Faculty of Engineering

ELECTRICAL AND ELECTRONIC ENGINEERING DEPARTMENT

EENG223 Circuit Theory I
INFE221 – Electrical Circuits

FALL 2008-09

<u>Instructor:</u>

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Final EXAMINATION

January 29, 2009

Duration : 150 minutes

Number of Problems: 6

Good Luck

STUDENT'S	
NUMBER	
NAME	
SURNAME	
GROUP NO	

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

1. (a) Use superposition to find v_0 in the circuit in Fig.P1(a). (5 pts.)

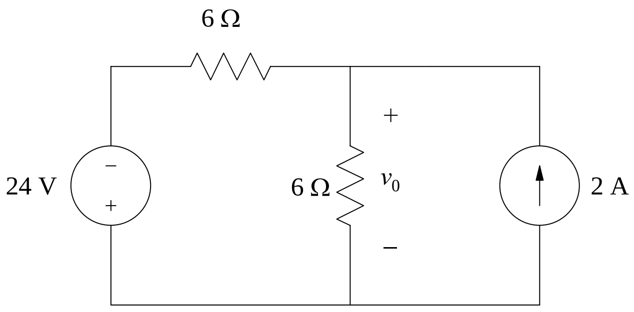
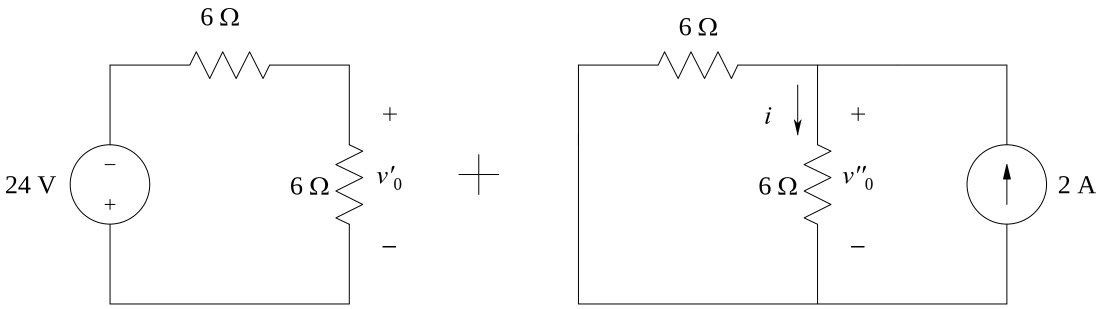


Figure P1(a)



$$v_0' = -24\frac{6}{12} = -12 \text{ V} \qquad v_0'' = 6i = 6\left(2\frac{6}{12}\right) = 6 \text{ V}$$

$$v_0 = v_0' + v_0'' = -12 + 6 = -6 \text{ V}$$

1. (b) Use source transformation to find v_0 in the circuit in Fig.P1(b). (5 pts.)

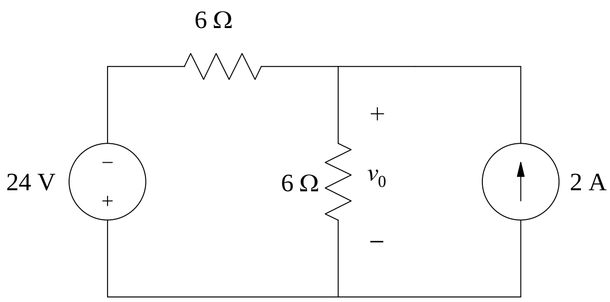
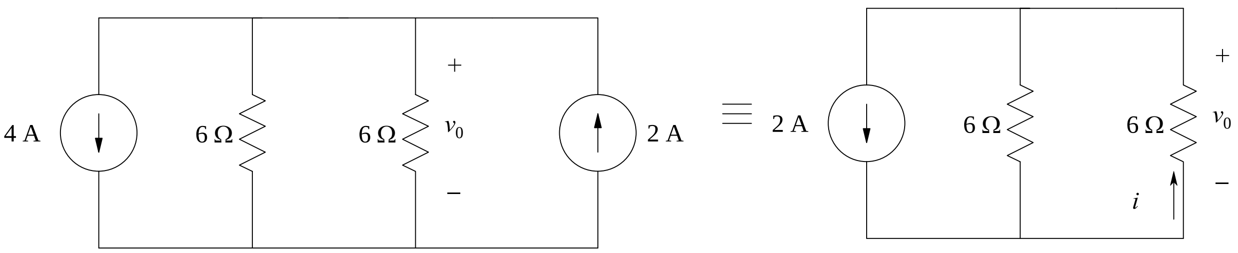


