Faculty of Engineering

ELECTRICAL AND ELECTRONIC ENGINEERING DEPARTMENT

EEE 223 Circuit Theory I

Spring 2005-06

<u>Instructor:</u>

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Midterm EXAMINATION

Apr 20, 2006

Duration : 100 minutes

Number of Problems: 6

Good Luck

STUDENT'S	
NUMBER	
NAME	
SURNAME	
GROUP NO	

Problem		**Points**
1		20
2		15
3		15
4		20
5		15
6		15
TOTAL		100

1. Consider the circuit shown below.

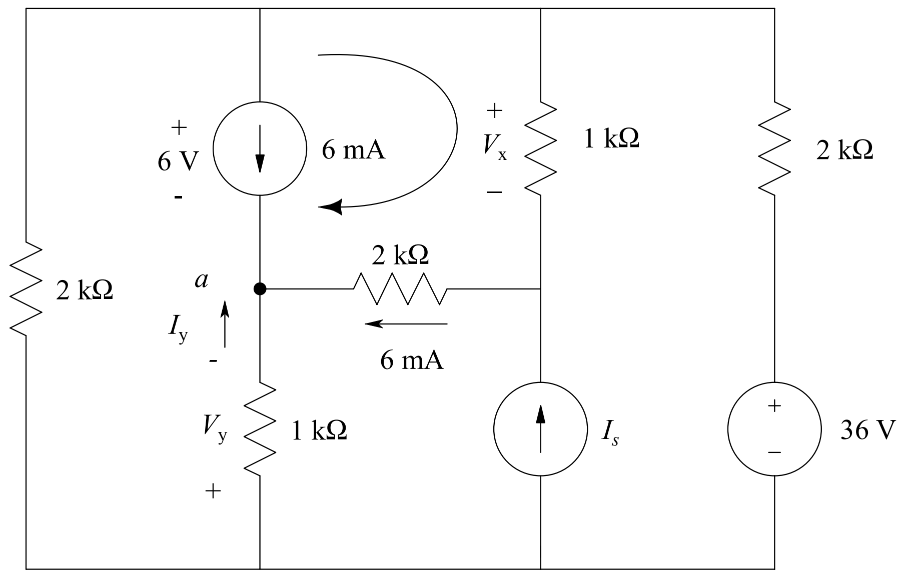


Figure P1

(a) (5 pts.) How much charge flows through the resistor in the center of the circuit in a 3 second interval of time?

$$q_T = \int_0^3 6\times10^{-3}\,dt = 6\times10^{-3}t\Big|_0^3 = 18mC$$

(b) (5 pts.) How much energy does the upper-left current source supply in a 5 second interval of time?

$$w = \int_0^5 vi\,dt = \int_0^5 (6)\left(6\times10^{-3}\right)dt = 36\times10^{-3}\Big|_0^5 = 180mJ \;\; Absorbs$$

$$w_{\text{supply}} = -180mJ$$

(c) (5 pts.) Find the voltage V_x.

KVL around the loop:

$$6m\times2k - 6 + V_x = 0$$

$$V_x = -6V$$

(d) (5 pts.) Find the voltage V_y.

KCL at node *a*:

$$I_y + 6mA + 6mA = 0$$

$$I_y = -12mA$$

$$V_y = I_y \times 1k = -12V$$

2. (15 pts.) Use a Δ to Y transform on the $5k\Omega$, $3k\Omega$, and $7k\Omega$ resistors (plus series and parallel combinations) to reduce this circuit to a single resistor connected to the voltage source.

$$R_1 = \frac{3\times5\times10^6}{(3+5+7)\times10^3} = 1k\Omega$$

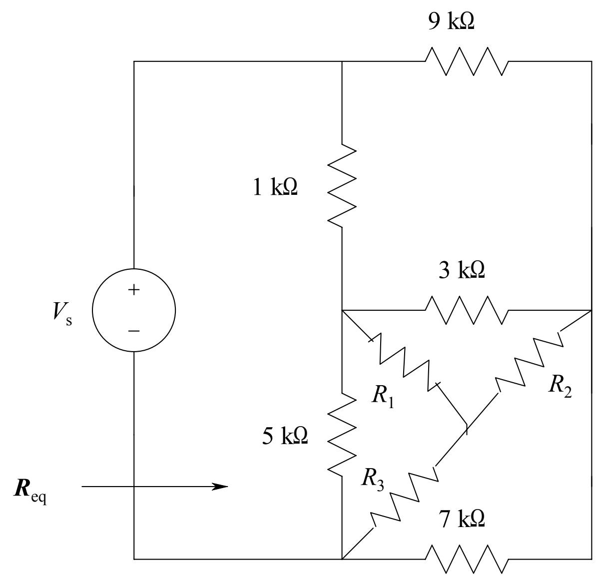
$$R_2 = \frac{21\times10^6}{15\times10^3} = 1.4k\Omega$$

