EECS40 **Spring 2004**
Professor Sanders

Midterm Exam # 1
March 2, 2004
Time Allowed: 90 minutes

Name:_____SOLUTIONS______, ______________________
Last First

Student ID #:_______________, Signature:______________________

Discussion Section:__________________________________

This is a closed-book exam, except for use of one 8.5 x 11 inch sheet of your notes. Show all your work to receive full or partial credit. Write your answers clearly in the spaces provided.

Problem #:	Points:
1	/20
2	/20
3	/10
Total	/50

1.

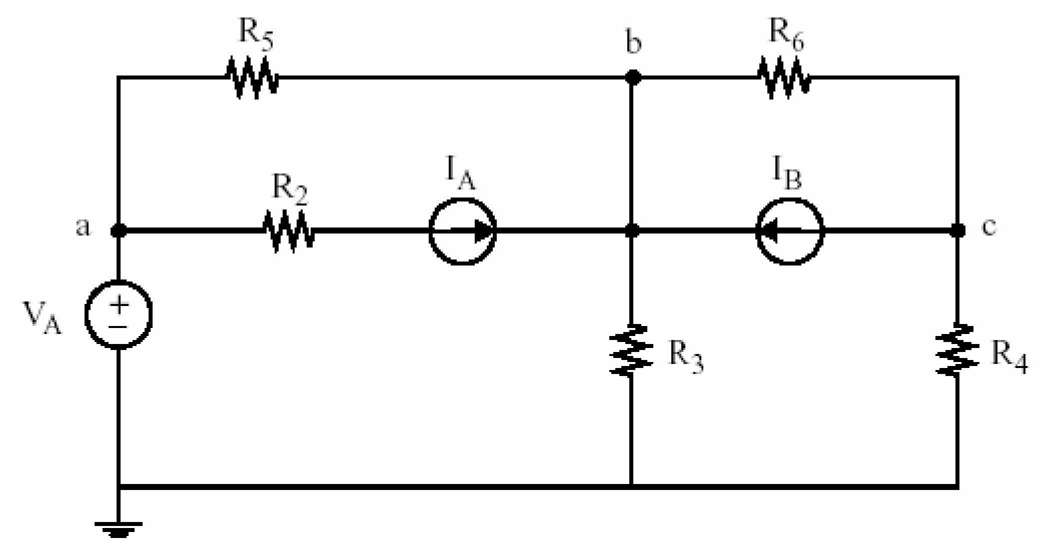


Figure 1(a)

a) (2 points)
In the circuit shown in Figure 1(a), the independent source values and resistances are known. Given the indicated reference potential, list the unknown node potentials in the circuit of Figure 1(a).

V_b V_c

b) (8 points)
Write down a complete set of node equations sufficient to solve for the node potentials you listed in part (a). Do not solve! Write your node equations in the box below.

b: $-I_A + \dfrac{V_b - V_A}{R_5} + \dfrac{V_b - V_c}{R_6} - I_B + \dfrac{V_b}{R_3} = 0$

c: $\dfrac{V_c}{R_4} + I_B + \dfrac{V_c - V_b}{R_6} = 0$

c) (2 points)
How many meshes would be required to solve the circuit of Figure 1(a) by the mesh analysis method?

4

d) (8 points)

