ELECTRICAL ENGINEERING DEPARTMENT
CALIFORNIA POLYTECHNIC STATE UNIVERSITY

EE 112 Electric Circuit Analysis I

FINAL EXAM **Winter 2004**

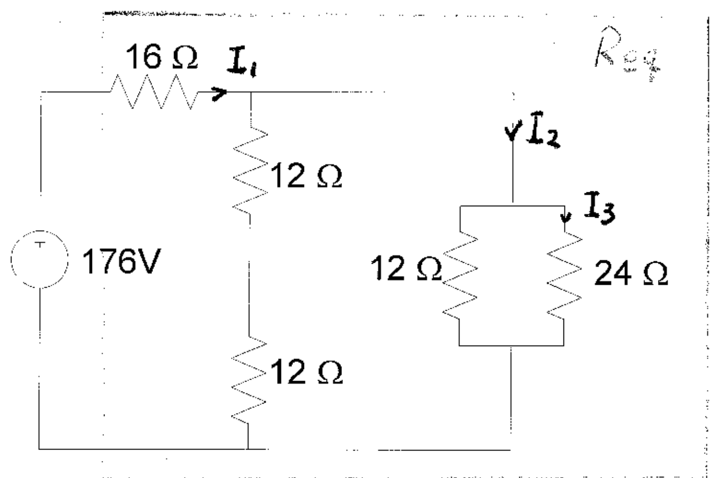
Name:______________________ **Last 4 digits of Student ID:**______________

Section #:______

1 (20)	2 (20)	3 (15)	4(15)	5 (15)	6(15)	Total (100)

PROBLEM #1

(a) Find the power supplied by the voltage source and the power absorbed by the 24 Ω resistor in the following figure.
(b) Repeat (a) if the 176 V source is increased to 300 V.



(a) $R_{eq} = 16 + (12+12) \,//\, (12 \,//\, 24) = 16 + \dfrac{24 * \frac{12\times 24}{12+24}}{24+8} = 22\Omega$

$I_1 = \dfrac{176}{R_{eq}} = 8\,A$

Using current division: $I_2 = \dfrac{24}{24+8}\cdot I_1 = 6\,A$, $I_3 = \dfrac{12}{12+24}\cdot I_2 = 2A$.

$P_{24\Omega} = I_3^2 \cdot R = 2^2 \times 24 = \underline{96\,W}$

$P_{176V} = -VI_1 = -176\times 8 = \underline{-1408\,W}$

(b) Using linearity Property

$\tilde{I}_1 = k\cdot I_1$ where $k = \dfrac{300}{176} = 1.704$

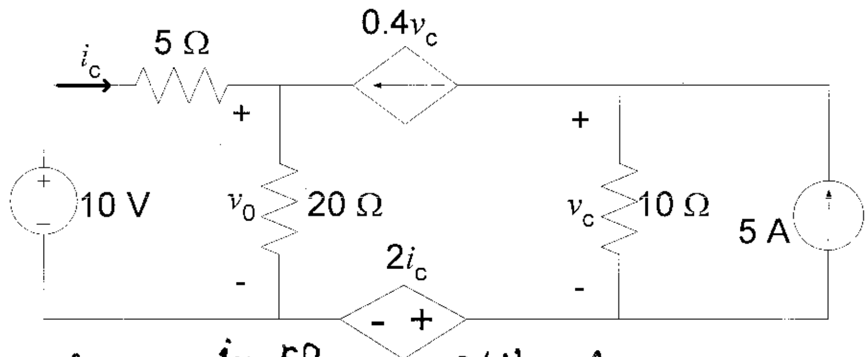
$\tilde{I}_3 = k\cdot I_3$

$\therefore$ $\tilde{P}_{24\Omega} = \tilde{I}_3^2 \cdot R = (1.704\times 2)^2 \times 24 = \underline{279W}$

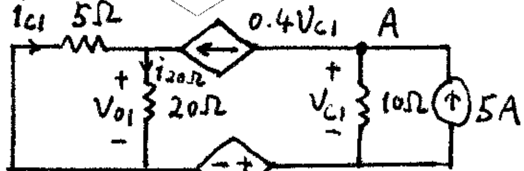
$\tilde{P}_{300V} = -300\tilde{I}_1 = -300\times 1.704\times 8 = \underline{-4090.9W}$

PROBLEM #2

Use the principle of superposition to find v_0 and power absorbed by the 20Ω resistor.