$$R_3 = \frac{35\times10^6}{15\times10^3} = \frac{7}{3}k\Omega$$

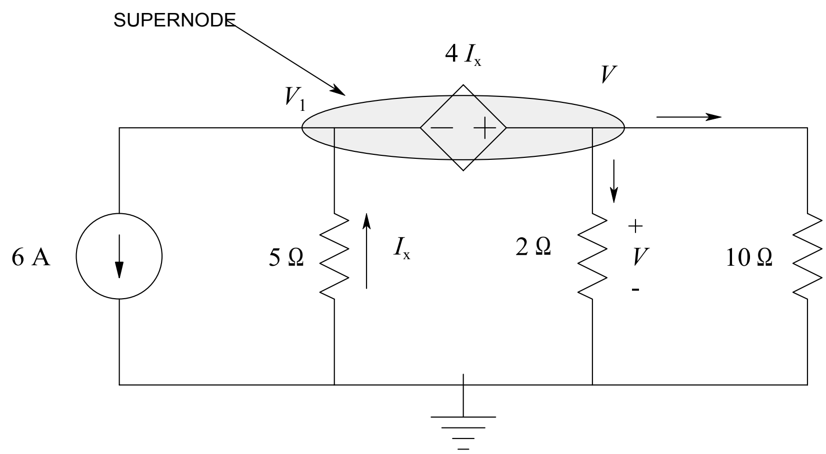
$$R_{eq} = (1k + R_1)//(9k + R_2) + R_3$$

$$R_{eq} = 2k//10.4k + \frac{7}{3}k$$

$$R_{eq} = \frac{2\times10.4\times10^6}{12.4\times10^3} + \frac{7}{3}k = 4.01k\Omega$$



3. (15 pts.) Find I_x and V using *nodal analysis*.



KCL at the supernode:

$$-\left(\frac{-V_1}{5}\right)+6+\frac{V}{2}+\frac{V}{10}=0$$

multiply both sides by 10 gives:

$2V_1+6V=-60$........(1)

where

$$V-V_1=4I_x=4\left(\frac{-V_1}{5}\right)$$

$V_1=5V$.......(2)

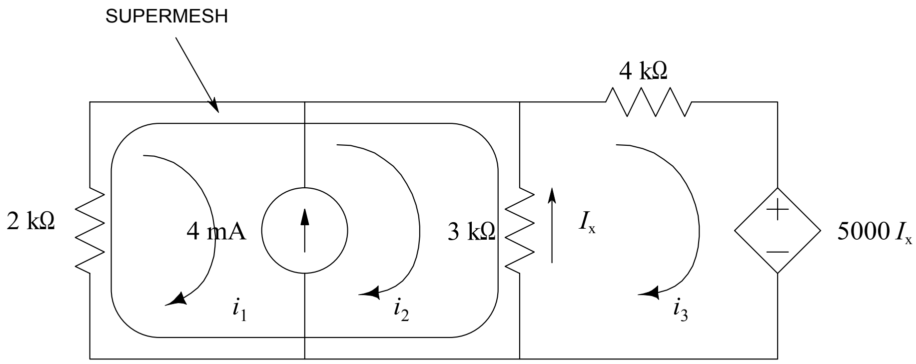
Substitute Eq. (2) into (1) yields:

$$2(5V)+6V=-60$$

$$16V=-60\Rightarrow \boxed{V=-\frac{60}{16}=-3.75\text{V}}$$

$$I_x=-\frac{V_1}{5}=-\frac{5V}{5}=-V=\boxed{3.75\text{A}}$$

4. (15 pts.) Use mesh analysis to find I_x.



$I_x = i_3 - i_2$

$i_2 - i_1 = 4$

$i_1 = i_2 - 4$

KVL around the supermesh:

$2k\left(i_2 - 4\right) + 3k\left(i_2 - i_3\right) = 0$

$5i_2 - 3i_3 = 8m$........(1)

KVL around i_3:

$3k\left(i_3 - i_2\right) + 4ki_3 + 5k\left(i_3 - i_2\right) = 0$

$-8i_2 + 12i_3 = 0$.........(2)

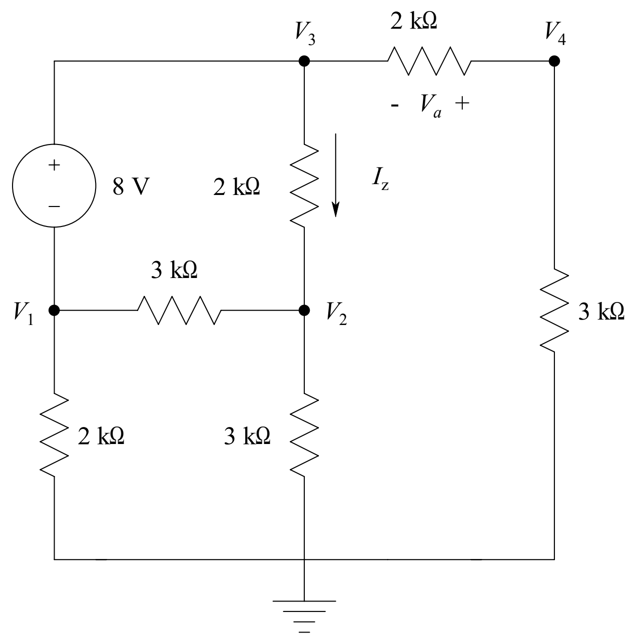
From Eqs. (1) and (2)

