**ECE 202: Linear Circuit Analysis II – Fall 2013**

**HOMEWORK SET 3: DUE THURSDAY, SEPTEMBER 5, 5 PM IN MSEE 180**

**ALWAYS CHECK THE ERRATA on the web.**

**9.** **(a)** Compute the relationship $H(s) = \dfrac{V_{out}(s)}{V_{in}(s)}$ associated with the integro-differential equation by taking the Laplace transforms of both sides and obtaining the indicated ratio assuming any initial conditions are zero and time functions from the past are all zero.

$$2\frac{dv_{out}}{dt} + 7v_{out} + 6\int_{-\infty}^{t} v_{out}(\tau)d\tau = 2\frac{dv_{in}}{dt} + 6v_{in} + 5\int_{-\infty}^{t} v_{in}(\tau)d\tau$$

**Check**: $H(s) = \frac{2s^2+6s+D}{2s^2+7s+E}$. Note: there are a variety of ways to solve this problem. For example, you could also differentiate both sides first or as suggested take the Laplace transform of both sides and simplify.

**(b)** Reconsider the integro-differential equation of part (a). This time, assume that $v_{in}(t) = e^{-t}u(t)$ V for $t \geq 0$ and $v_{out}(0^-) = 12$ V. Find an expression for $V_{out}(s)$ in terms of $V_{in}(s)$ and numerical values, and then perform an inverse Laplace transform to find $v_{out}(t)$.

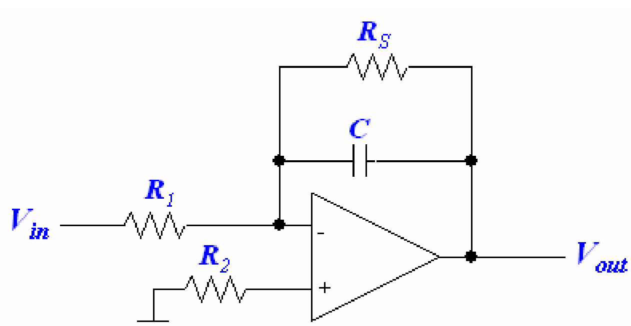
**10.** Assume the op amp in the circuit below is ideal. $R_1 = 100\ \Omega$, $R_2 = R_s = 200\ \Omega$, and C=5 mF.

**(a)** Use nodal analysis to construct a first-order differential equation describing the input-output relationship of the voltages. Hints: how much current enters the inverting terminal of the op amp? What is the voltage drop from the inverting terminal to ground?

**(b)** Laplace transform your equation for (a). Solve for $V_{out}(s)$ in terms of $V_{in}(s)$ and $v_{C1}(0^-)$.

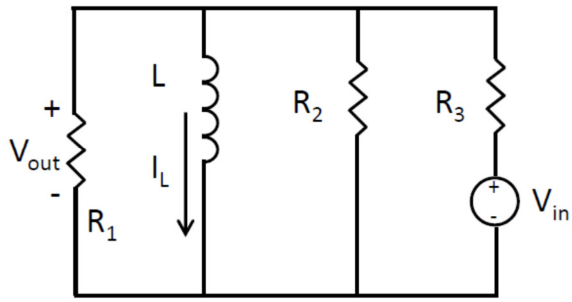
**(c)** If $v_{in}(t) = 2e^{-4t}u(t)$ V, and $v_{C1}(0^-) = 0$, find $v_{out}(t)$. Plot your response in MATLAB for $0 \leq t \leq 2$ s using the plot command.

**(d)** If $v_{in}(t) = 2e^{-2t}u(t)$ V, and $v_{C1}(0^-) = 4$ V, find $V_{out}(s)$ and then $v_{out}(t)$. Plot your response in MATLAB for $0 \leq t \leq 2$ s using the plot command.



**11**. Find the input impedance $Z_{in}(s)$ (seen by the source) and the indicated response for each of the circuits below:

(a) Find $V_{out}(s)$ and the response $v_{out}(t)$ for the circuit below, where $R_1 = 120\ \Omega$, $R_2 = 30\ \Omega$, $R_3 = 40\ \Omega$, $L = 5$ H. All initial conditions are zero.




