Winter 2006 **EECS 215**

Midterm 1

SOLUTIONS

NAME:______________________________________

Instructions

Read all of the instructions and all of the questions before beginning the exam.

You must sign the Honor Pledge below to receive credit for the exam.

Closed Book, Closed Notes.

There are 5 problems in this exam. The total score is 100 points. Points are given next to each problem to help you allocate time. Do not spend all your time on one problem.

Unless otherwise noted on a particular problem, you must show your work in the space provided, on the back of the exam pages or in the extra pages provided at the back of the exam. Simply providing answers will only result in partial credit, even if the answers are correct. Draw a BOX or a CIRCLE around your answers to each problem.

Be sure to provide units where necessary.

Honor Pledge: I have neither given nor received aid in this exam.

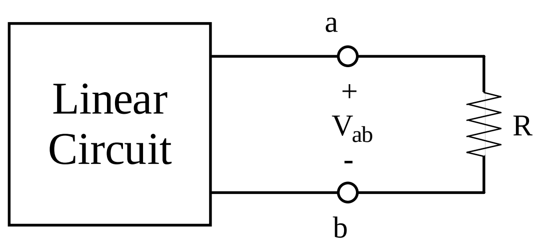
Signature: ____

GOOD LUCK!

PROBLEM	POINTS	MAX
1		20
2		20
3		20
4		20
5		20

Problem 1 Voltage, Current, Power *15 points*

Suppose we have the situation shown below:



and we know the following:

1. **If** R = 6 kΩ, **then** V_{ab} = +6 V

2. **If** R = 375 Ω, **then** V_{ab} = +1.5 V

V_{TH}= 7.5 **V**

I_N= 5 m**A**

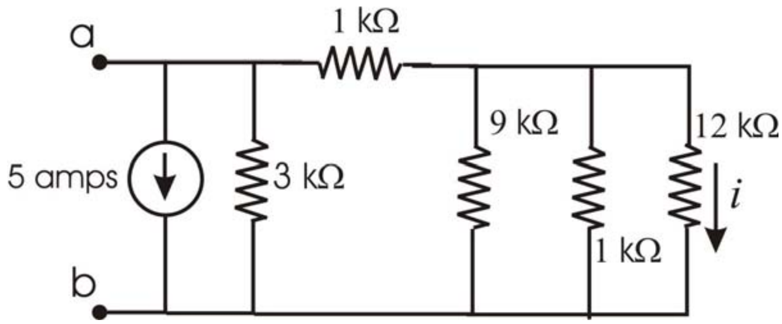
R_N=R_{TH}=R_{eq}= 1.5 K**Ω**

a) Find the values for the Thevenin and Norton equivalent circuits:

b) What is the maximum power that this circuit can deliver to a load?

$P_{L,max}$= 9.375 m**W**

c) Find the current i and the voltage V_{ab} in the circuit below



i=	___-0.2163______A
V_{ab}=	____-5697_______V

Problem 2 Nodal Analysis *25 points*

Consider the circuit shown on the next page.

A combination of *4* equations are needed to find the *4* unknown node voltages (v_1, v_2, v_3, v_4). Write down these 4 equations so that (v_1, v_2, v_3, v_4) are the *only* unknowns in the equations and **circle for each equation whether it is a *KVL* (voltage units) or *KCL* (current units) equation**. Show your intermediate work on the following pages.

USE THE NODE VOLTAGE LABELS (v1, v2, v3, v4) PROVIDED!

1) $V_2 - V_1 = 0.5 V_0 = 0.5 (V_2 - V_3)$

KVL or KCL

2) $V_3 = 24V$

KVL or KCL

3) $(V_1 - V_4)\left(\frac{1}{5\Omega}\right) + (V_2 - V_4)\left(\frac{1}{5\Omega}\right) + (V_2 - V_3)\left(\frac{1}{10\Omega}\right) = 1A$

