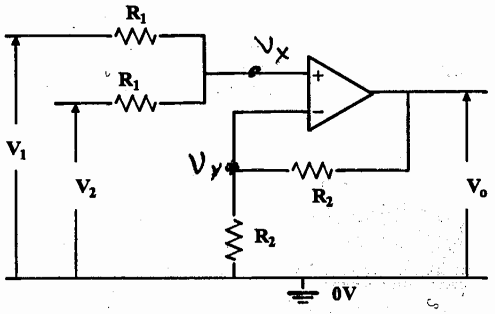
wlg

ECE 300
Spring 2008
Test 2A

(1) You are given the op amp circuit of Figure 1. Use ideal op amp assumptions in answer the following questions. V_o can be expressed in the following form:

$$V_o = [A]V_1 + [B]V_2$$

(a) Find the coefficients [A] and [B].
(b) If $V_1 = 2V$ and $V_2 = 5$ V, given the value of V_o.



(a) $V_x = \dfrac{V_o R_2}{R_2 + R_2} = \dfrac{V_o}{2}$ (1)

We also can write;

$$\frac{V_x - V_1}{R_1} + \frac{V_x - V_2}{R_1} = 0$$

OR

$2V_x - V_1 - V_2 = 0$ (2)

substitute (1) into (2);

$\boxed{V_o = V_1 + V_2}$

(b) If $V_1 = 2V$, $V_2 = 5V$;

$\boxed{V_o = 2 + 5 = 7V}$

Test 2A

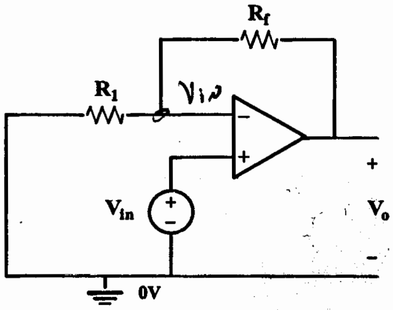
(2) For the following problems assume ideal op amps.

(a) Design an inverting op amp circuit using a single op amp such that the gain is given by

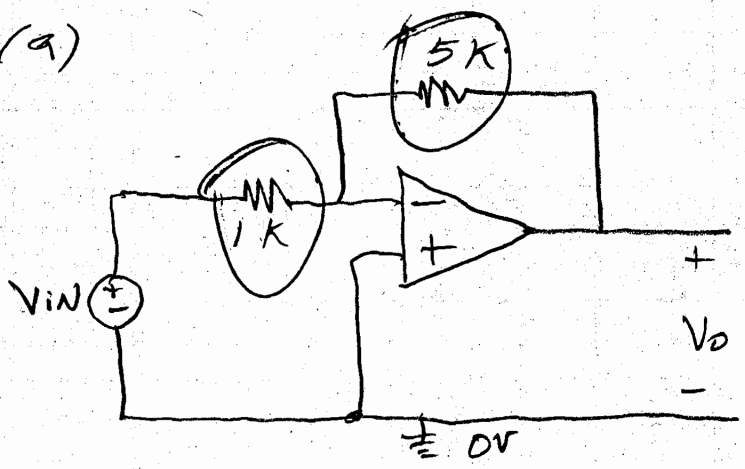
$$\frac{V_o}{V_{in}} = +5$$

Show (draw) your op amp circuit and give the values of all resistors on your circuit diagram. Also, show on your diagram, an appropriate ground along with V_o and V_{in}.

(b) You are given the non-inverting op amp circuit shown in Figure 2(b). Determine values of R_f and R_1 so that $V_o = 5V_{in}$. You are restricted to resistors of values 1 kΩ, 2 kΩ, 3 kΩ, 4 kΩ and 5 kΩ..



(a)



(b) We have

$$\frac{V_{IN}}{R_1} + \frac{V_{IN} - V_o}{R_f} = 0$$

OR

$$\boxed{V_o =} \; R_f\left(\frac{V_{IN}}{R_1} + \frac{V_{IN}}{R_f}\right) = \boxed{\left(1 + \frac{R_f}{R_1}\right)V_{IN}}$$

make $\frac{R_f}{R_1} = 4$ with $R_f = 4k\Omega$, $R_1 = 1k\Omega$

$$\boxed{V_o = 5\,V_{IN}}$$

Test 2A

(3) You are given the following circuit.

