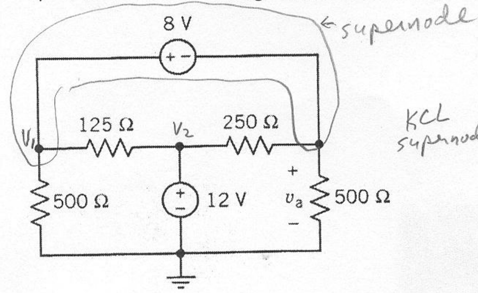
ENGR 204 Test #2 Spring 2011 **Name** Key

Show work. Use a different method than asked and you lose at least 5 points.

1) Use the node voltage method to find v_a.



$V_2 = 12\text{ v}$

KCL supernode: $\dfrac{V_1}{500} + \dfrac{V_1 - 12}{125} + \dfrac{V_a - 12}{250} + \dfrac{V_a}{500} = 0$

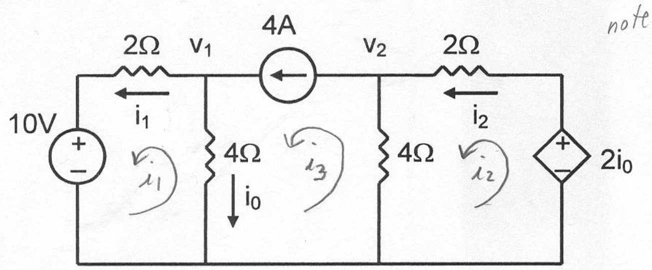
also $V_1 - V_a = 8$

solved with Matlab

$V_1 = 12\text{ V}$

$\boxed{V_a = 4\text{ v}}$

2) Using the mesh-current method, find i_1, i_2, and v_1.



note: $i_3 = 4A$

KVL mesh 1: $10 + 4(i_1 - i_3) + 2i_1 = 0 \Rightarrow 10 + 4i_1 - 16 + 2i_1 = 0$

$6i_1 = 6$ so $\boxed{i_1 = 1A}$

KVL mesh 3: $V_2 - V_1 + 4(i_3 - i_1) + 4(i_3 - i_2) = 0$

or $V_2 - V_1 + 4(4-1) + 4(4 - i_2) = 0$

or $V_2 - V_1 + 12 + 16 - 4i_2 = 0$

or $V_2 - V_1 + 28 - 4i_2 = 0$

don't need this!

KVL mesh 2: $-2i_0 + 2i_2 + 4(i_2 - i_3) = 0$

but $i_0 = \dfrac{V_1}{4}$

or $-2(3) + 2i_2 + 4i_2 - 16 = 0$

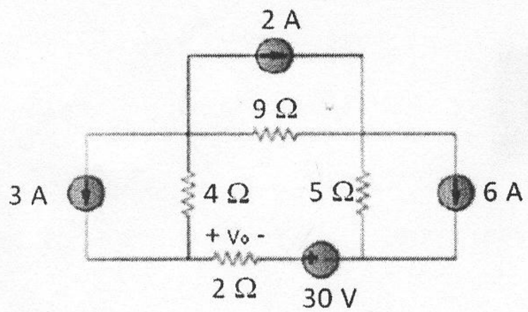
and $V_1 = 10 + 2i_1$

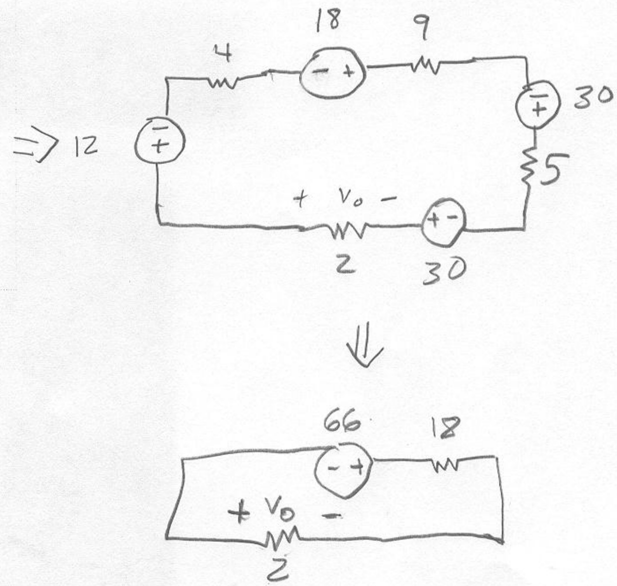
or $6i_2 = 22$ so $\boxed{i_2 = 3.67A}$ so $i_0 = \dfrac{10 + 2i_1}{4}$

and $V_1 = 10 + 2i_1 = 10 + 2(1) = \boxed{12\text{v}}$

$= \dfrac{10+2}{4} = 3A$

3) Find v_o in the circuit below using source transformations.