5 A acting alone:



Apply KCL @ node A:

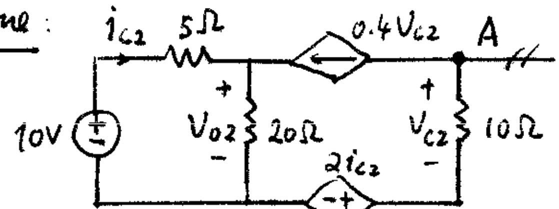
$$5 - \frac{V_{c1}}{10} - 0.4V_{c1} = 0$$

$$0.5V_{c1} = 5 \rightsquigarrow V_{c1} = 10\,V$$

$$i_{20\Omega} = 0.4V_{c1} \cdot \frac{5}{5+20} = 4 \times \frac{1}{5} = 0.8\,A$$

$$V_{01} = 20 \cdot i_{20\Omega} = 16\,V$$

10 V acting alone:



Apply KCL @ node A:

$$+0.4V_{c2} + \frac{V_{c2}}{10} = 0 \rightsquigarrow V_{c2} = 0\,V$$

$$V_{02} = 10 \cdot \frac{20}{20+5} = 8\,V$$

$$V_0 = V_{01} + V_{02} = 16 + 8 = \underline{24\,V}$$

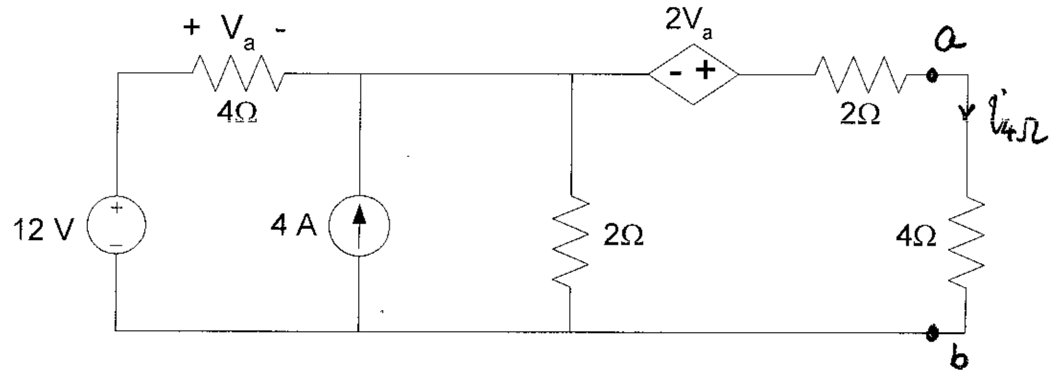
$$P_{20\Omega} = V_0^2 / R = 24^2/20 = \underline{28.8\,W}$$

Note:
the same results can be obtained by using standard mesh analysis + eq. for controlled sources. However donot (!) attempt to write KVL eq. for the mesh containing ⬄, or ignore the voltage drop across ⬄ !!!

The mesh current in the mesh with ⬄ equals $-0.4V_{c1}$.

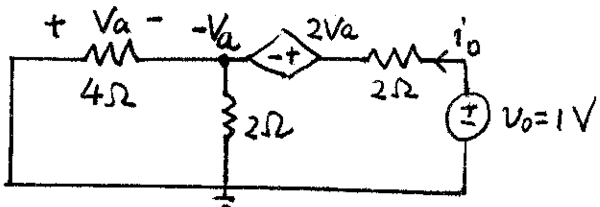
PROBLEM #3

Use Norton's theorem to determine the current flowing through the right-hand 4 Ω resistor in the figure below.



