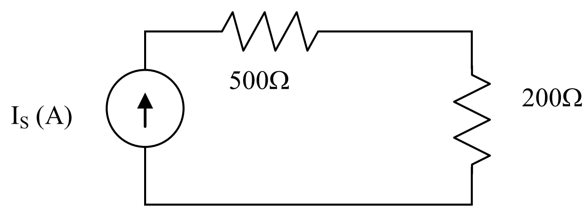
NAME:_____SOLUTIONS ______

EEE 202: Test 1

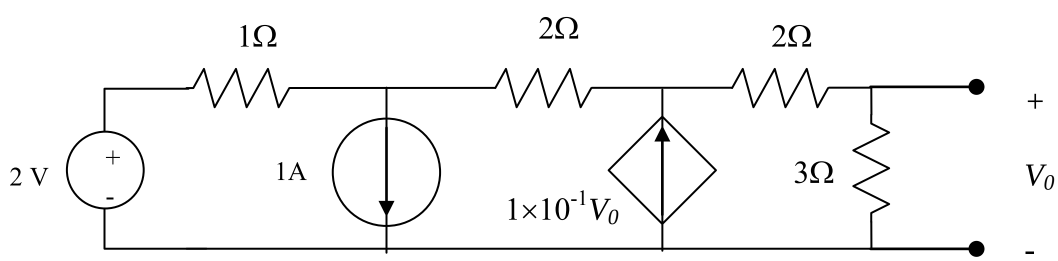
2 Problems, Equal Credit, Closed-book/notes, one sheet of formulae allowed

Problem 1. In the following circuit, find "I_S" so that the power absorbed by the 200Ω resistance is 1W.



$$P_{200} = I_s V_{200} = I_s^2 200 = 1 \Rightarrow I_s^2 = \frac{1}{200} \Rightarrow I_s = \frac{1}{10\sqrt{2}} = \frac{1}{14.14} = 0.07(A)$$

Problem 2. Develop a set of equations to compute V_0 in the following circuit. Express your answers in matrix form.



Nodal analysis (4 nodes)

$V_1 = 2$

$$\frac{V_1 - V_2}{1} - 1 + \frac{V_3 - V_2}{2} = 0$$

$$\frac{V_2 - V_3}{2} + 0.1V_0 + \frac{V_4 - V_3}{2} = 0 \quad \Rightarrow \begin{bmatrix} 1 & 0 & 0 & 0 \\ 1 & -1.5 & 0.5 & 0 \\ 0 & 0.5 & -1 & 0.6 \\ 0 & 0 & 0.5 & -0.83 \end{bmatrix} V = \begin{bmatrix} 2 \\ 1 \\ 0 \\ 0 \end{bmatrix}, \; V_0 = V_4$$

$$\frac{V_3 - V_4}{2} + \frac{0 - V_4}{3} = 0$$

$$V_0 = V_4$$

Loop analysis (3 loops)

$$I_1 - I_2 = 1$$

$$I_2 - I_3 = -0.1V_0$$

$$-2 + I_1 1 + I_2 2 + I_3(2 + 3) = 0 \quad \Rightarrow \begin{bmatrix} 1 & -1 & 0 \\ 0 & 1 & -0.7 \\ 1 & 2 & 5 \end{bmatrix} V = \begin{bmatrix} 1 \\ 0 \\ 2 \end{bmatrix}, \; V_0 = I_3 3$$

$$V_0 = I_3 3$$

Both result in the same solution: $V_0 = 0.423$.

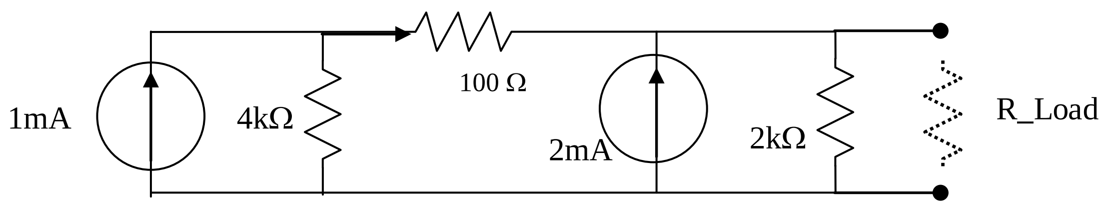
EEE 202, TEST 2, **NAME:___SOLUTIONS___**