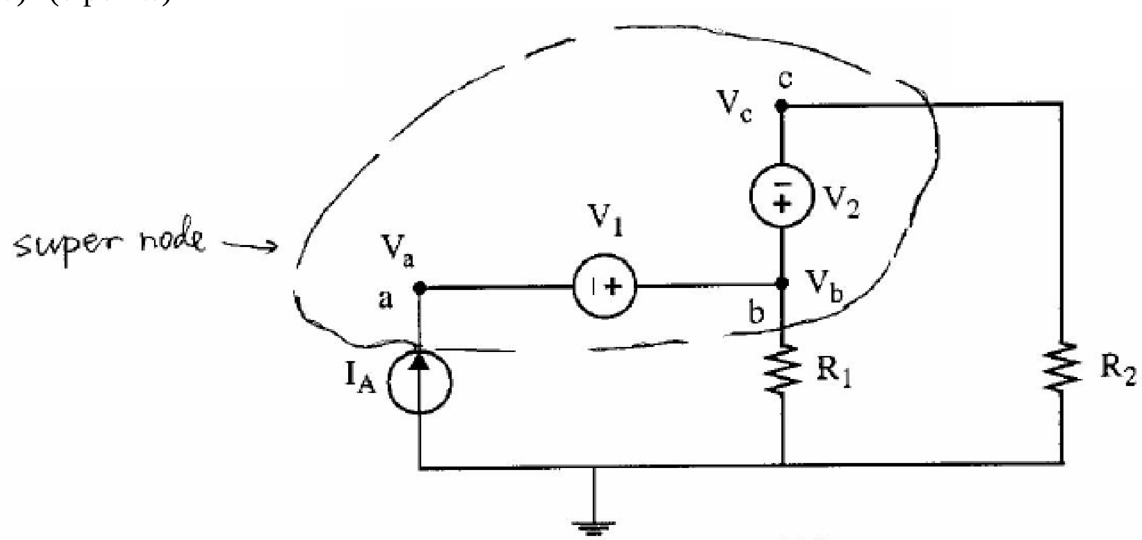


Figure 1(d)

In the circuit of Figure 1 (d), the independent source values and resistances are known. Use the node voltage method to write three equations sufficient to solve for the node potentials V_a, V_b, and V_c. Write your equations in the box below. Do not solve!

$$V_b - V_a = V_1$$

$$V_b - V_c = V_2$$

$$-I_A + \frac{V_b}{R_1} + \frac{V_c}{R_2} = 0$$

2.

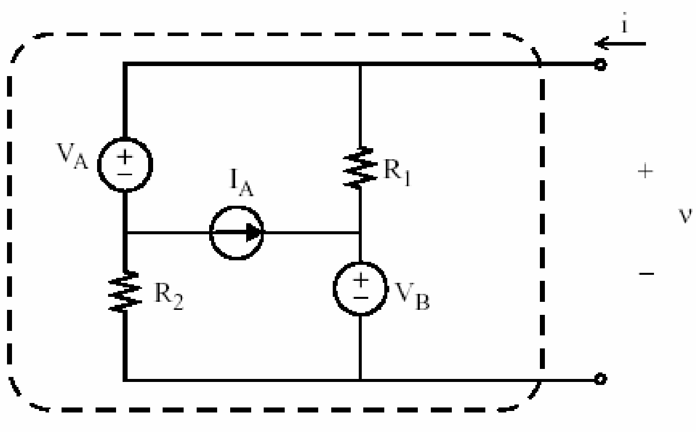
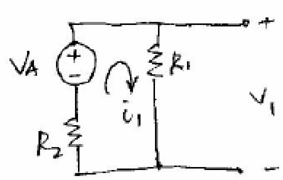
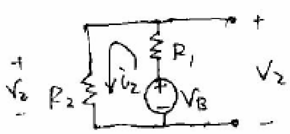


Figure 2(a)

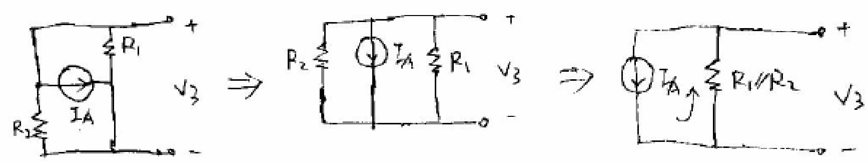
a) (10 points)
Determine the Thevenin equivalent circuit for the circuit in Figure 2(a).
Hint: superposition. Write your answer in the box at the bottom of the page.



$$V_1 = i_1 R_1 = \frac{V_A}{R_1+R_2} R_1$$



$$V_2 = i_2 R_2 = \frac{V_B}{R_1+R_2} R_2$$

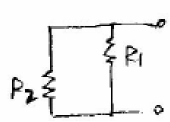


$$V_3 = -I_A (R_1 /\!/ R_2) = -\frac{I_A R_1 R_2}{R_1+R_2}$$

$$V_{th} = V_1 + V_2 + V_3 = \frac{V_A R_1}{R_1+R_2} + \frac{V_B R_2}{R_1+R_2} - \frac{I_A R_1 R_2}{R_1+R_2}$$

R_{th} : zero all the independent sources.