Figure P1(b)



$$v_0 = -6i = -6\left(2\frac{6}{12}\right) = -6 \text{ V}$$

1. (c) Determine V_{TH}, R_{TH}, I_N, and R_N at terminals 1-2 of the circuit in Fig.P1c. (5 pts.)

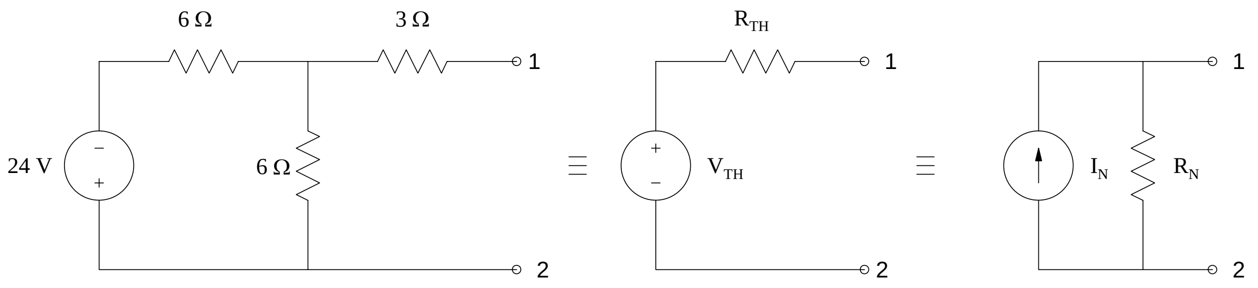
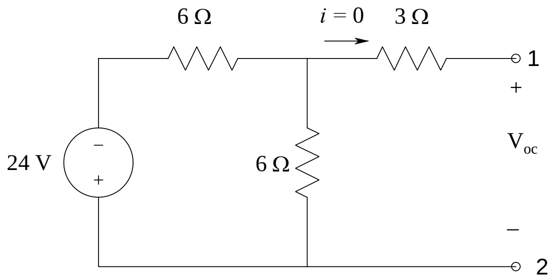
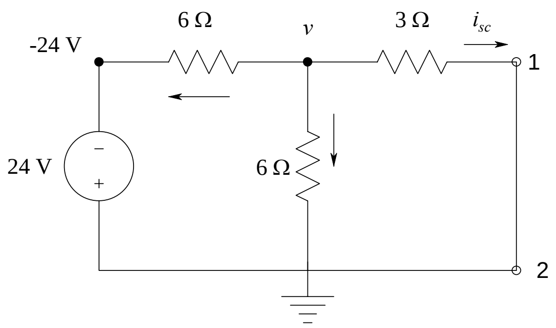


Figure P1(c)



$$V_{oc} = -24\frac{6}{6+6} = -12 \text{ V} = V_{TH}$$



KCL at v:

$\frac{v+24}{6} + \frac{v}{6} + \frac{v}{3} = 0$ multiply bot sides by 6 yields:

