214 Hemmer sections – Final exam -- Name JOAQUIN SALAS

214Final Exam

1) In zyBooks exercises 5.6.8 --10 a circuit is given along with different input voltages for each problem, and you are asked to solve for the current. Repeat this for the circuit and input voltage shown below. Be sure to write down and label all the equations needed to arrive at the solution. Hint: In class I showed you a simpler way to get the answer without using an integrating factor.

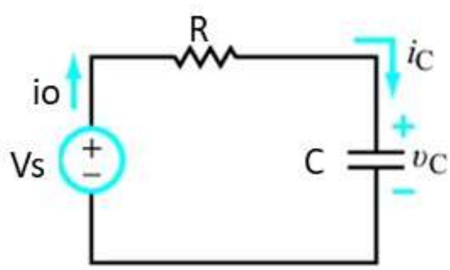
• Use Mesh to get the Differential Equation

KCL MESH

$$RC\frac{dV_c}{dt} + V_c = V_s$$

$$\frac{dV_c}{dt} + \frac{1}{RC}V_c = \frac{V_s}{RC} \quad \text{and} \quad \tau = RC$$

$$V_s = -\alpha t, \quad \alpha = \alpha R$$



$$\frac{dv_i}{dt} + \frac{i}{\tau} = -\frac{\alpha}{C}t$$

Driver Part $i_d = b(t - t_0)$

$$b + b\frac{t}{\tau} - b\frac{t_0}{\tau} = \frac{\alpha}{C}t$$

$$b = \frac{\alpha}{C}\tau, \quad t_0 = \tau$$

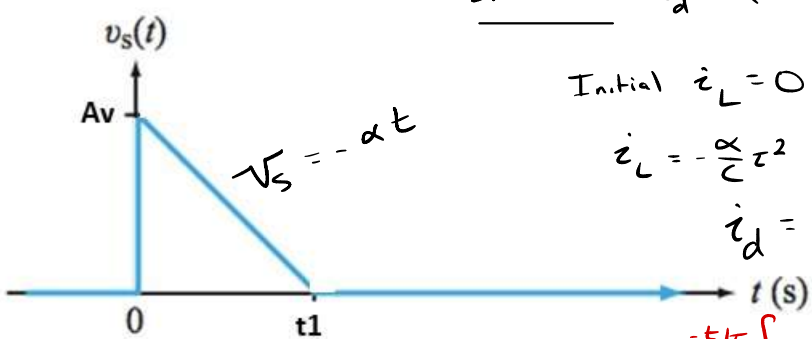
$$i_d = \frac{\alpha}{C}\tau^2\left(t/\tau - 1\right)$$

Initial $i_L = 0 = i_d(0) + i_{trans}$

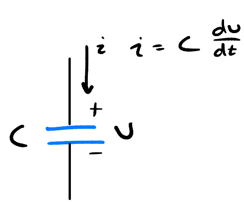
$$i_c(0) = \frac{dv}{dt} = C\cdot\left(-\frac{Av}{t}\right)$$

$$i_L = -\frac{\alpha}{C}\tau^2$$

$$i_d = -\frac{Av}{t}C\tau^2\left(\frac{t}{\tau} - 1\right)$$



$$V_c = e^{-t/\tau}\int \frac{e^{t/\tau}}{RC} V_s\,dt$$



$$v(t) = v(0)e^{-t/\tau} + v(\infty)\left(1 - e^{-t/\tau}\right)$$

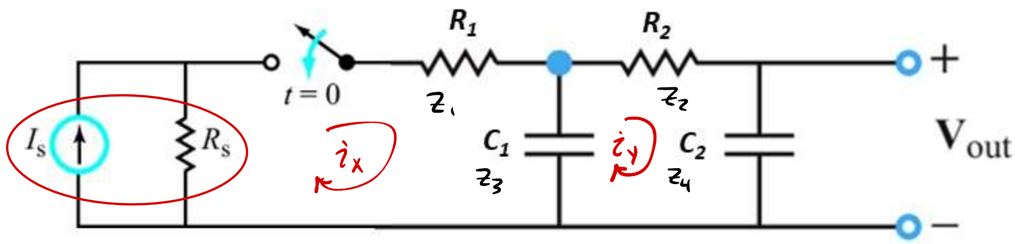
$$V_c = V_s\left(1 - e^{-t/\tau}\right)$$