V_{th} =	
R_{th} =	



$$R_{th} = R_1 /\!/ R_2 = \frac{R_1 R_2}{R_1+R_2}$$

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b)

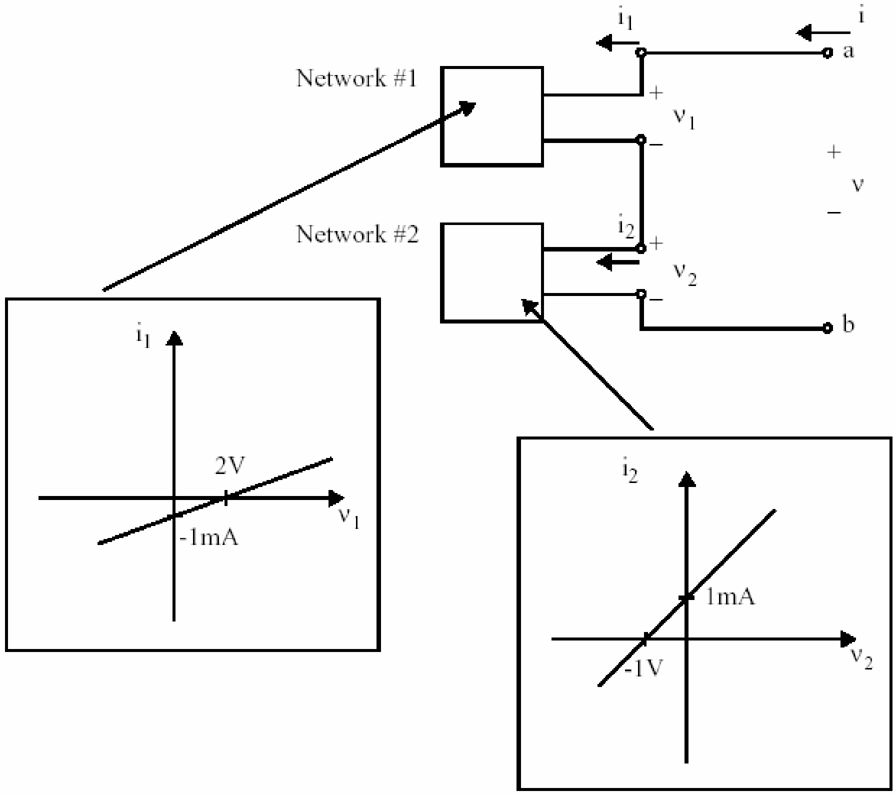
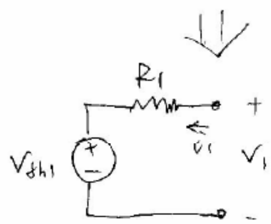
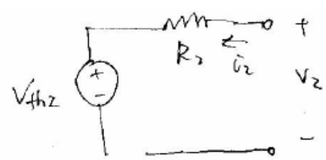


Figure 2(b)