$$v + 24 + v + 2v = 0$$

$$v = -6 \text{ V}$$

$$i_{sc} = \frac{v}{3} = -2 \text{ A} = I_N$$

$$R_{TH} = R_N = \frac{v_{oc}}{i_{sc}} = \frac{-12}{-2} = 6\Omega$$

2. Find v in the circuit in Fig.P2 using nodal analysis. (15 pts.)

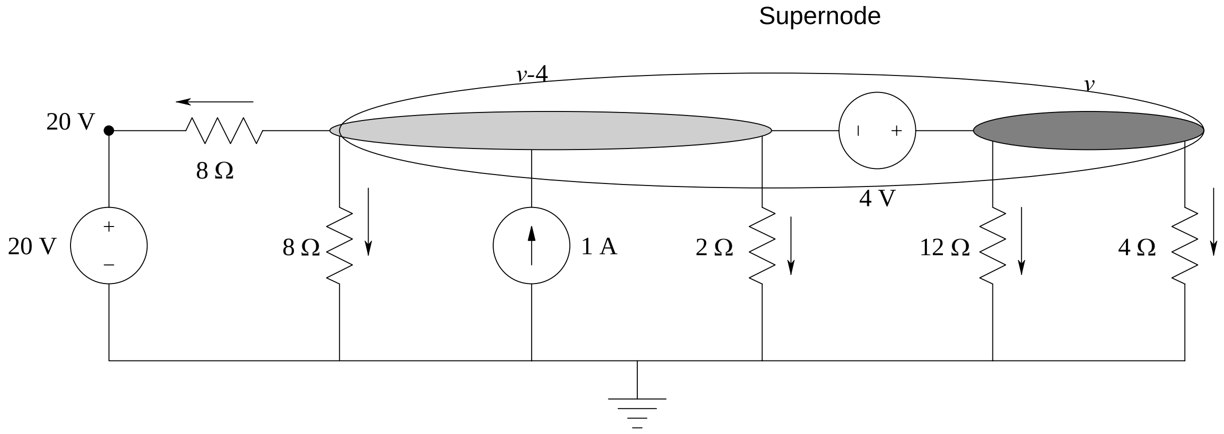


Figure P2

KCL at SUPERNODE:

$$\frac{v-4-20}{8}+\frac{v-4}{8}+\frac{v-4}{2}+\frac{v}{12}+\frac{v}{4}=1$$

Multiply both sides by 24 yields:

$$\frac{v-4-20}{8}+\frac{v-4}{8}+\frac{v-4}{2}+\frac{v}{12}+\frac{v}{4}=1$$

$$3v-72+3v-12+12v-48+2v+6v=24$$

$$26v=156$$

$$\boxed{v=6\text{ V}}$$

3. Find v in the circuit in Fig.P3 using mesh analysis. (15 pts.)

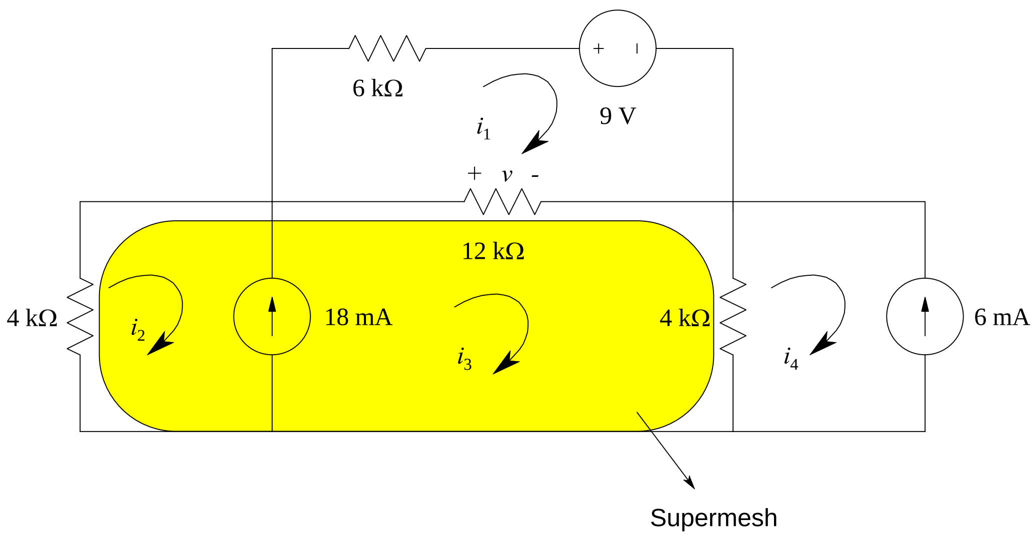


Figure P3

$i_4 = -6mA$

$i_3 - i_2 = 18mA$

$i_3 = 18mA + i_2$

KVL around i_1:

