Name: Solutions **ECE 2A–Spring 2008**

Perm No. ______________________ **Prof. K. Banerjee**

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Department of Electrical and Computer Engineering

MIDTERM EXAMINATION-ECE124A

Room: NH 1111, May 12, 3:30-4:45 PM

READ CAREFULLY:

- **This is an OPEN BOOK/NOTES Exam. However, only the course Text Book + notes + homeworks are allowed. Any other material is not allowed. Calculators OK.**

- **READ the questions carefully before answering. Include all your answers in locations specified on these pages. Show ALL WORKING used to arrive at answers. Use space provided for all working. Use the back sides if necessary. There are 9 pages including the cover page. Be sure to write Your NAME/Perm No. on EVERY PAGE.**

Question	Scores
#1	/ 30
#2	/ 25
#3	/ 20
#4	/ 25
TOTAL	/ 100

Good Luck!

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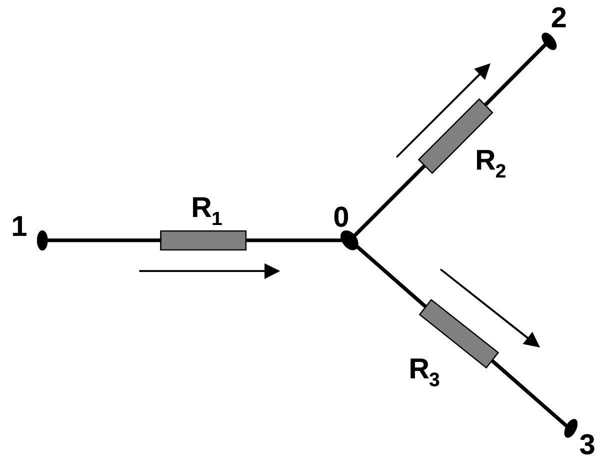
1. (30 pts): (suggested time: 25 minutes)

Find the current flowing through the resistance R_1 of the circuit shown below if the resistances are equal to R_1 = 10 Ω, R_2 = 20 Ω, and R_3 = 30 Ω, and the potentials of points 1, 2, and 3 are equal to V_1 = 10 V, V_2 = 6 V, and V_3 = 5 V. Which resistor dissipates the maximum power?



Solution:
Assume voltage at node 0 = V_x

Assuming current is entering from a and leaving to 2 and 3 (which is intuitive as node 1 is at highest potential).
The KCL at node 0 becomes :

$$\frac{-(10-V_x)}{10}+\frac{(V_x-6)}{20}+\frac{(V_x-5)}{30}=0\,;$$

(convention used is entering current = -ve and leaving as ve)

Solving, we get V_x = 8 V.

Current flowing through R_1 = $\frac{10-8}{10}=0.2A$

Current flowing through R_2 = $\frac{8-6}{20}=0.1A$

Current flowing through R_2 = $\frac{8-5}{30}=0.1A$

Power dissipated by R_1 = 0.4 W
Power dissipated by R_2 = 0.2 W

Power dissipated by R_3 = 0.3 W
R_1 dissipates max. Power.

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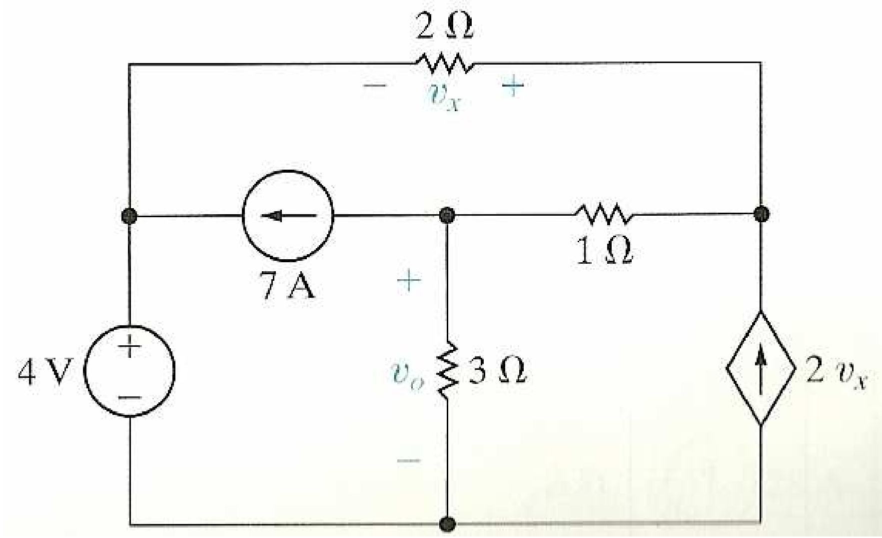
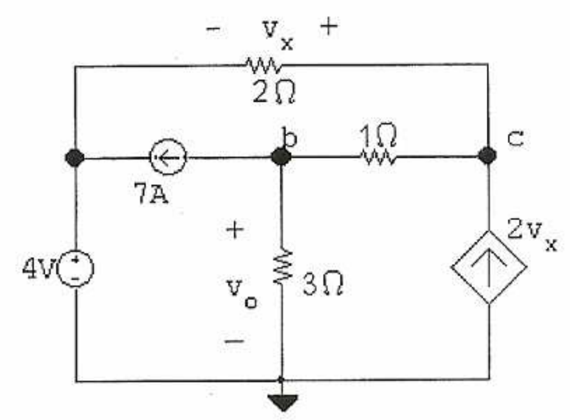
2. (25 pts): (suggested time: 20 minutes)