Find the Norton equivalent left to a-b :

1. Req:



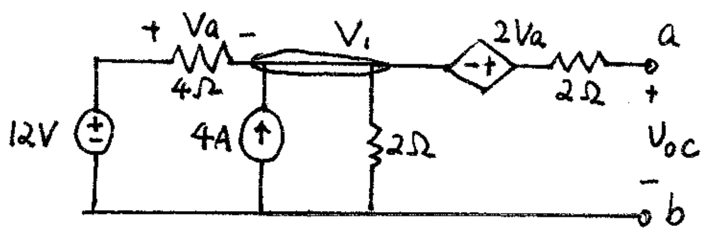
nodal eq. for -Va : $-\frac{-V_a}{4} - \frac{-V_a}{2} + \frac{1-(-V_a+2V_a)}{2} = 0$

$+V_a + 2V_a + 2 - 2V_a = 0 \leadsto V_a = -2\,V$

$i_o = \frac{1 - V_a}{2} = 3/2\ A$

$R_{eq} = V_o/i_o = 1/(3/2) = \underline{2/3\ \Omega}$

2. Voc :



note:
$V_{oc} \neq V_1$
there is voltage drop across ⟨-+⟩ !!!

nodal eq. for V_1 :

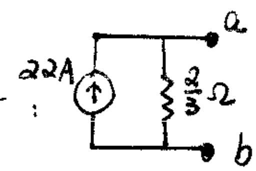
$\frac{12-V_1}{4} + 4 - \frac{V_1}{2} = 0 \leadsto 12 - V_1 + 16 - 2V_1 = 0 \leadsto V_1 = 28/3\ V$

$V_a = 12 - V_1 = 8/3\ V$

$V_{oc} = 2V_a + V_1 = \frac{16+28}{3} = 44/3\ V$

$I_N = \frac{V_{oc}}{R_{eq}} = \frac{44/3}{2/3} = 22\ A$

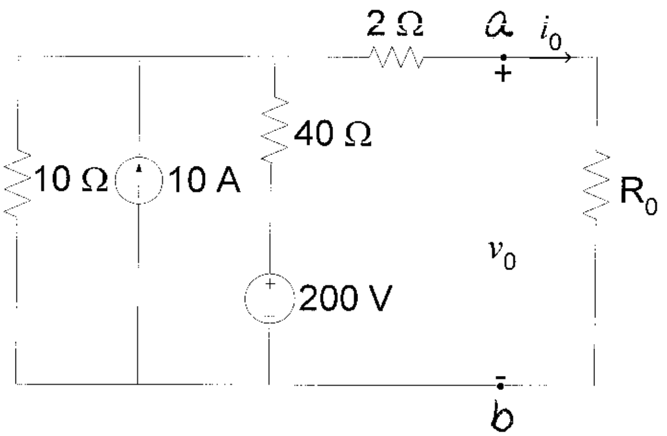
∴ Norton equivalent :



Using current division: $i_{4\Omega} = 22 \cdot \frac{2/3}{2/3+4} = \underline{22/7\ A}$

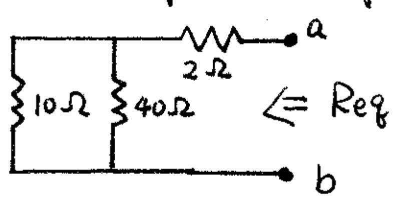
PROBLEM #4

Determine i_0 and v_0 in the following circuit when R_0 is 0, 2, 10, 20, and 50 Ω.



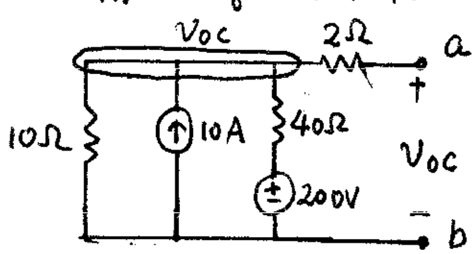
Find the Thevenin equivalent left to a-b :