$(6k + 12k)i_1 - 12k(i_2 + 18m) = -9$

$18ki_1 - 12ki_2 = 207...............(1)$

KVL around the SUPERMESH:

$4ki_2 + (12k + 4k)(i_2 + 18m) - 12ki_1 - 4k(-6m) = 0$

$-12ki_1 + 20ki_2 = -312.............(2)$

$$\begin{array}{r} 2\times(18ki_1 - 12ki_2 = 207) \\ +\left[3\times(-12ki_1 + 20ki_2 = -312)\right] \\ \hline \end{array}$$

$36ki_2 = -936 + 414 = -522$

$i_2 = -14.5\ m\text{A}$

$i_1 = \dfrac{11}{6}m\text{A}$

$v = 12k\left(-14.5m + 18m - \dfrac{11}{6}m\right) = 20\ \text{V}$

4. Find the maximum power transferred to resistor R in the circuit of Fig.P2.
   (20 pts.)

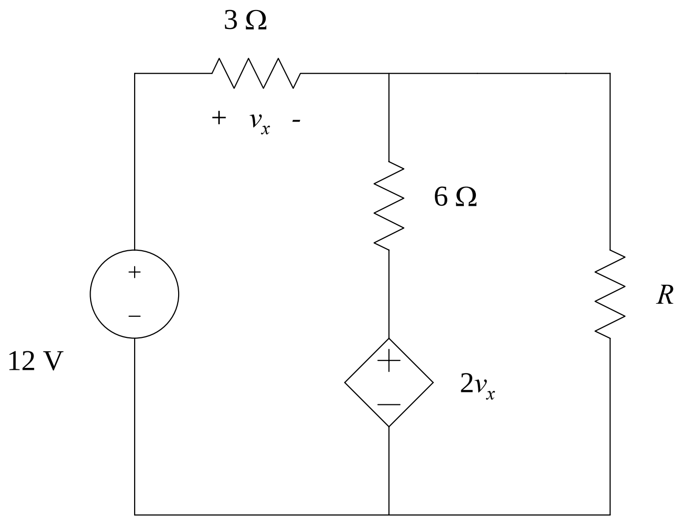
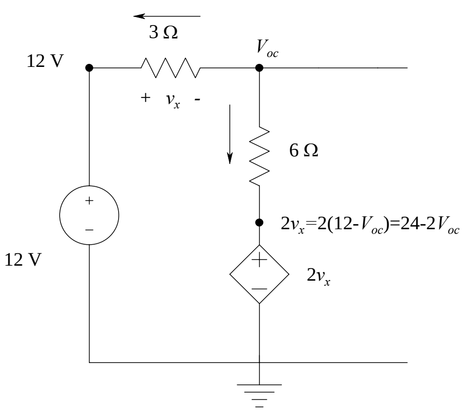


Figure P4

When $R = R_{TH}$, it will absorb maximum power. The maximum power absorbed by the resistor R:

$$P_{\max} = \frac{{V_{TH}}^2}{4R_{TH}}$$

In order to find V_{TH}, open circuit voltage is found between the terminals of R.



KCL at V_{oc}:

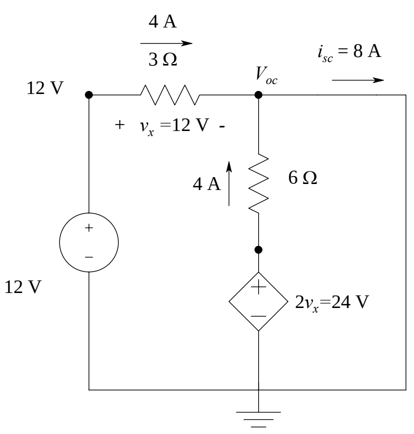
$$\frac{V_{oc} - 12}{3} + \frac{V_{oc} - 24 + 2V_{oc}}{6} = 0$$