At time 0

$$\frac{dV_c}{dt} + \frac{V_c}{RC} = 0, \quad V_c(0) = V_s$$

$$V_c(t) = V_s e^{-t/\tau}$$

2) In zyBooks exercises 6.10.5 – 11 a circuit is given, and you are asked to develop the differential equation for one of the currents or voltages in the circuit. Do the same for the output voltage in the circuit below. Be sure to write down and label all the equations needed to arrive at the solution.



KCL

$$\frac{V_1 - V_s}{R_s + R_1} + \frac{V_1 - V_2}{R_2} + V_1' C_1 = 0 \quad ①$$

$$V_2 = V_1'(-C_1R_1 - C_1R_3) + V_2'(-C_2R_1 - C_2R_2 - C_2R_3) + V_s$$

$$V_2' = V_1''(-C_1R_1 - C_1R_3) + V_2''(-C_2R_1 - C_2R_2 - C_2R_3)$$

$V_s = I_s R_s$ Oms law

$$\frac{V_2 - V_1}{R_2} + V_2' C_2 = 0 \quad ②$$

$$R_2 \cdot \frac{V_2 - V_1}{R_2} = -V_2' C_2 \cdot R_2$$

$$V_2 - V_1 = -V_2' C_2 R_2$$

$$V_1 = V_2' C_2 R_2 + V_2 \quad -2$$

Plug V_2 & V_2' into V_1

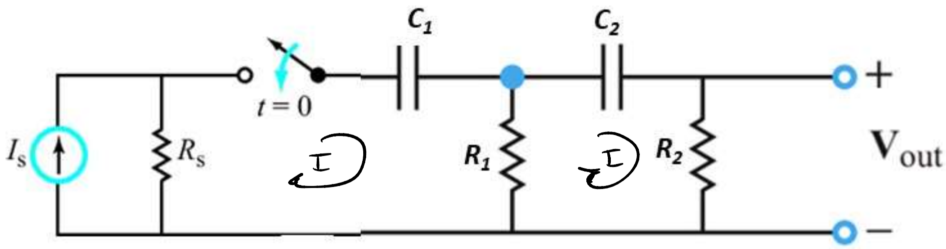
$$V_A = C_2 R_2 \left(\frac{C_1 V_1'' R_1 R_2 + C_1 V_1'' R_2 R_3 + R_1 V_1 - R_2 V_s + R_3 V_1}{R_1 + R_s} \right) + \left(\frac{C_1 V_1' R_1 R_2 + C_1 V_1' R_2 R_3 + R_1 V_1 - R_2 V_s + R_3 V_1}{R_1 + R_s} \right)$$

Solve for Vout which is Vout of V_2 in this Circuit

$$= V_1'' = C_2 V_2'' R_2 + V_2' \rightarrow V_1' = \frac{-C_2 V_2' \cancel{R_1} - C_2 V_2' R_2 - C_2 V_2' \cancel{R_2} - V_2 + V_s}{C_1 \cancel{R_1} + C_1 R_2} = C_2 V_2'' R_2 + V_2'$$

$$V_{out} = C_2 R_2 V_2'' + V_2'$$

3) In zyBooks exercises 6.10.4 – 7 a circuit is given, and you are asked to find the initial values of voltage and current on one or more of the elements. Do the same for both capacitors in the circuit below. Be sure to write down and label all the equations needed to arrive at the solution.