1. Req :



$$R_{Th} = R_{eq} = 10 \parallel 40 + 2 = \underline{10\,\Omega}$$

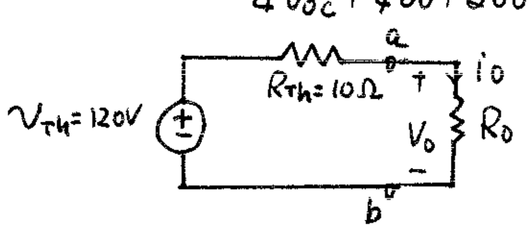
2. Voc :



nodal eq. for Voc

$$-\frac{V_{oc}}{10} + 10 + \frac{200 - V_{oc}}{40} = 0$$

$$-4V_{oc} + 400 + 200 - V_{oc} = 0 \rightsquigarrow V_{oc} = 120V$$



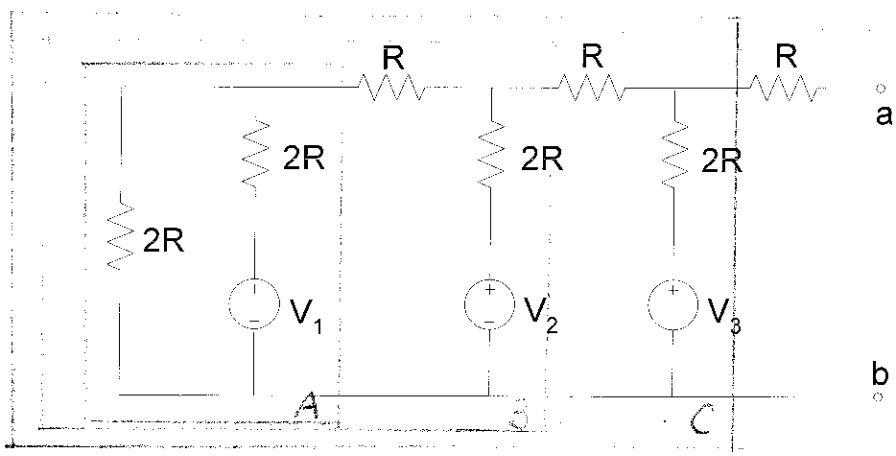
$$i_0 = \frac{120}{10 + R_0}$$

$$V_0 = i_0 \cdot R_0$$

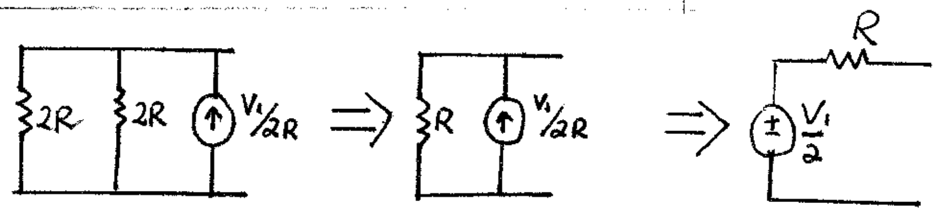
R_0	i_0 /A	V_0/V
0 Ω	12	0
2 Ω	10	20
10 Ω	6	60
20 Ω	4	80
50 Ω	2	100

PROBLEM #5

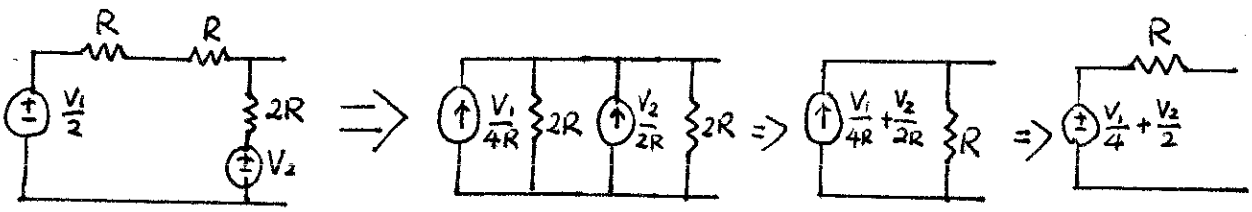
Find the Thevenin equivalent seen at a-b for the circuit below. (*Hint: for this type of problem, the more natural solution technique is source transformation.*)