Multiply both sides by 6 yields:

$$2V_{oc} - 24 + 3V_{oc} - 24 = 0$$

$$5V_{oc} = 48$$

$$V_{oc} = \frac{48}{5} = 9.6\,\text{V}$$



$$R_{TH} = \frac{V_{oc}}{i_{sc}} = \frac{9.6}{8} = 1.2\,\Omega$$

$$P_{\max} = \frac{{V_{TH}}^2}{4R_{TH}} = \frac{9.6^2}{4 \times 1.2} = 19.2\,\text{W}$$

5. In the circuit in Fig. P3, find k in the voltage transfer function $v_0 = kv_s$. (15 pts.)

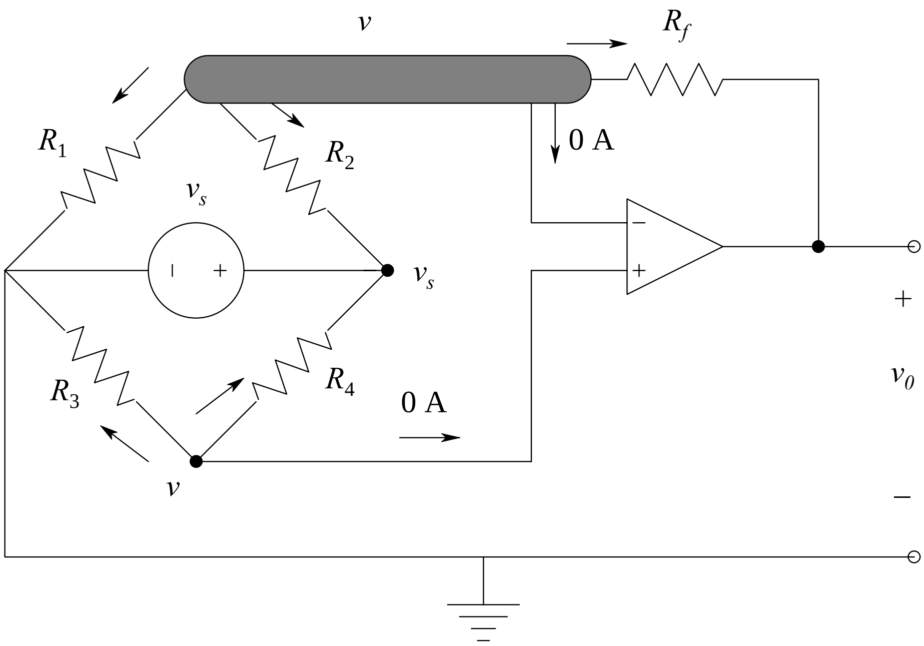


Figure P5

KCL at non-inverting input terminal:

$$\frac{v}{R_3} + \frac{v - v_s}{R_4} = 0$$

$$v = v_s \frac{R_3}{R_3 + R_4}$$

KCL at inverting input terminal:

$$\frac{v}{R_1} + \frac{v - v_s}{R_2} + \frac{v - v_0}{R_f} = 0$$

$$\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_f}\right) v - \frac{1}{R_2} v_s = \frac{v_0}{R_f}$$

$$v_0 = \underbrace{\left(\left(\frac{R_f}{R_1} + \frac{R_f}{R_2} + 1\right)\left(\frac{R_3}{R_3 + R_4}\right) - \frac{R_f}{R_2}\right)}_{k} v_s$$

6. The switch in Fig. P6 has been in position *a* for a long time. At $t=0$, the switch moves to *b*. Determine $i(t)$ for $t>0$. (20 pts.)