2 Problems, 30', Closed Book&Notes, 1 sheet of formulae allowed

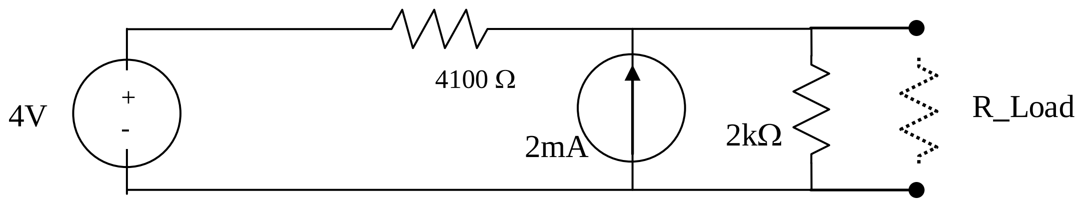
Problem 1.

Problem 1. Determine the Thevenin and Norton Equivalents for the circuit below (without the load).

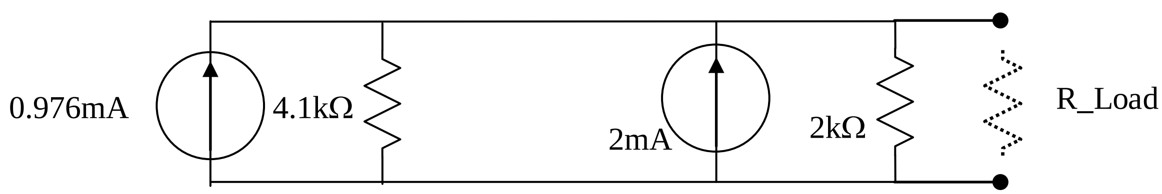
$\boldsymbol{V_{OC} = \quad 4V}$ $\boldsymbol{I_{SC} = \; 2.98mA}$ $\boldsymbol{R_{TH} = \; 1.34k\Omega}$



Simplify with a source transformation: Is = 1mA, R = 4k => Vs = 4V

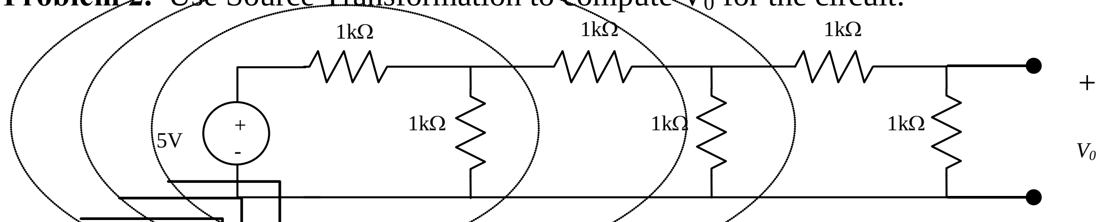


Apply a second source transformation to obtain a single node pair circuit



It now follows easily that $I_{sc} = 2.98mA, R_{TH} = 4.1k||2k = 1.344k\Omega, V_{oc} = R_{TH}I_{sc} = 4V$

Problem 2. Use Source Transformation to compute V_0 for the circuit:



Starting from the left

$I_{s1} = 5mA, R_1 = 1k||1k = 0.5k\Omega$

$V_{s2} = 2.5V, R_2 = 1k + 0.5k = 1.5k\Omega$

$I_{s2} = 1.67mA, R_3 = 1.5k||1k = 0.6k\Omega$

$V_{s3} = 1.0V, R_4 = 0.6k + 1k = 1.6k\Omega$

Finally, a voltage division yields

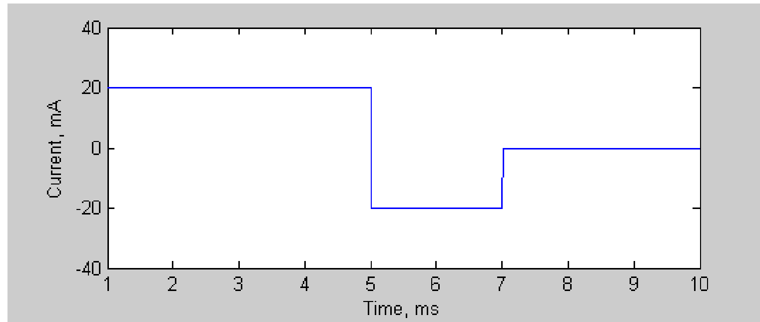
$$V_o = V_{s3}\frac{1k}{1.6k + 1k} = 0.385V$$

EEE 202: TEST 3 **NAME:___SOLUTIONS_______**

2 Problems, equal credit, 50', Closed Book&Notes, 1 sheet of formulae allowed

Problem 1.