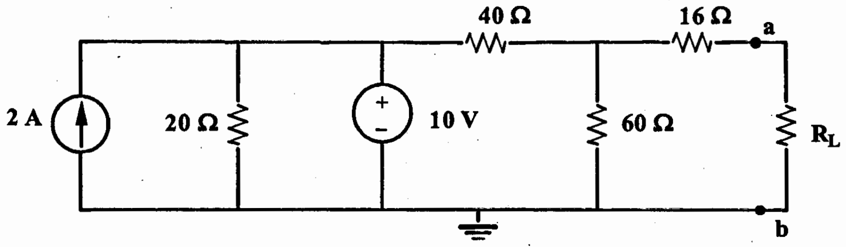
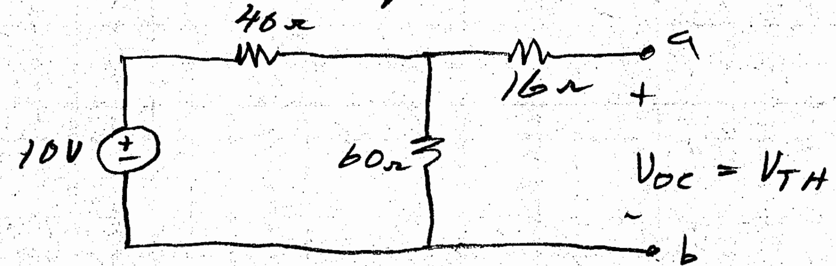


Figure 3: Circuit for Problem 3.

(a) Determine V_{TH} and R_{TH} looking into terminals a-b with R_L removed.
(b) Draw your Thevenin circuit. Show V_{TH} and R_{TH} on the circuit diagram connected to R_L.
(c) Assign a value of R_L that will give maximum power transfer to R_L and Determine this value of power.

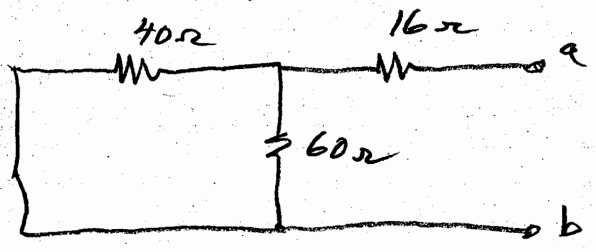
For purposes of finding V_{TH} and R_{TH}, the circuit above is equivalent to the following:



(a)
We have;

$$V_{oc} = V_{TH} = \frac{10 \times 60}{40 + 60} = 6V$$

To find R_{TH};



$$R_{TH} = 40 /\!/ 60 + 16 = \frac{2400}{100} + 16 = 40Ω$$

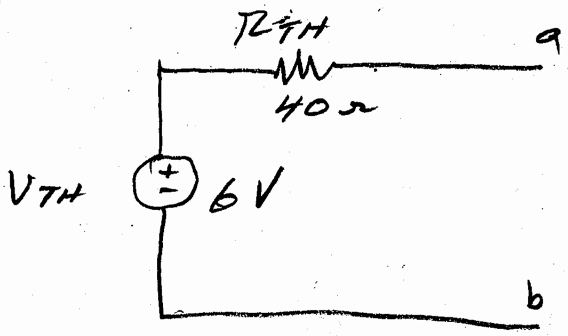
$$V_{TH} = 6V$$

$$R_{TH} = 40Ω$$

Test 2A

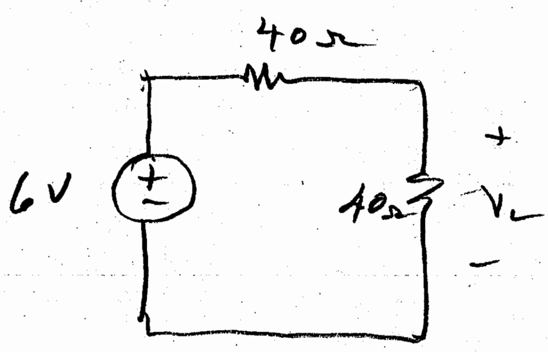
(3) cont.

(b)



(c) make $R_L = 40\Omega$;

We then have



$V_L = 3\text{ V}$

$$P_{OUT} = \frac{V_L^2}{40} = \frac{9}{40} = 0.225\text{ W}$$

$$\boxed{P_{OUT} = 0.225\text{ W}}$$

Test 2A

(4) You are given the circuit of Figure 4. Assume that the circuit is in steady state.