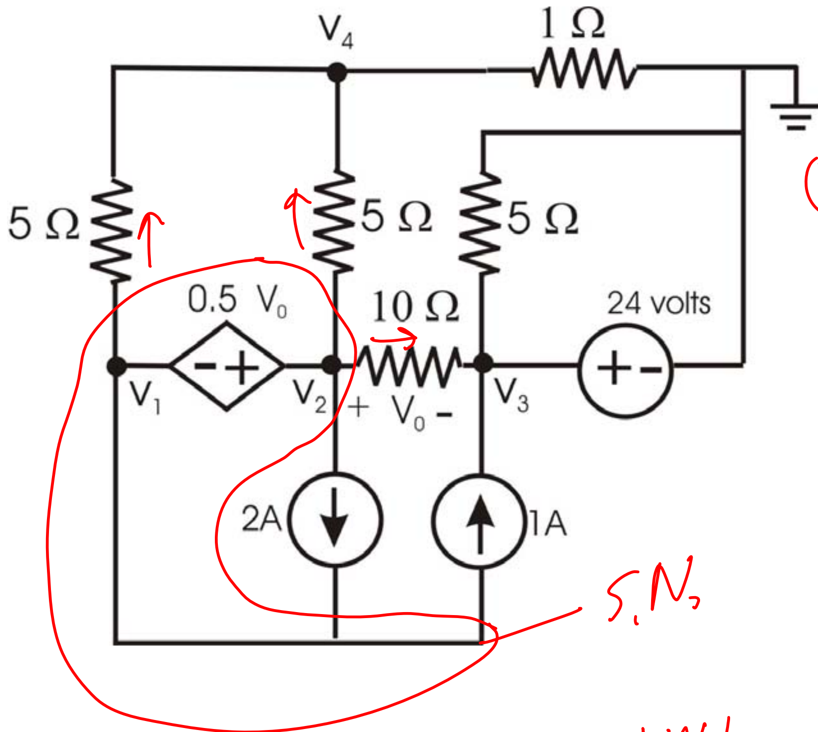
KVL or KCL

SN 1-2

4) $(V_4 - V_1)\left(\frac{1}{5\Omega}\right) + (V_4 - V_2)\left(\frac{1}{5\Omega}\right) + V_4\left(\frac{1}{1\Omega}\right) = 0$

KVL or KCL

Normal node 4



(4) $\left\{(V_4 - V_1)\frac{1}{5\Omega} + (V_4 - V_2)\frac{1}{5\Omega} + V_4\left(\frac{1}{1\Omega}\right)\right\} = 0$

KCL

$V_0 = V_2 - V_3$ KVL

$V_2 - V_1 = 0.5\,V_0 = 0.5(V_2 - V_3)$ KVL

(1) $\Rightarrow (-1)V_1 + (0.5)V_2 + (0.5)V_3 = 0$ KVL

(2) $V_3 = 24\,V$ KVL

SN KCL $\rightarrow$ (3) $(V_1 - V_4)\left(\frac{1}{5\Omega}\right) + (V_2 - V_4)\left(\frac{1}{5\Omega}\right) + (V_2 - V_3)\left(\frac{1}{10\Omega}\right) = 2A - 1A = 1A$ KCL

$\left\{\left(\frac{1}{5\Omega}\right)V_1 + \left(\frac{1}{5\Omega} + \frac{1}{10\Omega}\right)V_2 + \left(-\frac{1}{10\Omega}\right)V_3 + \left(-\frac{1}{5\Omega}\right)V_4 = 1A\right.$

Problem 3 Mesh Analysis ***20 points***

a) For the circuit shown below, there are 3 mesh loops, and thus 3 equations are needed to solve for (i_1,i_2,i_3). Find these equations and write them below so that the *only* unknowns are the mesh currents (i_1,i_2,i_3). Indicate whether these equations are KVL (voltage units) or KCL (current units) equations.

1) $(i_2 - i_3) = 9A$

KVL or KCL

2) $i_1 = -\frac{1}{3}V_0 = -3\,i_3$

KVL or KCL

3) $(i_2 - i_1)3\Omega + i_2(6\Omega) + 24V$
$-(12\,\Omega)\,i_2 + i_3\,(9\Omega) = 0$ KVL or KCL

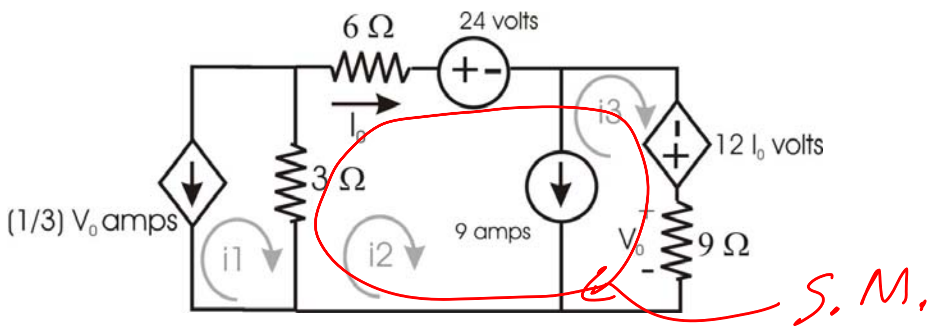
S. M.

b) Find the resulting mesh currents (i_1,i_2,i_3). Be sure to specify the sign of the current.