$V_{C_1}(0^-) = 0$

$V_{C_1}(0^-) = V_{C_1}(0^+) = 0$

$V_{C_2}(0^-) = V_{C_2}(0^+) = 0$

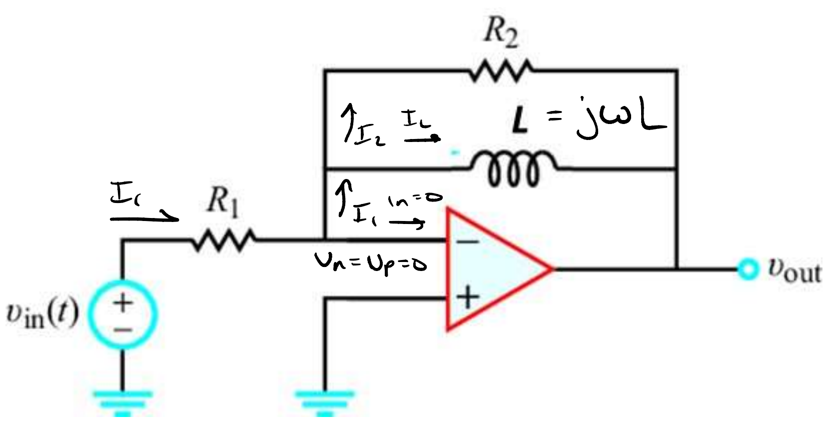
First, $I_C = I_{R_1} + I_{C_2}$

$R_1 \| R_2 = \dfrac{R_1 R_2}{R_1 + R_2}$

$i_{C_1}(0) = \dfrac{V_S}{R_S + R_1 \| R_2}$

$i_{C_2}(0) = i_{C_1}(0) \cdot \dfrac{R}{R_1 + R_2}$

4) In zyBooks exercises 7.12.2 – 5 you are asked to find the output voltage of a circuit as a function of the input voltage. Do the same for the circuit below. Be sure to write down and label all the equations needed to arrive at the solution.



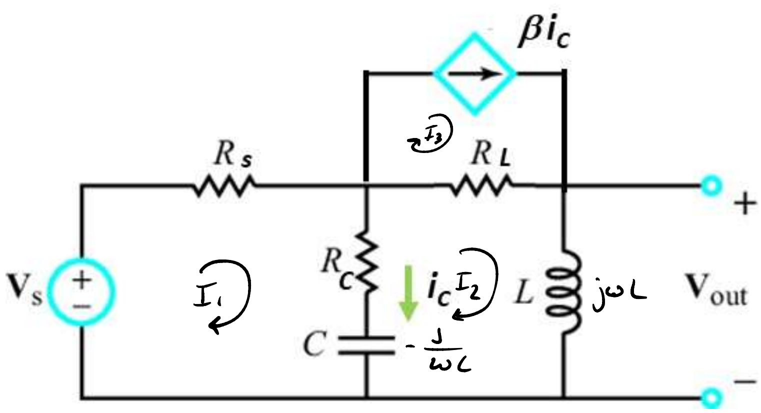
$$V_{in} = V_{in}(t), \quad I_1 = \frac{V_{in}}{R_1}, \quad I_1 = I_2 + I_L \quad L = j\omega L$$

$$\frac{V_n - V_{out}}{R_2} + \frac{V_n - V_{out}}{j\omega L} = -V_{out}\left(\frac{1}{R_2} + j\omega L\right)$$

So, $$V_{out} = -\left(\frac{R_2}{R_1}\right)\left(\frac{1}{1 + j\omega R_2 L}\right)V_{in}$$

$$= -\left(\frac{R_2}{R_1}\right)\frac{1 - j\omega R_2 L}{1 + \omega^2 R_2^2 L^2} V_{in}$$

5) In zyBooks exercises 7.10.5 -- 11 you are asked to find one of the currents or voltages in a circuit. Do the same for Vout in the circuit below. Be sure to write down and label all the equations needed to arrive at the solution.