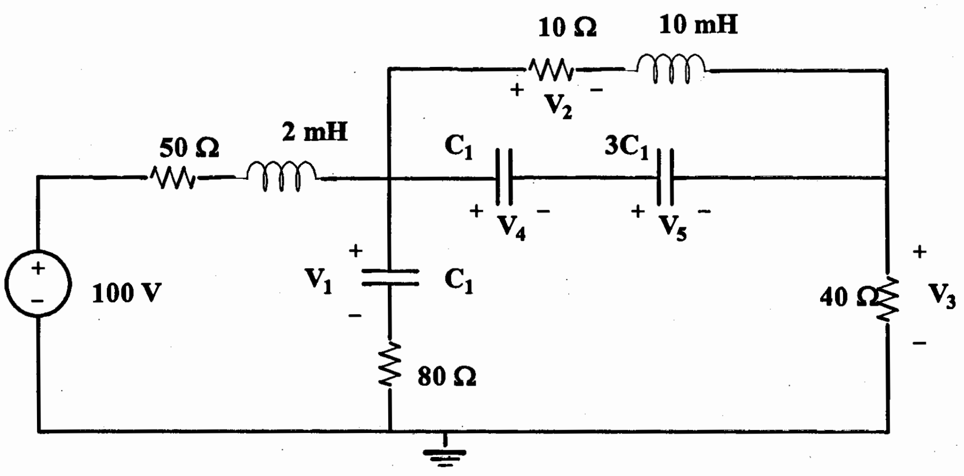
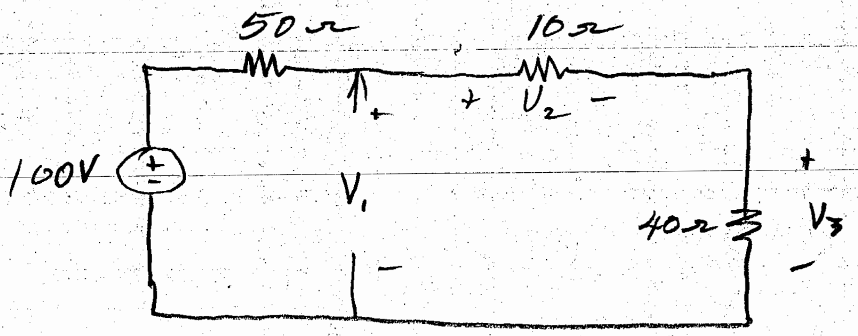


Figure 4: Circuit for Problem 4.

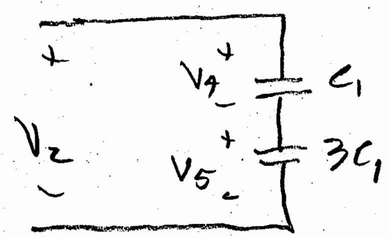
C_1 can be any value you want to use between 1µF and 10 µF.
You are required to find the values of V_1, V_2, V_3, V_4 and V_5.

In steady state the circuit is equivalent to the following:



$V_1 = 50V$; $V_2 = \frac{50 \times 10}{10+40} = 10V$; $V_3 = 40V$

We Also have



Test 2A

(4) continued

Using voltage division for capacitors in series;

$$V_4 = \frac{V_2 \times 3C_1}{3C_1 + C_1} = 0.75 V_2$$

0.8

$V_4 = 7.5\,V$

It follows that since $V_2 = 10\,V$ and $V_4 = 7.5\,V$ that

$V_5 = 2.5\,V$

Summary

$V_1 = 50V$

$V_2 = 10V$

$V_3 = 40V$

$V_4 = 7.5V$

$V_5 = 2.5V$

Test 2A

(5) You are given the circuit of Figure 5(a).

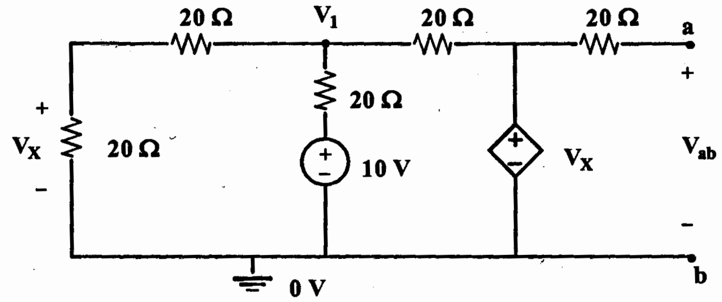


Figure 5 (a): Circuit for Problem 5 (a).

(a) Use the ***nodal analysis method*** to find the open circuit voltage, V_{ab}, as shown in Figure 5 (a).