Plot $v_{out}(t)$ in MATLAB using the plot command for $0 \le t \le 5$ s:

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>> t = 0:0.001:5;
>> vout = ?????
>> plot(t,vout)
>> grid
>> xlabel('time t')
>> ylabel('V_{out}')
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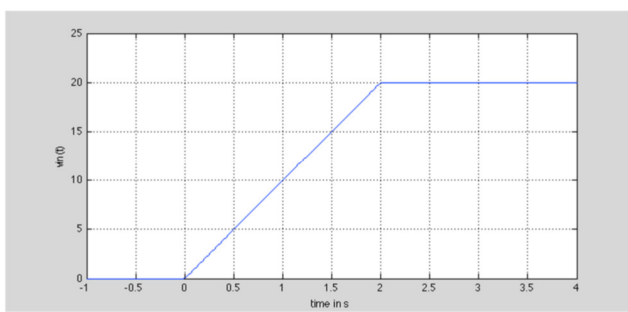
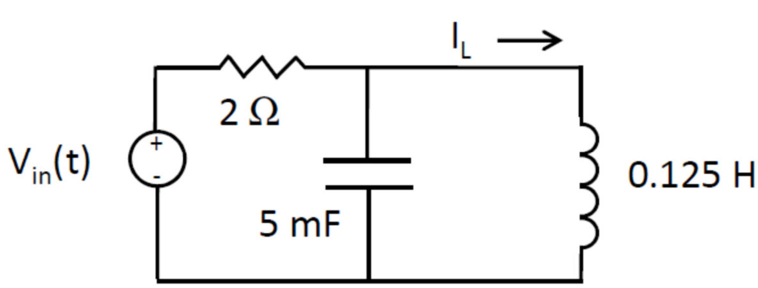
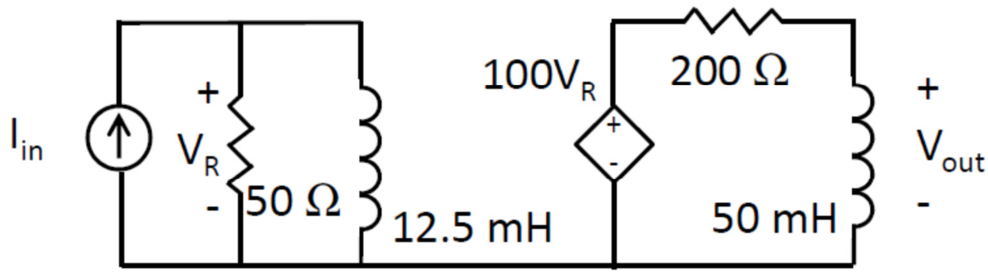



(b) Consider the circuit depicted below. All initial conditions are zero. Let $Y_{in}(s)$ be the input admittance seen by the voltage source. Find $Y_{in}(s)$ and the response, $i_L(t)$ to $v_{in}(t) = 10e^{-t}u(t)$ V.

Hint: Compute $V_C(s) = \dfrac{????}{Z_{in}(s)} V_{in}(s)$ assuming all initial conditions are zero.



**12.** Consider the dependent source problem in the circuit depicted below.




(a) Find $Y_{in}(s) = K\dfrac{(s+?)(s+?)}{(s+?)(s+?)}$ and $Z_{in}(s) = \hat{K}\dfrac{(s+?)(s+?)}{(s+?)(s+?)}$, the admittance and impedance seen by the current source.

(b) Find an expression for $V_{out}(s)$ in terms of $Z_{in}(s)$ and $I_{in}(s)$--Ohm's law in s-domain. Simplify your expressions to a ratio of polynomials.

(c) Find $V_{out}(s)$ and $v_{out}(t)$ when $I_{in}(t) = 40/s^2$ A. Assume all initial inductor currents are zero.

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NON REQUIRED PROBLEM THAT IS PERTINENT TO EXAM Material.

NR-Problem. (a) Find an RC circuit realization for $Z_{in}(s) = \dfrac{4s+36}{s+8}$.

(b) Find an RL circuit realization for $Y_{in}(s) = \dfrac{2s+12}{s+2} + \dfrac{2s+12}{s+4}$.

(c) Find an LC realization of $Z_{in}(s) = \dfrac{s^2+4}{2s} + \dfrac{2s}{s^2+4}$

(d) Find an LC realization of $Y_{in}(s) = \dfrac{s^2+1}{2s} + \dfrac{0.25s}{s^2+4}$.