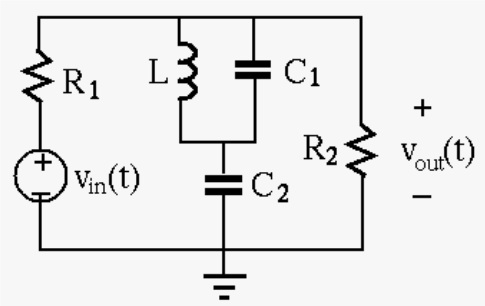
E84 Midterm Exam 2

Instructions

- Take home, open notes, feel free to use a calculator, but not any software package such as Multisim.
- Mark your start and end times. Don't spend more than 3 hours. Due on Monday in class.
- Compare your print-out of the exam with the online version to make sure your hard copy is complete.
- Mark your name and question number clearly on top of each page. Indicate the total number of pages submitted.
- When solving a problem, list all the steps. In each step, indicate concisely what you are doing in English, then show the calculation and the result of for the step. Box the final answer. A final answer, even if correct, without evidence of the steps leading to it will receive ZERO credit.

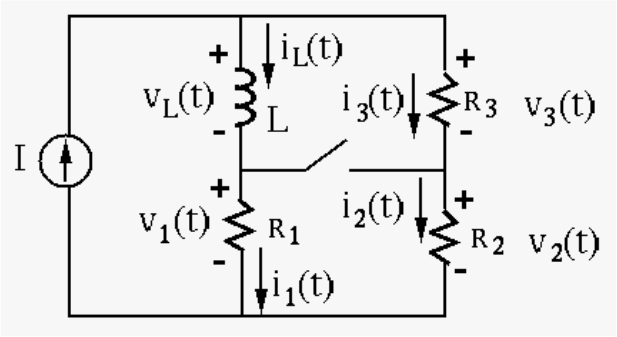
- **Problem 1. (33 pts)**

  In the circuit shown in the figure, $R_1 = R_2 = 5\,\Omega$, $C_1 = 0.01\,F$, $C_2 = 0.03\,F$, $L = 1\,H$, and the input voltage is $v_{in}(t) = 10 + 20\cos 5t + 30\cos 10t$ V. Find the output voltage $v_{out}(t)$ across R_2. (Hint: the circuit is linear, therefore the superposition principal applies.)



- **Problem 2. (33 pts)**

  The circuit in the figure below is composed of three resistors $R_1 = R_2 = R_3 = 1k\Omega$, and an ideal inductor $L = 1\ mH$. The current source is 6 mA. The switch is open when $t < 0$ and the circuit has reached steady state. The switch is then closed at $t = 0$.



- Fill out the following table for the initial and final values of various variables in the circuit (12 pts).

time t	$i_L(t)$	$i_1(t)$	$i_2(t)$	$i_3(t)$	$v_L(t)$	$v_1(t)$	$v_2(t)$	$v_3(t)$
0^-								
0^+								
∞								

  where $v_i(t)$ and $i_i(t)$ and the voltage and current associated with R_i for $i = 1, 2, 3$, respectively. Their polarities and directions shown in the figure.

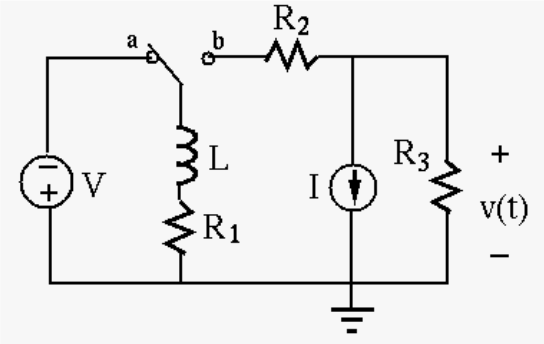
- Find the time constant $\tau = L/R$ of the circuit, and give the expressions of $i_L(t)$ and $v_L(t)$ associated with the inductor L (6 pts).

- Sketch the waveforms of all eight functions. (16 pts)

- **Problem 3. (34 pts)**

  In the circuit shown in the following figure, $R_1 = 10\Omega$, $R_1 = 2\Omega$, $R_3 = 8\Omega$, $L = 2H$, $V = 20V$, $I = 1.25A$. The switch is in position a and the circuit has reached steady state, until the moment $t = 0$ when the switch is turned to position b. Determine the voltage $v(t)$ across R_3 as the response of the system to the change of position of the switch.

  Hint: $v(t)$ is the superposition of $v'(t)$ and $v''(t)$ responding to two processes respectively: (a) the voltage drop across R_3 due to the initial current through L alone after the switch is turned from a to b; and (b) the voltage across R_3 as the complete response to the current source I alone after the switch turned from a to b.



Now solve the problem in the following steps by superposition theorem:

- Find $v'(t)$ across R_3 due to $i_L(t)$ alone:
  1. (2 pts) Find the steady state current $i_L(0^-)$ through the inductor L before the switch is turned from a to b at $t = 0$;
  2. (2 pts) Find the current $i_L(0^+)$ through L right after the switch is turned from a to b at $t = 0$;
  3. (3 pts) Find the voltage $v'(0^+)$ across R_3 due to $i_L(0^+)$;
  4. (3 pts) Find the time constant τ after $t = 0$;
  5. (3 pts) Find the $v'(t)$ across R_3 corresponding to the decay of $i_L(t)$.
  6. (3 pts) Sketch $v'(t)$.
- Find $v''(t)$ across R_3 due to current source $I = 1.25A$:
  1. (3 pts) Find the initial condition for the voltage $v''(0^+)$ across R_3 due to I right after $t = 0$;
  2. (4 pts) Find the steady state response $v''(\infty)$ across R_3 due to the I alone;
  3. (4 pts) Find the complete response $v''(t)$ due to the current source I alone.
  4. (3 pts) Sketch $v''_t(t)$.
- (4 pts) Find and sketch the total voltage $v(t) = v'(t) + v''(t)$ across R_3.