The current across a 0.1nF capacitor is shown in the following figure. Plot the capacitor voltage. (Carefully label your plot.)



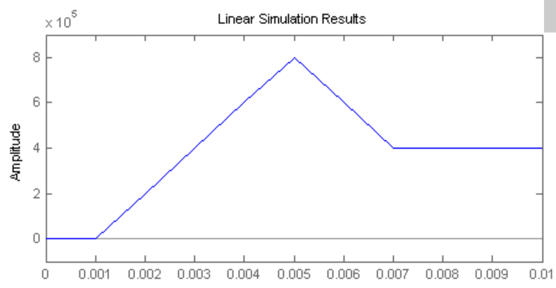
$V = V(0) + \frac{1}{C}\int_0^t i(\tau)d\tau$ =>

At t = 5, $V(5) = V(0) + \frac{1}{1e{-}10} 20m \times 4m$

At t = 7, $V(7) = V(5) + \frac{1}{1e{-}10} (-20)m \times 2m$

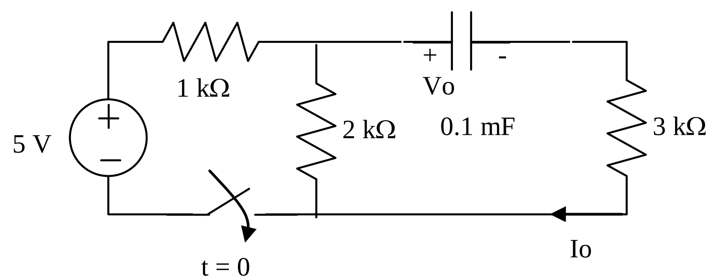
V(0) is not given and it is an offset for the entire response.

$V(0) +$



Problem 2. In the following circuit, find:

1. The voltage V_o for t > 0.
2. The current I_o for t > 0.



$t < 0$: $V_c(0^-) = 0 = V_c(0^+) = V_o(0^+)$

$t > 0$: $V_o(\infty) = 5 \times \frac{2}{1+2} = 3.33(V)$

$t > 0$: $R_{TH} = 3k + 2k||1k = \frac{11}{3}k(\Omega) \Rightarrow \tau = R_{TH}C = \frac{11}{3}k \times 0.1m = \frac{11}{30} = 0.367(s)$

$t > 0$: $V(t) = V_o(\infty) + [V_o(0^+) - V_o(\infty)]e^{-t/\tau} = 3.33 - 3.33e^{-\frac{t}{0.367}}$

$t > 0$: $I_o(0^+) = 5m\frac{\frac{1}{3k}}{\frac{1}{1k}+\frac{1}{2k}+\frac{1}{3k}} = \frac{10}{11}m(A)$ (After using a source transformation and current division to find the current through the 3k resistance.

$t > 0$: $I_o(\infty) = 0(A)$

$t > 0$: $R_{TH} = 3k + 2k||1k = \frac{11}{3}k(\Omega) \Rightarrow \tau = R_{TH}C = \frac{11}{3}k \times 0.1m = \frac{11}{30} = 0.367(s)$

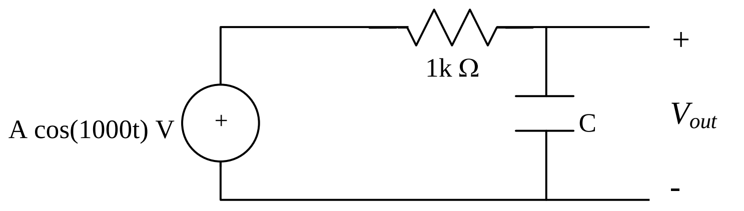
$t > 0$: $V(t) = I_o(\infty) + [I_o(0^+) - I_o(\infty)]e^{-t/\tau} = \frac{10}{11}e^{-\frac{t}{0.367}}$

Note: We could get the same answer by observing that Io is the current through the capacitor and using the formula $I_o = C\frac{dV_o}{dt}$.