$i_3 = 1.78m\text{A}$

$i_2 = 2.67m\text{A}$

$I_x = i_3 - i_2 = -0.89m\text{A}$

In the circuit below, V_1, V_2, V_3, and V_4 are *node voltages* (relative to the reference node).



In this circuit, two of the node voltages are known: $V_2 = 1.34$ V and $V_3 = 5.08$ V. Using this information, complete the following parts of this problem.

(a) (5 pts.) Find the value of node voltage V_1.

$$V_3 - V_1 = 8 \Rightarrow V_1 = V_3 - 8 = 5.08 - 8 = -2.92\text{V}$$

(b) (5 pts.) Find the value of current I_z.

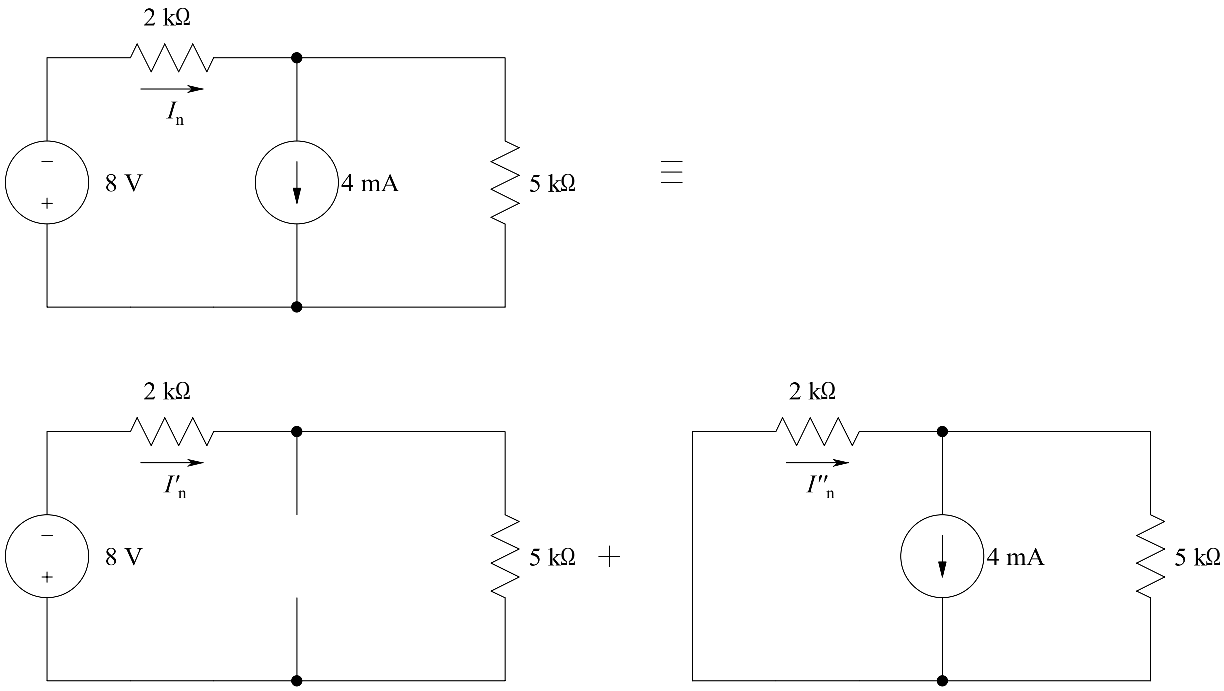
$$I_z = \frac{V_3 - V_2}{2k} = \frac{5.08 - 1.34}{2k} = 1.87m\text{A}$$

(c) (5 pts.) Find the value of the voltage V_a.

Using voltage division principle:

$$V_a = -\frac{2k}{2k+3k}V_3 = (-0.4)(5.08) = -2.03\text{V}$$

5. (15 pts.) Find the value of I_n in the circuit below using *superposition*.



$$I'_n = -\frac{8}{7k} = -\frac{8}{7} mA$$

$$I''_n = 4m\frac{5k}{7k} = \frac{20}{7} mA$$

$$I_n = I'_n + I''_n = -\frac{8}{7} + \frac{20}{7} = \frac{12}{7} mA \; 12/7$$