Eastern Mediterranean University

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Faculty of Engineering

ELECTRICAL AND ELECTRONIC ENGINEERING DEPARTMENT

INFE221 – Electrical Circuits

Midterm Exam
Fall 2015-16

27 November 2015
Duration: 100 minutes

Instructor: M. K. Uyguroğlu

STUDENT'S	
NUMBER	
NAME	
SURNAME	SOLUTIONS
GROUP NO.	

Problem		**Points**
1		25
2		25
3		25
4		25
TOTAL		100

Problem 1

Find i and R_{eq} in the circuit of Fig. P1

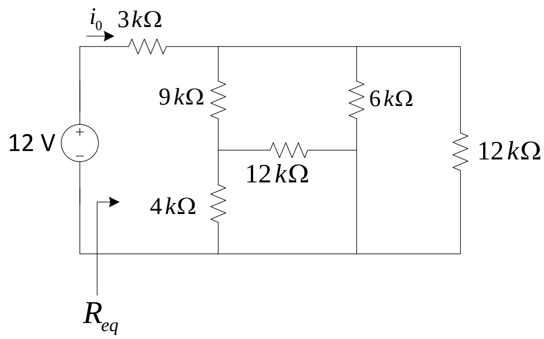
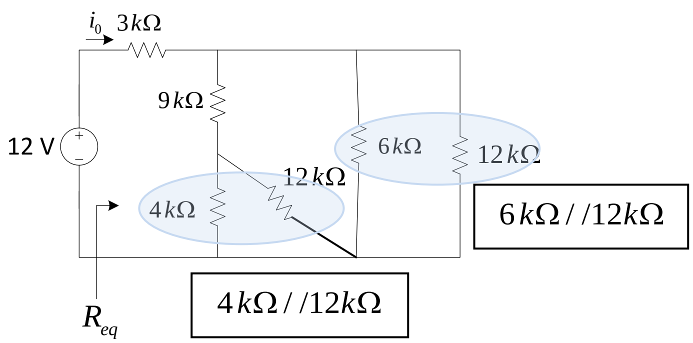


Figure P1



$$R_{eq} = \underbrace{\underbrace{\underbrace{(6k//12k)}_{4k}//\underbrace{(9k+\underbrace{4k//12k}_{3k})}_{12k}}_{3k}+3k}_{6k}$$

$$R_{eq} = 6k\Omega$$

Therefore

$$i_0 = \frac{12}{6k} = 2mA$$

Problem 2

Use nodal analysis to determine the node voltages defined in the circuit in Fig. P2.

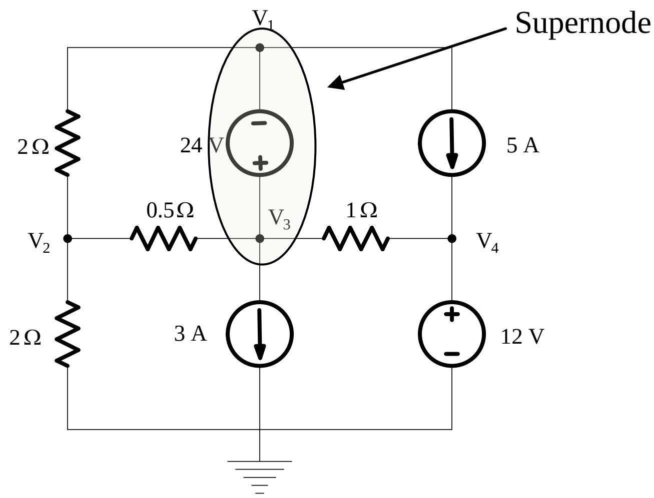


Figure P2

$V_4 = 12V$

$V_3 - V_1 = 24V$

$V_3 = 24 + V_1$

Since we have 4 non reference nodes and 2 voltage sources we will write 2 nodal equations.