Use the node-voltage method to find the value of v_0 in the circuit below:



Solution :



The two node voltage equations are:

$$7 + \frac{v_b}{3} + \frac{v_b - v_c}{1} = 0$$

$$-2v_x + \frac{v_c - v_b}{1} + \frac{v_c - 4}{2} = 0$$

The constraint equation for the dependent source is:

$v_x = v_c - 4$

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Place these equations in standard form:

$$
\begin{array}{lclclcl}
v_{\mathrm{b}}\left(\frac{1}{3}+1\right) & + & v_{\mathrm{c}}(-1) & + & v_x(0) & = & -7 \\
v_{\mathrm{b}}(-1) & + & v_{\mathrm{c}}\left(1+\frac{1}{2}\right) & + & v_x(-2) & = & \frac{4}{2} \\
v_{\mathrm{b}}(0) & + & v_{\mathrm{c}}(1) & + & v_x(-1) & = & 4
\end{array}
$$

Solving, $v_o = v_{\mathrm{b}} = 1.5$ V Also, $v_c = 9$ V and $v_x = 5$ V.

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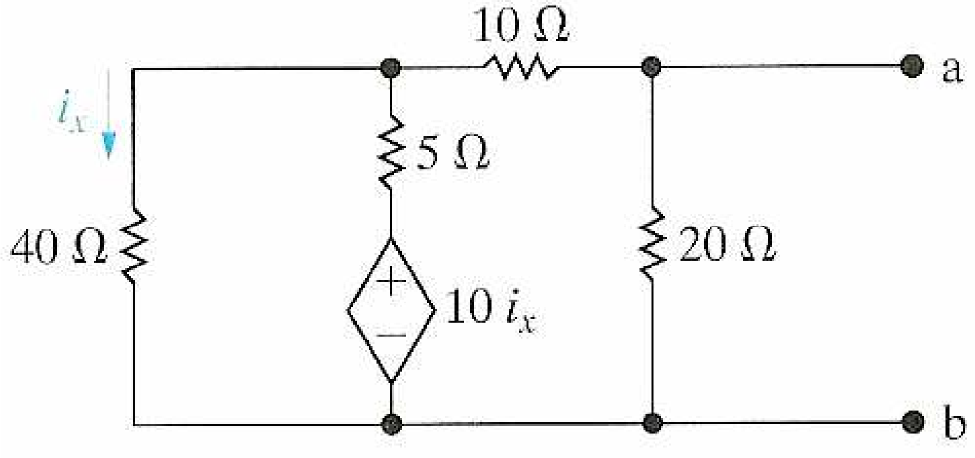
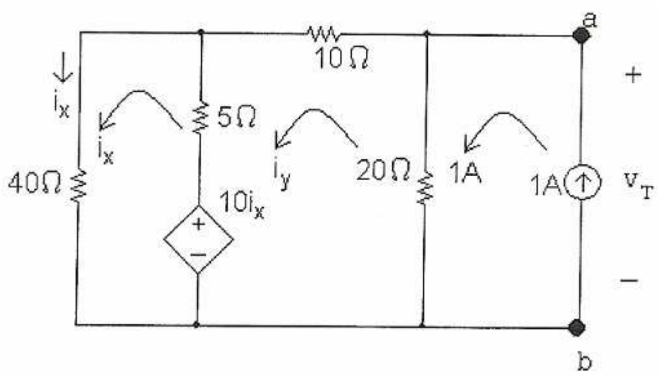
3. (20 pts): (suggested time: 15 minutes)

Find the Thevenin equivalent with respect to the terminals a,b for the circuit shown below. :



Solution :

$V_{\mathrm{Th}} = 0$ since there are no independent sources in the circuit. To find R_{Th}, apply a 1 A test source and calculate the voltage drop across the test source. Use the mesh current method.



