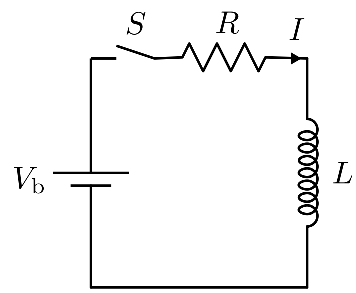
PHYS 231 – Assignment #2

Due Wednesday, Oct. 18 at 10:00 am

Clearly explain all of the logic used to arrive at your final answers. Supplement your solutions with diagrams and words as needed. Include sketches of ALL relevant circuits in your solutions.

1. In class, we analyzed the transient response of the charge on a capacitor in a series RC circuit. In this problem, you will analyze the transient response of the current in a series LR circuit.



(a) Show that when the switch S is closed, the time-dependence of the current is governed by the following first-order differential equation:

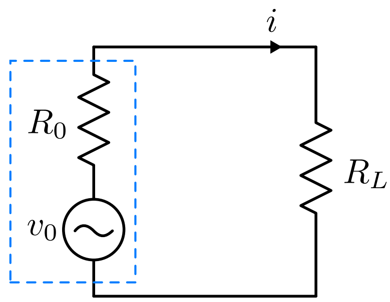
$$\frac{V_b}{L} = \frac{dI}{dt} + \frac{R}{L}I$$

(b) Follow the methods used in class to solve this differential equation and find an expression for $I(t)$. Assume that the switch is closed at time $t = 0$ and $I(0) = 0$. For the RC circuit, the relevant charging time constant was $\tau = RC$. What is the time constant that determines how the current increases after the switch is closed?

(c) What is the time dependence of the voltage across the inductor after the switch is closed?

(d) Sketch $I(t)$ and $V_L(t)$ as a function of time. Indicate the maximum values of I and V_L and their values when $t = \tau$ where τ is the time constant you found in part (b).

2. Function generators, like the one you use in the lab, have an internal resistance R_0 in series with the output of the generator. For example, the high-resistance output of the PASCO PI–9587C is 600 Ω. The figure below shows a schematic of a function generator (inside the blue dashed line) connected across a load resistance R_L.



(a) For what value of R_L is the power dissipated by the load resistance a maximum? Express your answer in terms of R_0. That is, $R_L = c\,R_0$. Find the appropriate numerical value of the constant c. You must show your work/reasoning to earn full credit.

(b) If the power supplied by the generator is $P_0 = iv_0$ and the power dissipated by R_L is $P_L = i^2 R_L$, calculate the power transfer efficiency $\eta = P_L/P_0$. Give your answer in terms of R_0 and R_L.

(c) What is the numerical value of η when the maximum possible power is being delivered to R_L?

3. Recall that the voltage across an inductor is given by $V_L = -L\dfrac{dI}{dt}$. In this problem, you will consider a parallel combination of inductors L_1 and L_2. The goal is to determine the equivalent inductance of the parallel combination. Writing down the correct answer without explaining the logic/reasoning will not receive any credit. You must clearly present the details of the argument you use to arrive at your final answer. Supplement your solution with words and figures as needed.