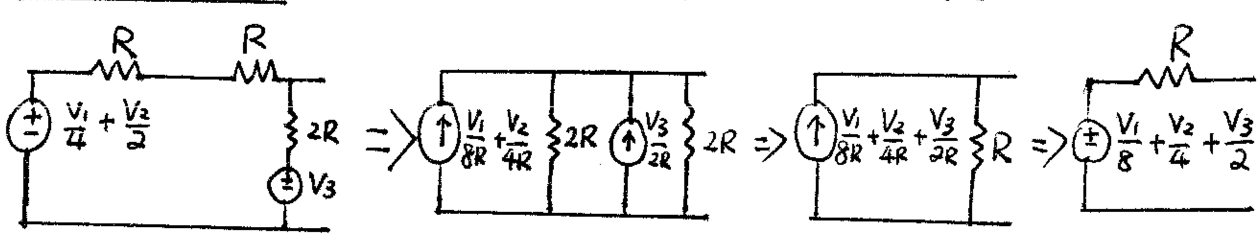
Part A:



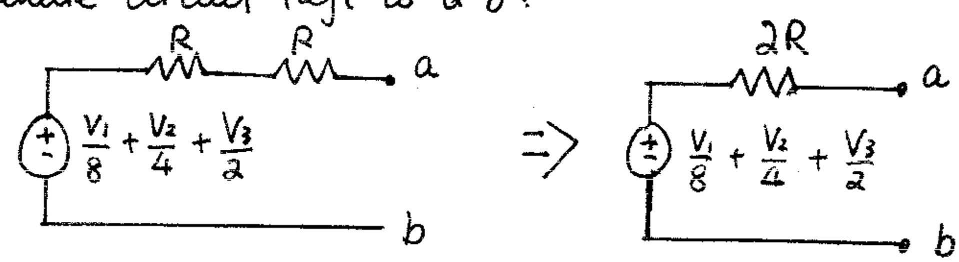
Part B:



Part C:

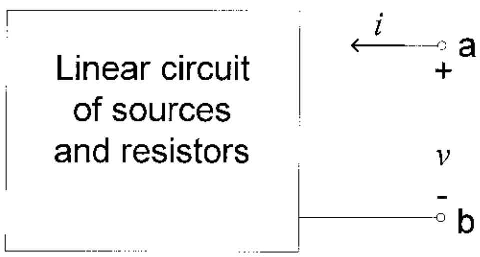


the entire circuit left to a-b:

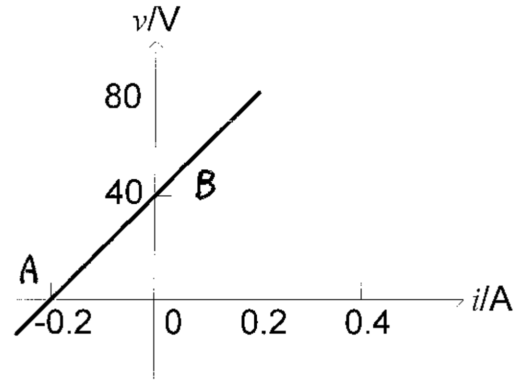


PROBLEM #6

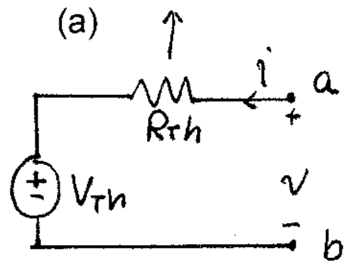
The linear resistive circuit in figure (a) is found experimentally to have the *v-i* relationship plotted in figure (b). Find the maximum power that can be absorbed by placing a load resistor across terminals a-b?



(a)



(b)



Apply KVL to the Thevenin equivalent:

$$-V_{Th} - iR_{Th} + V = 0$$

$$\rightsquigarrow \quad V = iR_{Th} + V_{Th} \qquad (1)$$

Find two points in (b)

A: $(-0.2A,\ 0V)$ substitute in (1)

B: $(0A,\ 40V)$

$$\begin{cases} 0 = -0.2R_{Th} + V_{Th} \\ 40 = 0 + V_{Th} \end{cases} \rightarrow \begin{cases} V_{Th} = 40V \\ R_{Th} = 200\Omega \end{cases}$$

Maximum power transfer occurs when

$$R_L = R_{Th} = 200\Omega$$

$$P_{L,max} = V_{Th}^2 / 4R_{Th} = 40^2 / 4 \times 200 = \underline{2W}$$