$i_1 = -3/5 = -0.6$ A

$i_2 = +9\,1/5 = +9.2$ A

$i_3 = +1/5 = +0.2$ A



$i_1 = -\frac{1}{3}V_0$ KCL

$V_0 = i_3 \, 9\Omega$ Ohm's Law

(1) $\Rightarrow i_1 = -3 i_3$

$I_0 = i_2$ (KCL)

(2) $i_2 - i_3 = 9A$ KCL

SM KVL:

(3) $3\Omega(i_2 - i_1) + 6\Omega(i_2) + 24V - 12 i_2 + 9\Omega i_3 = 0$

eliminating i_1

(3) $\Rightarrow 3\Omega(i_2 + 3i_3) + 6\Omega i_2 - 12 i_2 + 9 i_3 = -24V$

$i_2(-3) + i_3(18) = -24V$

From (1) $i_2 = i_3 + 9A$

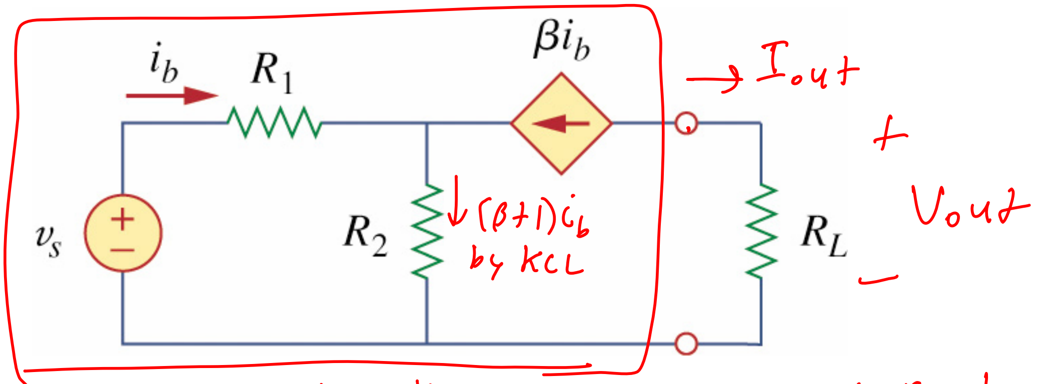
$(i_3 + 9A)(-3) + i_3(18) = -24 \Rightarrow i_3 = 1/5 \, A$

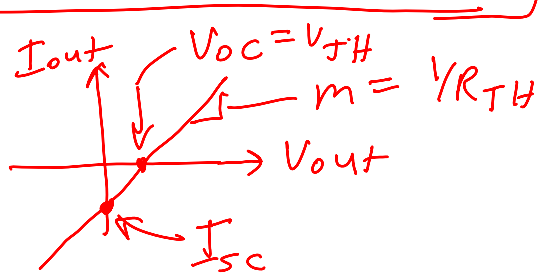
$\Rightarrow 15 i_3 = +3 \Rightarrow i_2 = 9\frac{1}{5} A$

$i_1 = -3/5 \, A$

Problem 4 Thevenin Transformations *15 points*

The network below models a bipolar transistor common-emitter amplifier connected to a load. Find the Thevenin equivalent voltage and resistance seen by the load. Your results should be in terms of only the quantities v_s, β, R_1, R_2.