$V_1 = R_1 i_1 + V_{th1}$

From figure,

when $i_1 = 0$, $V_1 = 2V \Rightarrow V_{th1} = 2V$

when $i_1 = -1mA$, $V_1 = 0 \Rightarrow R_1 = 2K\Omega$

$\therefore \ V_1 = 2K\Omega \cdot i_1 + 2V$

$V_2 = R_2 i_2 + V_{th2}$

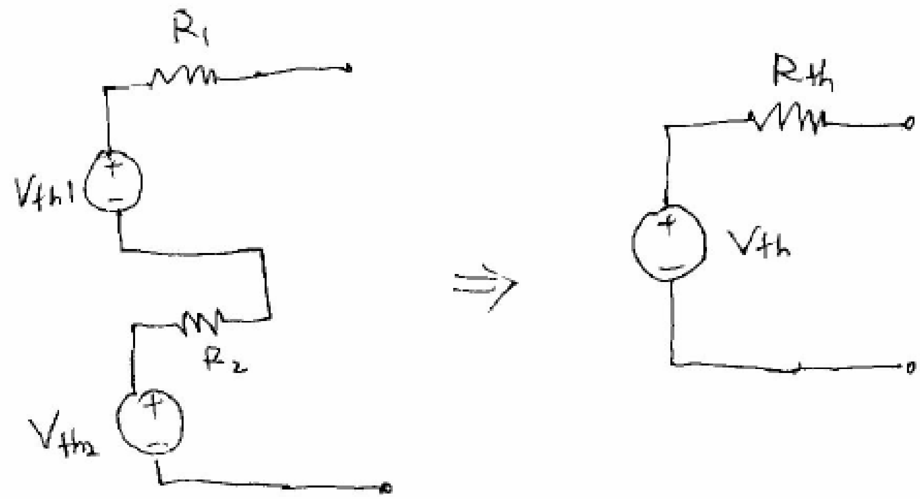
From figure

when $i_2 = 0$, $V_2 = -1V \Rightarrow V_{th2} = -1V$

when $i_2 = 1mA$, $V_2 = 0 \Rightarrow R_2 = 1K\Omega$

$V_2 = 1K\Omega \, i_2 - 1V$

One-port Networks #1 and #2 are interconnected as shown in Figure 2(b). Each of the one-port networks in Figure 2(b) is characterized by its indicated v-i graph. Determine the Thevenin equivalent network and the Norton equivalent networks for the one-port network shown in the figure by accessing the circuit at the terminals labeled a and b. Write your answer in the box below.



$$V_{th} = V_{th_1} + V_{th_2} = 2V + (-1V) = 1V$$

$$R_{th} = R_1 + R_2 = 2k\Omega + 1k\Omega = 3k\Omega$$

$$I_N = \frac{V_{th}}{R_{th}} = \frac{1V}{3k\Omega} = \frac{1}{3}mA$$

$$R_N = R_{th} = 3k\Omega$$

V_{th}= 1 V	R_{th}= 3 kΩ
I_N= $\frac{1}{3}$ mA	R_N= 3 kΩ

3)

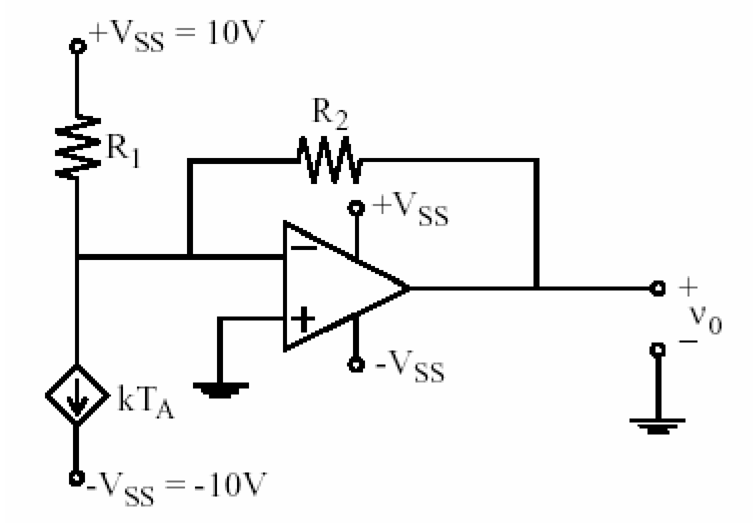


Figure 3

The op-amp in Figure 3 is ideal. The figure shows a temperature sensor modeled as a temperature controlled current source. This device senses absolute temperature T_A in the (°K) Kelvin scale and delivers a current kT_A, where $k = 1\ \mu A / °K$

a) (5 points)
   Determine the output voltage as a function of temperature T_A (°K) in terms of the circuit parameters.

As it is negative feckback, we know

$V_A = V_n = V_p = 0$ (virtual short)

$i_n = 0$ (virtual open)

Write KCL equation for node A:

$$kT_A + \frac{0 - V_{ss}}{R_1} + \frac{0 - V_o}{R_2} = 0$$

$$\Rightarrow V_o = KR_2 T_A - \frac{R_2}{R_1} V_{ss}$$

b) (5 points)
Determine values for R_1 and R_2 so that the output voltage sensitivity is $100\ mV / °K$ and the output is zero volts at $300\ °K$. Write your answer in the box below.

$$\frac{dV_o}{dT_A} = kR_2 = 100mV/K$$

$$R_2 = \frac{100mV/K}{k} = \frac{100mV/K}{1\mu A/K} = 10^5 \Omega = 100k\Omega$$

$$T_A = 300K \quad , \quad V_o = 0$$

$$V_o = kR_2T_A - \frac{R_2}{R_1}V_{SS}$$

$$\Rightarrow \quad 0 = 100mV/K \times 300K - \frac{R_2}{R_1} \times 10V$$

$$10V \times \frac{R_2}{R_1} = 30V$$

$$\frac{R_2}{R_1} = 3$$

$$R_1 = \frac{R_2}{3} = \frac{100k\Omega}{3} = 33k\Omega$$

$R_1 = 33k\Omega$
$R_2 = 100k\Omega$