(b) Place a short circuit from terminals a to b of the circuit shown in Figure 5 (a). Use the ***nodal analysis method*** to find I_{SC} as shown in Figure 5 (b).

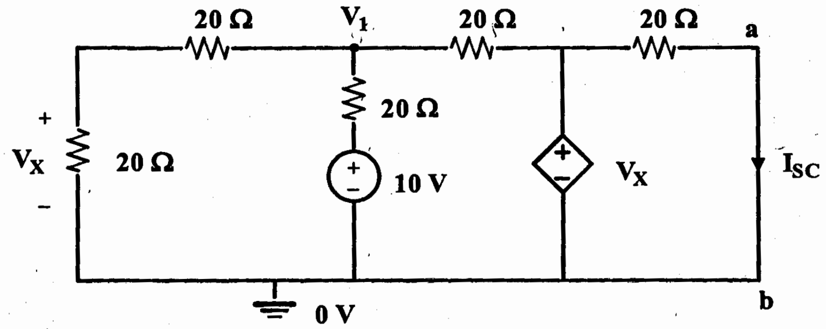


Figure 5 (b): Circuit for Problem 5 (b).

(c) Using the information of 5 (a) and 5 (b), determine the Norton equivalent circuit. Draw the circuit showing I_{Norton} and R_{Norton} and terminals a-b.

(a) Using Nodal:
At V_1

$$40\left(\frac{V_1}{40} + \frac{V_1 - 10}{20} + \frac{V_1 - V_x}{20} = 0\right)$$

or

$$V_1 + 2V_1 - 20 + 2V_1 - 2V_x = 0$$

$$5V_1 - 2V_x = 20$$

but $V_x = \frac{V_1}{2}$

Test 2A

(5) cont.

so;

$$5V_1 - \frac{\cancel{2} \times V_1}{\cancel{2}} = 20$$

$$4V_1 = 20$$

$$\underline{V_1 = 5\,V}$$

since

$$V_x = \frac{V_1}{2}$$

$$V_x = 2.5\,V$$

We see that $\underline{V_{ab} = V_x = V_{oc} = V_{TH} = 2.5V}$

(6) Finding I_{sc}: (Nodal Analysis)

At V_1

$$\frac{V_1}{40} + \frac{V_1 - 10}{20} + \frac{V_1 - V_x}{20} = 0$$

(same as in part (a))

$$V_x = \frac{V_1}{2} = 2.5\,V$$

$$\underline{I_{sc}} = \frac{V_x}{20} = \frac{2.5}{20} = \underline{0.125\,A} = I_N$$