KCL at V_2 :

$$\frac{V_2}{2} + \frac{V_2 - V_3}{0.5} + \frac{V_2 - V_1}{2} = 0$$

Multiply both sides of the equation by 2 gives:

$$V_2 + 4V_2 - 4V_3 + V_2 - V_1 = 0$$
$$6V_2 - 4(24 + V_1) - V_1 = 0$$
$$6V_2 - 5V_1 = 96 \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

KCL at the Supernode:

$$\frac{V_1 - V_2}{2} + 5 + \frac{V_3 - V_2}{0.5} + \frac{V_3 - V_4}{1} + 3 = 0$$

Multiply both sides of the equation by 2 yields:

$$V_1 - V_2 + 16 + 4V_3 - 4V_2 + 2V_3 - 2(12) = 0$$
$$V_1 - 5V_2 + 6V_3 = 8$$
$$V_1 - 5V_2 + 6(24 + V_1) = 8$$
$$7V_1 - 5V_2 = -136 \ldots\ldots\ldots\ldots\ldots\ldots(2)$$

If we multiply Eq.(2) by 6 and Eq.(1) by 5 then addition of Eqs.(1) and (2) gives:

$$(42-25)V_1 = -336$$
$$V_1 = -19.765V$$
$$V_3 = -19.765 + 24 = 4.235V$$

Then using Eq.(2), V_2 is calculated as:

$$V_2 = \frac{7V_1 + 136}{5} = -0.470V$$

Problem 3

Use mesh analysis to find I_0 in the circuit of Fig.P3.

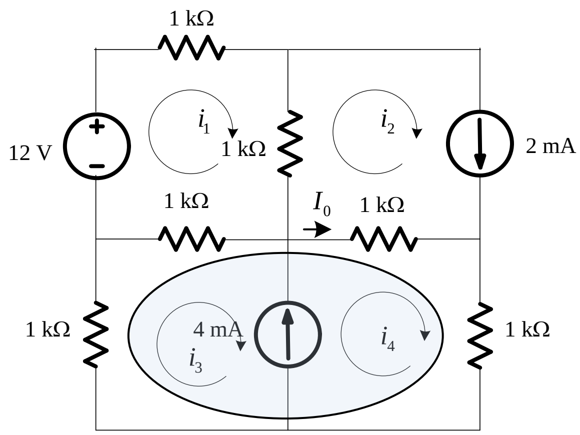


Figure P3

$i_2 = 2\,mA$

$i_4 - i_3 = 4\,mA \Rightarrow i_3 = i_4 - 4mA$

$I_0 = i_4 - i_2$

KVL around i_1 :

$$(1k + 1k + 1k)i_1 - 1ki_2 - 1k(i_4 - 4m) = 12$$

$$3ki_1 - 1ki_4 = 12 + 2 - 4 = 10 \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

KVL around the Supermesh

$$(1k + 1k)(i_4 - 4m) + (1k + 1k)i_4 - 1ki_1 - 1k(2m) = 0$$

$$-1ki_1 + 4ki_4 = 10 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Multiply Eq.(2) by 3 and add Eqs(1) and (2):

$$11ki_4 = 40$$

$$i_4 = \frac{40}{11}\,mA$$

Therefore

$$I_0 = \frac{40}{11} - 2 = \frac{18}{11} = 1.636\,mA$$

Problem 4

Find I_0 for the circuit of Fig.P4

a) using superposition (12 pts.)
b) using Thévenin's theorem. (13 pts.)
(*Thévenin's theorem* tells us that we can replace the entire network, exclusive of the branch where we will find the current flowing through it or the voltage across it, by an equivalent circuit that contains only an independent voltage source in series with a resistor in such a way that the current–voltage relationship at the branch is unchanged.)

