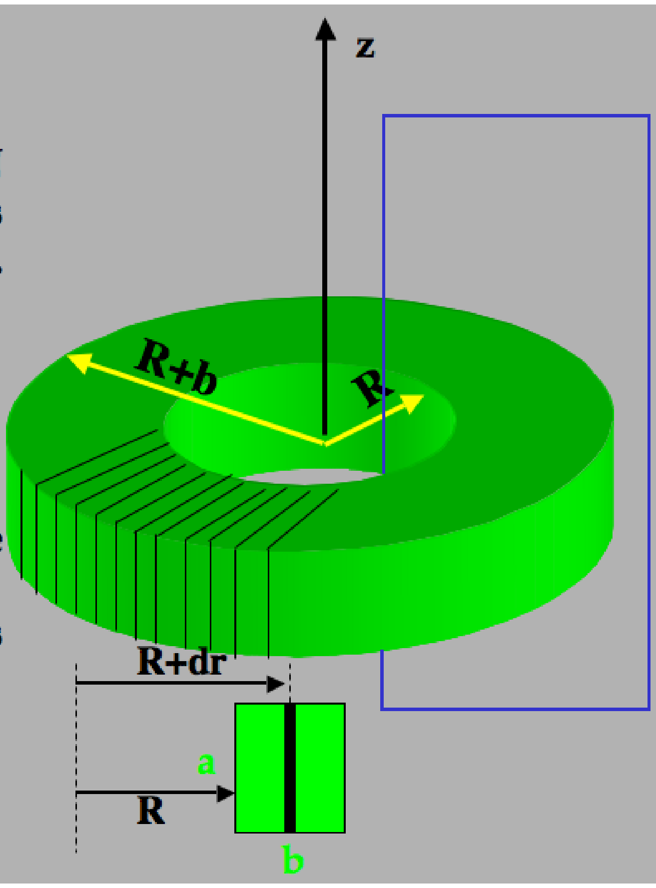
$$N = 48$$

Example:

A toroid consisting of N turns and rectangular cross section is shown below. Show that

$$L=(\mu_o N^2 a/2\pi)\ln[(R+b)/(R)]$$

The calculation of the inductance of a toroid with circular cross section is quite difficult.



$$B_{Torus} = \frac{\mu_o N I}{2\pi r} \qquad L = \frac{N\Phi}{I}$$

$dA = a\,dr$ r goes from R to R+b

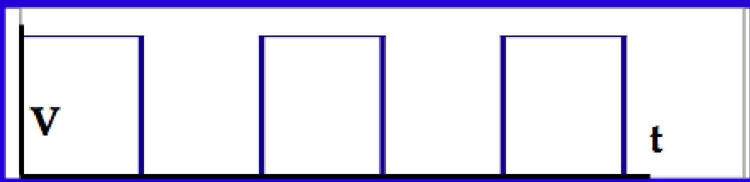
$$\Phi_B = \int_R^{R+b} B a\,dr = \int_R^{R+b} \frac{\mu_o N I}{2\pi r} a\,dr$$

$$\Phi_B = \frac{\mu_o N I a}{2\pi} \ln\left(\frac{R+b}{R}\right)$$

$$L = \frac{N\Phi_B}{I} = \frac{\mu_o N^2 a}{2\pi} \ln\left(\frac{R+b}{R}\right)$$

$I = V_b/R$

How does an RL circuit a affect signal like?



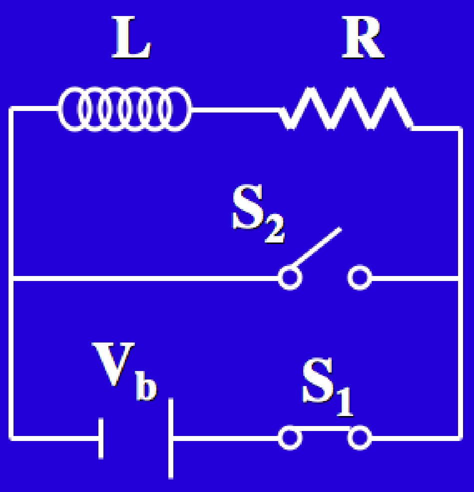
What happens if $T_{signal} << \frac{L}{R}$?

Does current have time to build up in circuit?

What happens if $T_{signal} >> \frac{L}{R}$?

What about intermediate values?

What happens to U_B?



U_B is dissipated in the resistor.

$$dE_R/dt = I^2R$$
$$= (I_0e^{-Rt/L})^2R$$
$$= I_0^2Re^{-2Rt/L}$$
$$E_R = \int I_0^2Re^{-2Rt/L}dt$$

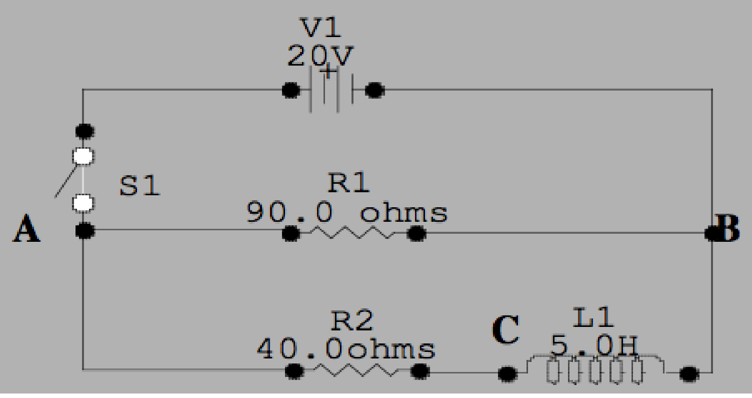
Limits: $t = 0$ to $t = \infty$

$$E_R = I_0^2R(L/2R)$$
$$= (1/2)LI_0^2$$

Nov 18-10:04 PM

Example:

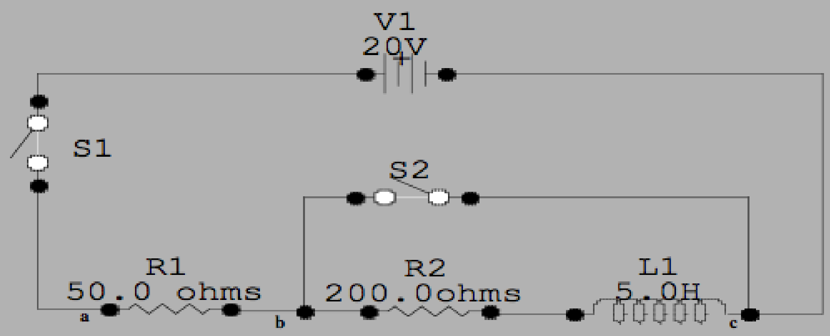
In the circuit shown, switch S1 is closed. Once the circuit reaches steady state conditions, the switch is opened. What is the potential difference between B and C just before S1 is opened? What is the potential difference between A and B immediately after S1 is opened. What about the potential difference between A and C?



Example:

Write the expression for the voltage drop across b and c after switch S1 is closed.

Suppose a long time has elapsed since switch S1 was closed. Now suppose that switch S2 is also closed S2. What is the current through switch S2 0.01s after it was closed. What is the energy dissipated in R2 from the time switch S2 is closed until the circuit reaches steady state conditions?



Due Wed 11/28

$V_{BC} = 16 + 4e^{-50t}$