EEE 202, TEST 4 NAME: SOLUTIONS

Closed-book/notes, 3 problems, equal credit, 1 sheet of formulae allowed

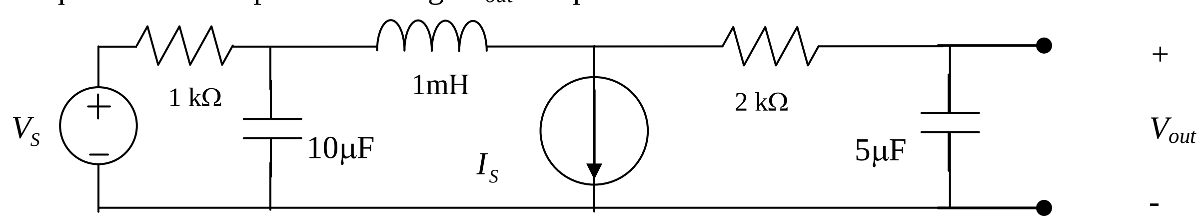
Problem 1: RC-filters are often used to reduce the effect of high-frequency noise in circuits. In the following example, the voltage source represents a high frequency signal that is to be attenuated at the output (Vout).
Write an expression for V_{out} and determine the value of the capacitance C so that the amplitude of V_{out} is 100 times smaller than the amplitude of the source.



$$1.\ V_{out} = \frac{\frac{1}{jwC}}{R+\frac{1}{jwC}} V_{in} = \frac{1}{RCjw+1} A\angle 0 = \frac{A}{\sqrt{R^2C^2w^2+1}} \angle -\tan^{-1}\left(\frac{RCw}{1}\right)$$

$$2.\ |V_{out}| = \frac{A}{\sqrt{R^2C^2w^2+1}} < \frac{A}{100} \Rightarrow R^2C^2w^2+1 > 100^2 \Rightarrow C \simeq \frac{100}{Rw} \Rightarrow C \simeq 100\mu F$$

Problem 2. In the following circuit, $I_S(t)$ = 0.001cos(10t) (A), $V_S(t)$ = 2cos(10t) (V). Write a set of equations to compute the voltage V_{out}. Express in a matrix form.



$I_S = 0.001\angle 0, V_S = 2\angle 0^o, Z_L = j(10)(0.001) = j0.01, Z_{C1} = -j10k, Z_{C2} = -j20k$

Loop analysis:

$-2\angle 0 + I_1 1k + (I_1 - I_2)(-j10k) = 0$

$I_2 - I_3 = 0.001\angle 0$

$-2\angle 0 + I_1 1k + I_2(j0.01) + I_3(2k - j20k) = 0$

$V_{out} = I_3(-j20k)$

or

$$\begin{bmatrix} 1k - j10k & j10k & 0 \\ 0 & 1 & -1 \\ 1k & j0.01 & 2k - j20k \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} 2 \\ 1m \\ 2 \end{bmatrix}$$

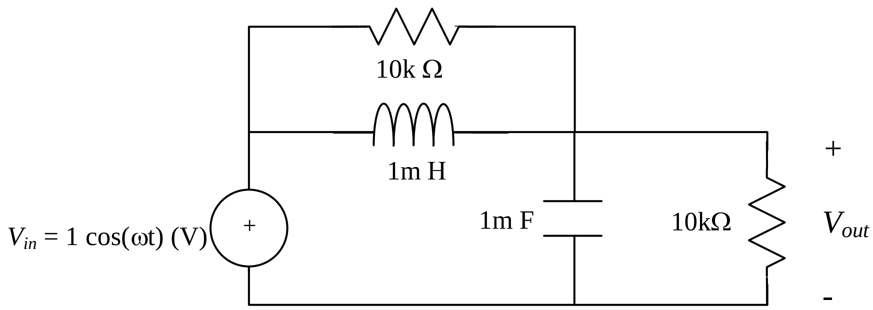
Nodal analysis: Simplify substituting Vs directly for the first node voltage

$$\begin{bmatrix} \frac{2-V_2}{1k} + \frac{-V_2}{-j10k} + \frac{V_3-V_2}{j10m} = 0 \\ \frac{V_2-V_3}{j10m} - 1m + \frac{V_4-V_3}{2k} = 0 \\ \frac{V_3-V_4}{2k} + \frac{-V_4}{-j20k} = 0 \end{bmatrix} \text{ or } \begin{bmatrix} \frac{-1}{1k} + \frac{1}{j10k} + \frac{-1}{j10m} & \frac{1}{j10m} & 0 \\ \frac{1}{j10m} & \frac{-1}{j10m} + \frac{1}{2k} & \frac{1}{2k} \\ 0 & \frac{1}{2k} & \frac{-1}{2k} + \frac{1}{j20k} \end{bmatrix} V = \begin{bmatrix} -\frac{2}{1k} \\ 1m \\ 0 \end{bmatrix},\ V_{out} = V_4$$