The mesh current equations for the two meshes on the left:

$$
\begin{aligned}
-10i_x + 5(i_x - i_y) + 40i_x &= 0 \\
10i_x + 20(i_y - 1) + 10i_y + 5(i_y - i_x) &= 0
\end{aligned}
$$

Place these equations in standard form:

$$i_x(-10+5+40)+i_y(-5) = 0$$

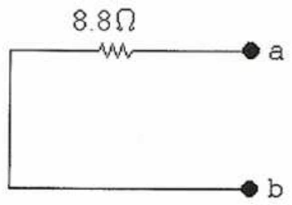
$$i_x(10-5)+i_y(20+10+5) = 20$$

Solving, $\quad i_x = 80$ mA; $\quad i_y = 560$ mA

Find the voltage drop across the 1 A source:

$v_\mathrm{T} = 20(1-0.56) = 8.8$ V

$\therefore \quad R_\mathrm{Th} = v_\mathrm{T}/1\text{ A} = 8.8/1 = 8.8\,\Omega$



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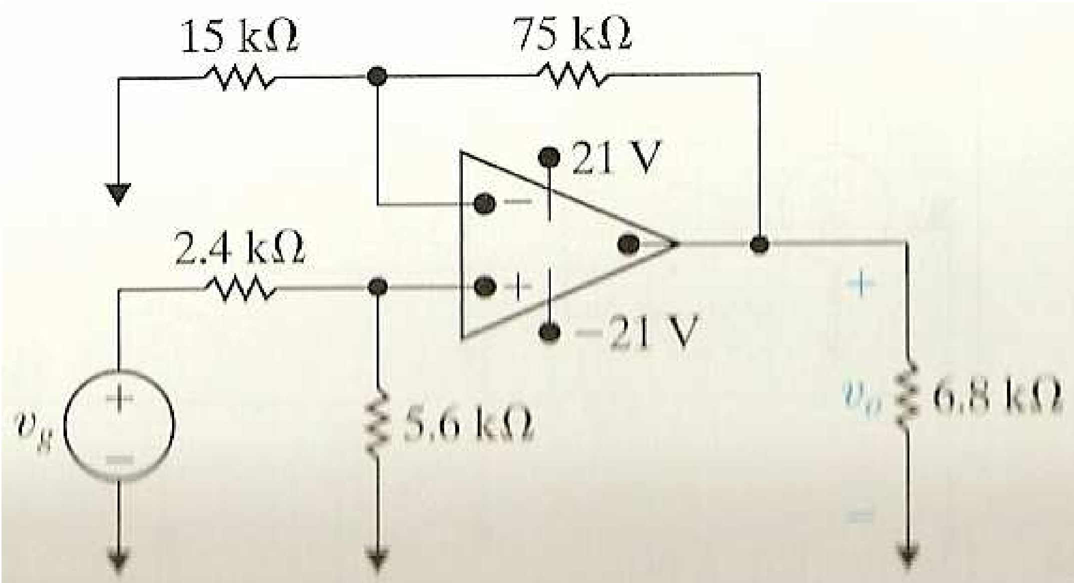
4. (25 pts): (suggested time: 20 minutes)

The signal voltage v_g in the circuit shown in figure below is described by the following equations:

$v_g = 0 \qquad t \le 0,$

$v_g = 10\sin(\pi/3)t$ V, $\quad 0 \le t \le \infty$

Sketch v_0 versus t, assuming the op-amp is ideal.



Solution :

$$v_p = \frac{5.6}{8.0} v_g = 0.7 v_g = 7\sin(\pi/3)t \text{ V}$$

$$\frac{v_n}{15{,}000} + \frac{v_n - v_o}{75{,}000} = 0$$

$$6v_n = v_o; \qquad v_n = v_p$$

$$\therefore \quad v_o = 42\sin(\pi/3)t \text{ V} \qquad 0 \le t \le \infty$$

$$v_o = 0 \qquad t \le 0$$

At saturation

$$42\sin\left(\frac{\pi}{3}\right)t = \pm 21; \qquad \sin\frac{\pi}{3}t = \pm 0.5$$

$$\therefore \quad \frac{\pi}{3}t = \frac{\pi}{6}, \quad \frac{5\pi}{6}, \quad \frac{7\pi}{6}, \quad \frac{11\pi}{6}, \quad \text{etc.}$$

$$t = 0.50\,\text{s}, \quad 2.50\,\text{s}, \quad 3.50\,\text{s}, \quad 5.50\,\text{s}, \quad \text{etc.}$$