General Picture for

Here $v_s = i_b R_1 + (\beta+1) i_b R_2$ KVL

$$\Rightarrow i_b = \frac{v_s}{R_1 + (\beta+1)R_2}$$

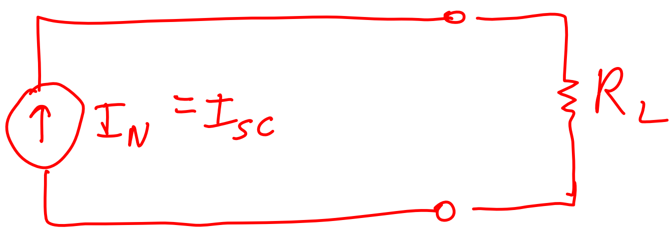
$$I_{out} = -\beta i_b = -\frac{\beta v_s}{R_1+(\beta+1)R_2} \leftarrow \text{independent of } R_L!$$

$$V_{out} = -R_L I_{out} = -v_s \frac{\beta R_L}{R_1+(\beta+1)R_2}$$

$V_{out} \to -\infty$ as $R_L \to \infty$ (open)

$$\Rightarrow V_{oc} = V_{TH} = -\infty$$

So really our best model is a Norton Equivalent

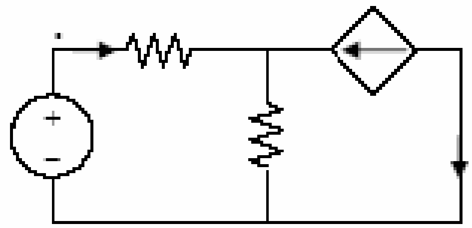


with $R_N = \infty$ (no output resistor/ perfect controlled current source)

$$I_N = I_{sc} = -v_s \frac{\beta}{R_1 + (\beta+1)R_2}$$

Alternate solution (same answer):

This problem does not have a solution as it was originally stated. The reason for this is that the load resistor is in series with a current source which means that the only equivalent circuit that will work will be a Norton circuit where the value of R_N = **infinity**. I_N can be found by solving for I_{sc}.



Writing the node equation at node v_o,

$$i_b + \beta i_b = v_o/R_2 = (1 + \beta)i_b$$

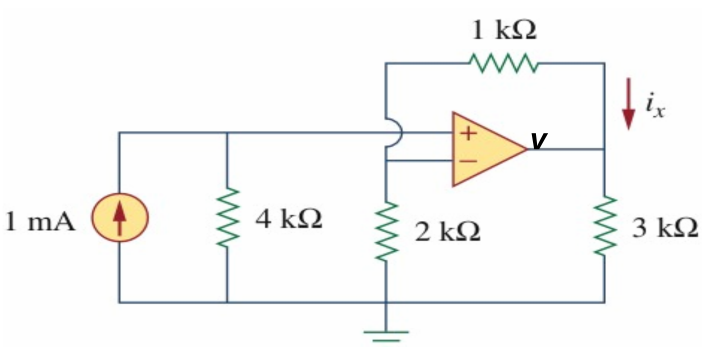
But $$i_b = (V_s - v_o)/R_1$$

$$v_o = V_s - i_bR_1$$

$$V_s - i_bR_1 = (1 + \beta)R_2i_b, \text{ or } i_b = V_s/(R_1 + (1 + \beta)R_2)$$

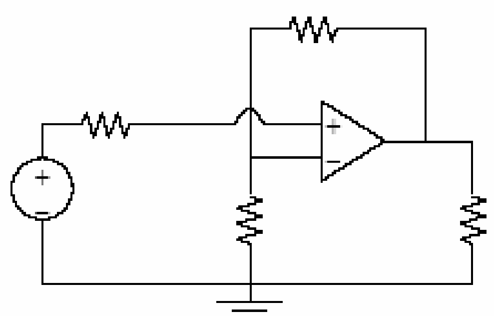
$$I_{sc} = I_N = -\beta i_b = \underline{-\beta V_s/(R_1 + (1 + \beta)R_2)}$$

Problem 5   Op Amps *20 points*



Find i_x and v_0

After transforming the current source, the current is as shown below:



This is a noninverting amplifier.

$$v_o = \left(1 + \frac{1}{2}\right)v_i = \frac{3}{2}v_i$$

Since the current entering the op amp is 0, the source resistor has a OV potential drop. Hence $v_i = 4V$.

$$v_o = \frac{3}{2}(4) = 6V$$

Power dissipated by the 3kΩ resistor is

$$\frac{v_o^2}{R} = \frac{36}{3k} = \underline{\textbf{12mW}}$$

$$i_x = \frac{v_a - v_o}{R} = \frac{4-6}{1k} = \underline{\textbf{-2mA}}$$