EEE 202, TEST 5 NAME:____SOLUTIONS_____

Closed-book/notes, 2problems, equal credit, 1 sheet of formulae allowed

Problem 1: For the following circuit



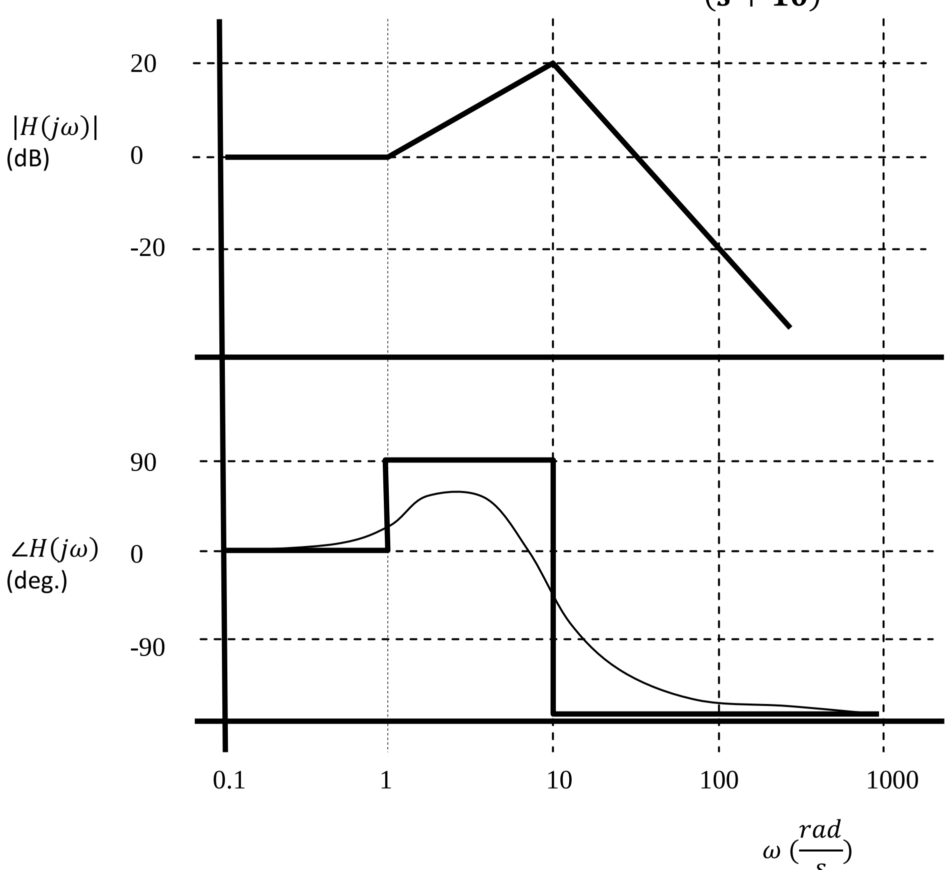
Find:

The transfer function $\frac{V_{out}}{V_{in}} = \frac{\left(sC+\frac{1}{R}\right)^{-1}}{(\left(\frac{1}{sL}+\frac{1}{R}\right)^{-1}+\left(sC+\frac{1}{R}\right)^{-1})} = \frac{R(Ls+R)}{R(Ls+R)+RLs(RCs+1)} = \frac{\left(\frac{L}{R}s+1\right)}{LCs^2+\frac{2L}{R}s+1}$

- The resonant frequency $\omega_0 = \frac{1}{\sqrt{LC}} = 1e3\ (rad/s)$
- The damping ratio $\zeta = \frac{\left(\frac{2L}{R}\right)}{LC}\frac{1}{2\omega_0} = \frac{1}{R}\sqrt{\frac{L}{C}} = 0.1e-3$

Problem 2: Sketch the Bode plot (magnitude and phase) for the transfer function

$$\boldsymbol{H(s) = \frac{1000(s+1)}{(s+10)^3}}$$



Corner frequencies:
1 (zero), 10(x3, poles)
DC: H(0) = 1 = 0dB, angle 0.