Using Mesh Analysis to get an Expression for phasor V_{out} in terms of V_s and R, we know that

$$R = \omega L = 1/\omega C$$

First, $-V_s + RI_1 + \left(R - \frac{j}{\omega C}\right)(I_1 - I_2) = 0$

$$\left(R - \frac{j}{\omega C}\right)(I_2 - I_1) + j\omega L I_2 = 0$$

$$R_L \beta I_c = 0$$

Use $R = \omega L = \frac{1}{\omega C}$

$$-V_s + RI_1 + (R - jR)(I_1 - I_2) = 0$$

$$(R - jR)(I_2 - I_1) + jRI_2 = 0$$

Simplify, $I_1(2 - j1) - I_2(1 - j1) = \frac{V_s}{R}$ ①

$$-I_1(1 - j1) + I_2 = 0 \quad ②$$

$$I_2 + R_L \beta I_c = 0 \quad ③$$

$$V_{out} = j\omega L I_2 = jRI_2.$$

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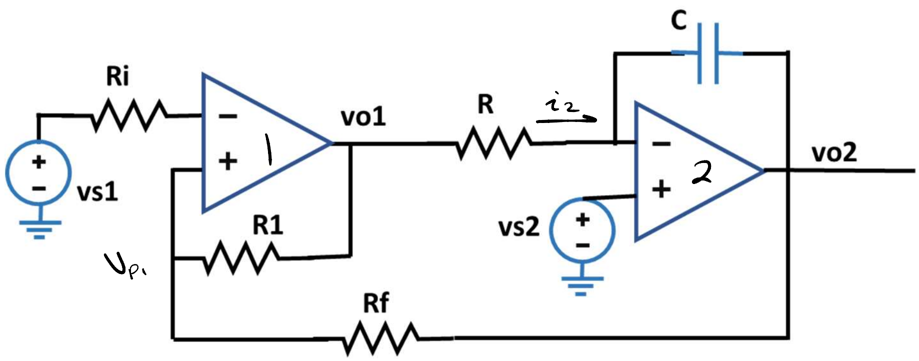
Extra credit) The dual op amp circuit below has two outputs vo1 and vo2. Note that the first op amp has positive feedback and so is saturated to +Vcc or –Vcc. Because of this the two input voltages, vn1 and vp1, are not necessarily equal. Begin with Vs1=0.

a) How does Vo2 depend on Vs2 for each value of Vo1?
b) If Vs1 is not zero, how does the maximum value of Vo2 depend on Vs1? Note there will be two answers, one for negative and one for positive output voltages.



Op amp 2 - Integrator

$$V_{o_2} = v(0) - \int_0^t i_2\,dt\,\frac{1}{C}$$

$$= V(0) - \frac{V_{o_1}}{RC}t$$

Node V_{P_1} $\quad \frac{V_{P_1}-V_{o_1}}{R_1} + \frac{V_{P_1}-V_{o_2}}{R_f} = 0$

(a) $+V = V_{P_2} > V_{n_2}$, $-V = V_{P_2} < V_{n_2}$

(b) $\frac{R_f}{R}(V_{o_1} - V_{s_1})$ AND

$\frac{R_f}{R}(V_{o_1} + V_{s_1})$

Starting at $t=0$, $V_{o_1} = V_{cc}$, $V_{o_2} = 0$

$V_{o2} = -V_{cc}\frac{t}{\tau}$ AND $\tau = RC$ → $V_{P_1} = (R_1 \| R_f)\left(\frac{V_{cc}}{R_1} - \frac{V_{cc}}{R_f}\frac{t}{\tau}\right)$

$\frac{t}{\tau} = \frac{R_f}{R_1} \to V_{o_1} \to -V_{cc} \to V_{o_2} = -\frac{V_{cc}}{\tau}\left(\tau\frac{R_f}{R_1}\right) + \frac{V_{cc}}{\tau}t$

$V_{o2} = V(0) - \frac{V_{o1}}{RC}t = -\frac{V_{cc}}{\tau}t$

V_{P_1} @ $t_1 = \tau\left(\frac{R_f}{R_1}\right)$, $V_{o2}(t_1) = -\frac{V_{cc}}{\tau}\tau\left(\frac{R_f}{R_i}\right)$, $V_{o1}(t-t_1) = -V_{cc}$

$V_{o2}(t > t_1) = -V_{cc}\left(\frac{R_f}{R_1}\right) + V_{cc}\frac{t}{\tau}$