so; Summary

$$V_{TH} = V_{OC} = 2.5\,V$$

$$I_N = I_{sc} = 0.125\,A$$

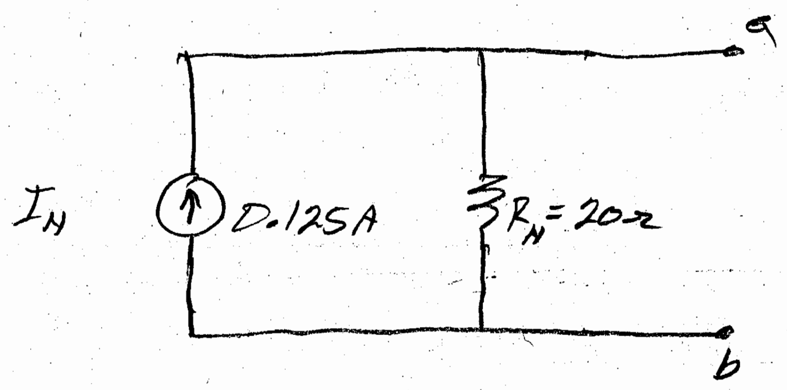
Test 2A

(3) cont,

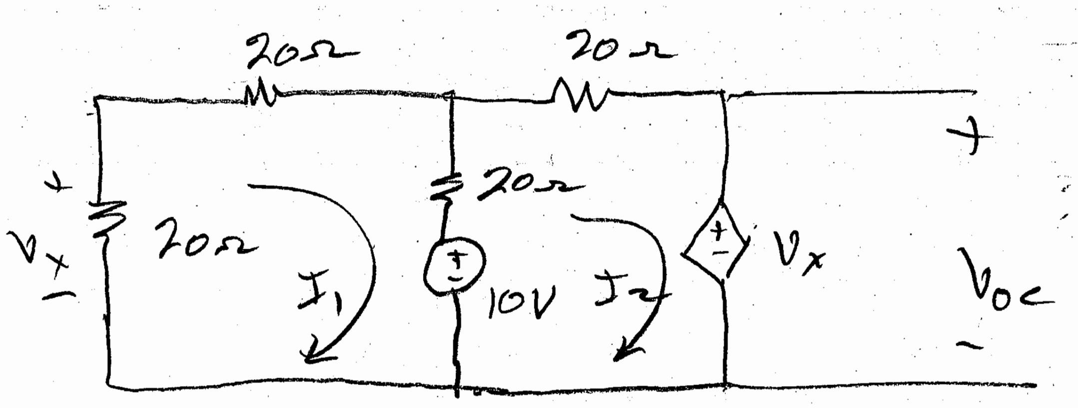
(c)

$$I_N = I_{sc} = 0.125\,A$$

$$\underline{R_N = R_{TH}} = \frac{V_{oc}}{I_{sc}} = \frac{2.5}{0.125} = \underline{20\,\Omega}$$



Check in V_{oc}



$$60 I_1 - 20 I_2 = -10$$

(5) cont.

$$\boxed{60I_1 - 20I_2 = -10}$$

$$-20I_1 + 40I_2 + V_x = 10$$

$$V_x = -20I_1$$

$$\boxed{\overset{40}{-40}I_1 + 40I_2 = 10}$$

$$\begin{bmatrix} 60 & -20 \\ -40 & 40 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} -10 \\ 10 \end{bmatrix}$$

$I_1 = -0.125 \qquad I_2 = 0.125$

$V_x = -I_1 \times 20 = +2.5\,V$ check

Test 3A

(6) Use any method you desire to find the voltage V_A in the circuit of Figure 6.

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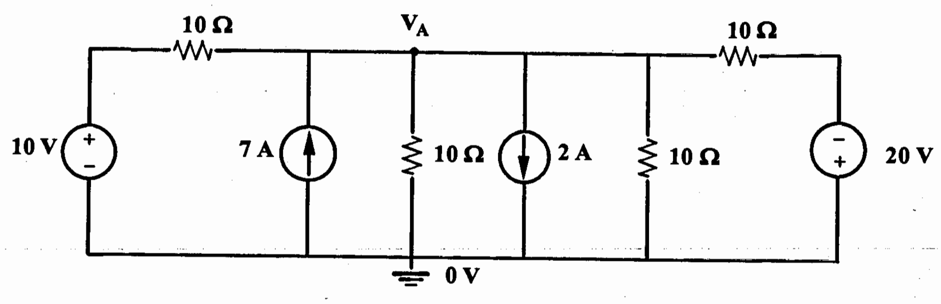
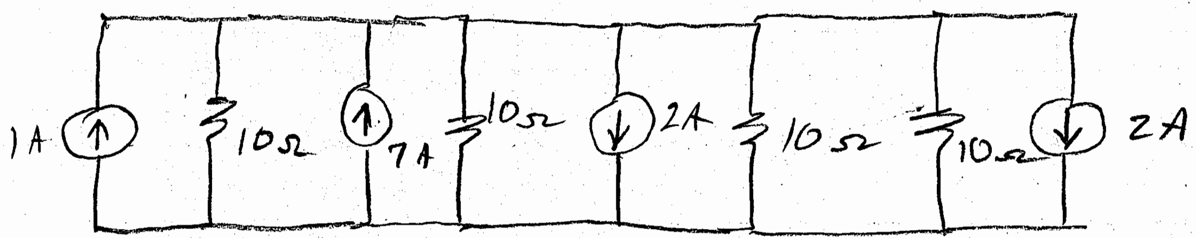
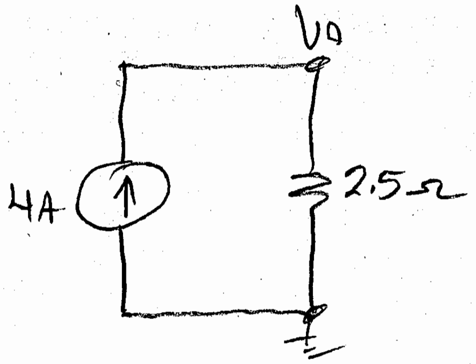


making source transformations, right and left side;



Net current: 4 A up

Equivalent resistance $\frac{10}{4} = 2.5\,\Omega$



$V_A = 4 \times 2.5 = 10\,V$