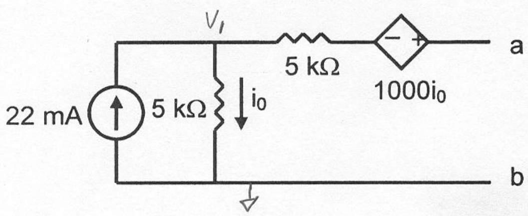


so

$$V_o = -66\left(\frac{2}{2+18}\right)$$

$$= \boxed{-6.6\ \text{V}}$$

4) A) Find the Thévenin equivalent circuit at terminals a – b.
B) What is the maximum power that can be delivered to a resistor attached across terminals a – b?



method 2A find $V_{ab} = V_{oc} = V_{th}$

$V_1 = (5k)(22m) = 110\,v$

and $i_o = 22\,mA$

so $V_{oc} = V_1 + 1000\,i_o$ (since no current thru 5k, no volts lost there)

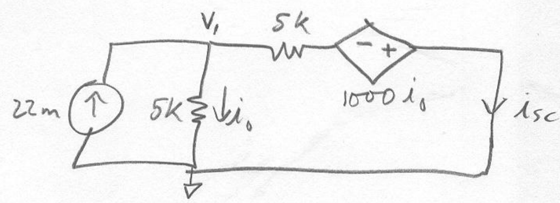
$= 110 + 1000\,(22m)$

$= 132\,v$

$= V_{th}$

method 2B:

now add a short:



In terms of node voltage V_1: $i_{sc} = \dfrac{V_1 + 1000\,i_o}{5k}$

and $V_1 = i_o\,(5k)$ sub in

so $i_{sc} = \dfrac{V_1 + 1000\left(\frac{V_1}{5000}\right)}{5000}$

$= \dfrac{V_1 + \frac{V_1}{5}}{5000}$

$= \dfrac{V_1}{5k} + \dfrac{V_1}{25k}$

$= \dfrac{1.2\,V_1}{5k}$

now KCL node 1: $-22m + \dfrac{V_1}{5k} + i_{sc} = 0$

$-22m + \dfrac{V_1}{5k} + \dfrac{1.2\,V_1}{5k} = 0$

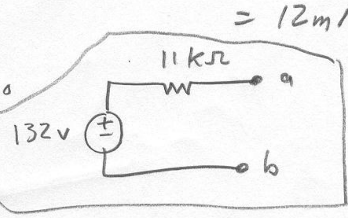
solve; $V_1 = 50\,v$

so $i_{sc} = \dfrac{1.2\,V_1}{5k} = \dfrac{1.2(50)}{5k}$

$= 12\,mA$

so $R_{th} = \dfrac{V_{th}}{i_{sc}} = \dfrac{132\,v}{12\,mA} = 11\,k\Omega$

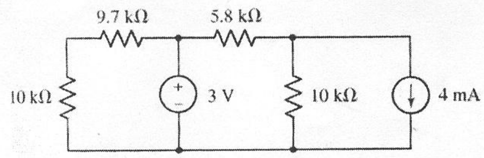
so



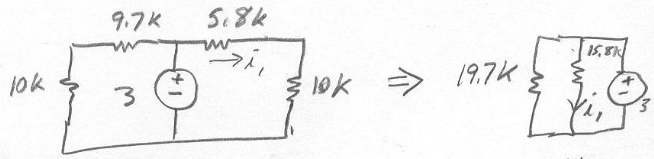
b.) $P_{max} = \dfrac{V_{th}^2}{4\,R_{th}} = \dfrac{(132\,v)^2}{4(11\,k\Omega)} = .396\,W$

$= \boxed{396\,mW}$

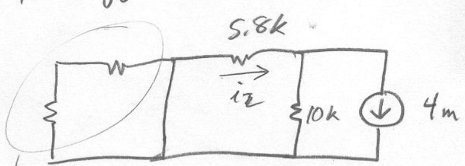
5) Use superposition to find the current through the 5.8kΩ resistor.



turn off 4mA source:



turn off 3V source:



shorted out so ignore

Ohm's law

$$i_1 = \frac{3V}{15.8k}$$

$$= 190\mu A$$

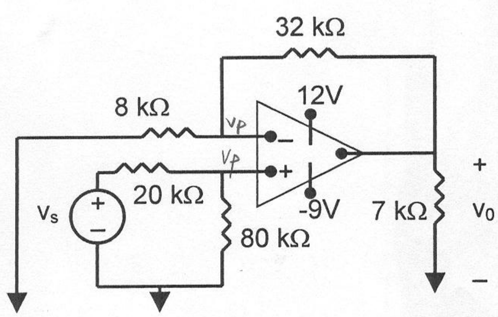
current divider

$$i_2 = 4m\left(\frac{10k}{10k + 5.8k}\right)$$

$$= 2.53 \text{ mA}$$

so $\boxed{i = 2.72 \text{ mA} \rightarrow}$

6) A) Find v_o in terms of v_s.
B) Find the range of values for v_s such that the op amp remains in its range of linear operation.



voltage divider: $V_p = V_s\left(\frac{80k}{80k + 20k}\right)$
$= V_s(.8)$

KCL at − input:

$$\frac{V_s(.8) - 0}{8k} + \frac{V_s(.8) - V_o}{32k} = 0$$

$$\frac{3.2V_s + .8V_s - V_o}{32k} = 0$$

so $\boxed{V_o = 4V_s}$

when $V_o = 12v$, $V_s = \frac{12}{4}v = 3V$

when $V_o = -9v$ $V_s = \frac{-9}{4}v = -2.25 V$

so $-2.25v \leq V_s \leq 3V$ to be in linear range