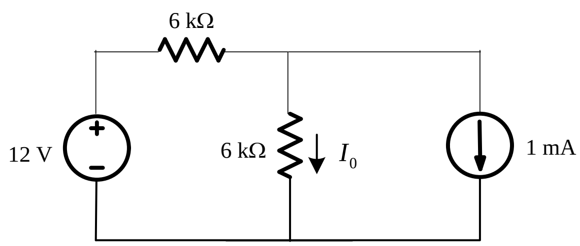
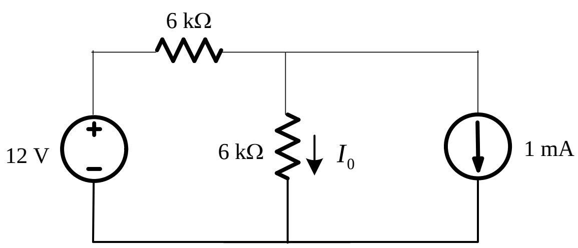
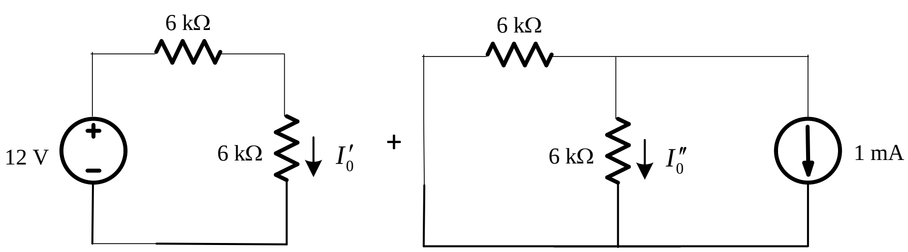


Figure P4

a) Superposition





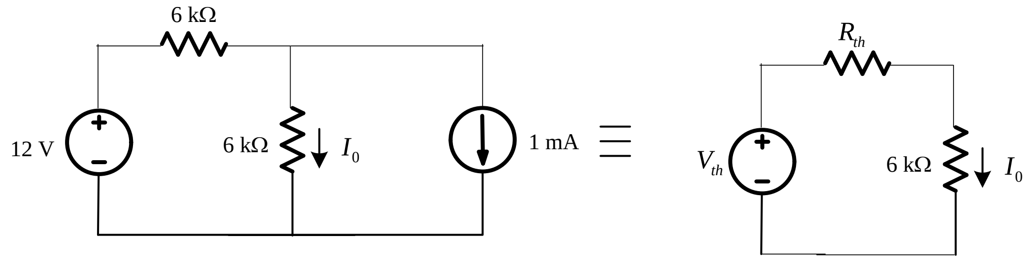
$$I_0 = I_0' + I_0''$$

$$I_0' = \frac{12}{12k} = 1mA$$

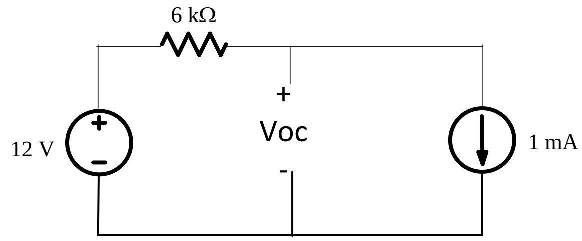
$$I_0'' = -1m\frac{6k}{12k} = -0.5mA$$

$$I_0 = 1m - 0.5m = 0.5mA$$

b) Thevenin's Theorem



In order to find the V_{th} :



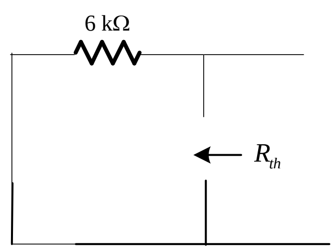
If we choose the bottom node as reference and write KCL at V_{oc} :

$$\frac{V_{oc}-12}{6k}+1m=0$$

or

$$V_{oc}-12+6=0 \Rightarrow V_{oc}=6\ V$$

For R_{th}



$$R_{th}=6k\Omega$$

$$I_0=\frac{V_{th}}{R_{th}+6k}=\frac{6}{12k}=0.5mA$$