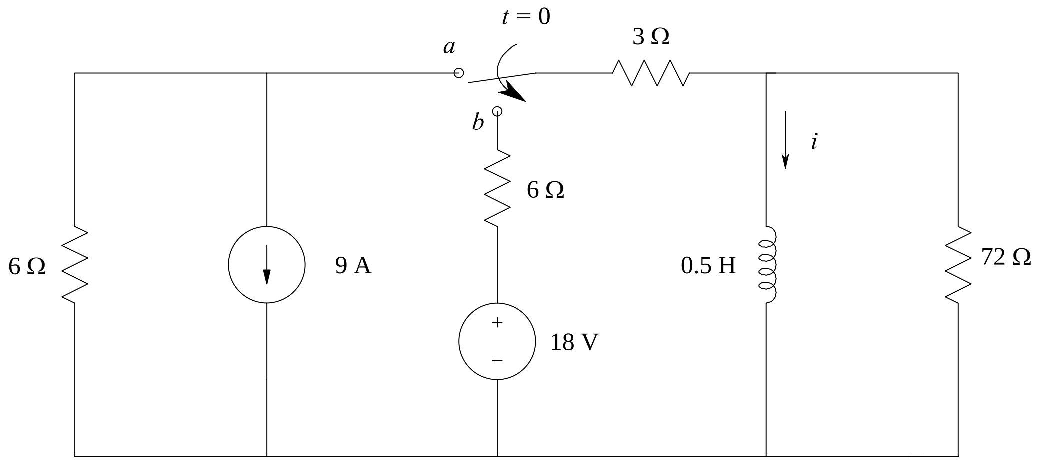
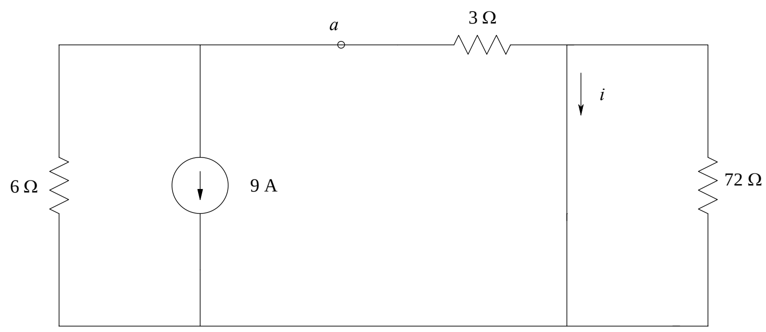


Figure P6

At $t=0-$, the circuit is under dc conditions.

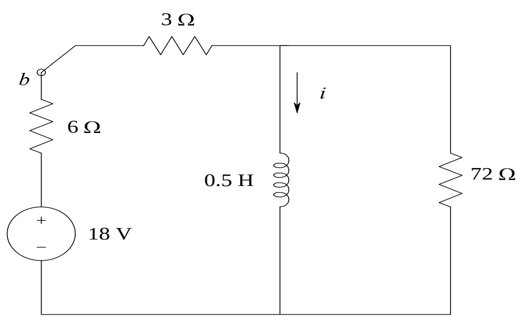


$$i(0-)=-9\frac{6}{6+3}=-6\text{ A}$$

Since the inductor current cannot change instantaneously,

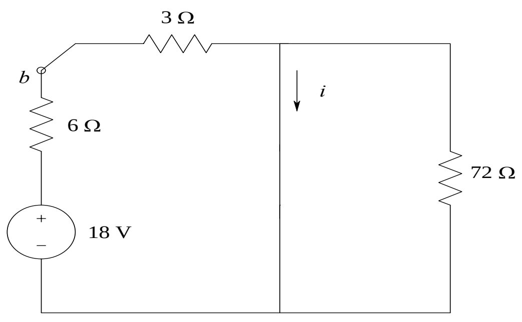
$$i(0-)=i(0+)=i(0)=-6\text{ A}$$

For $t>0$



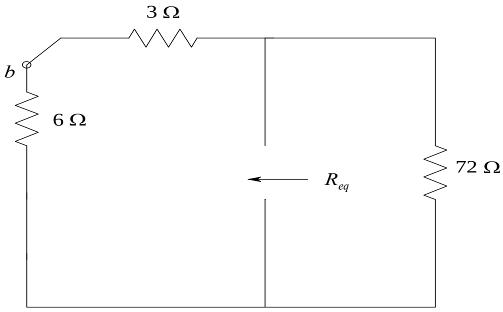
$$i(t)=i(\infty)+\left[i(0)-i(\infty)\right]e^{-\frac{t}{\tau}}\text{ A}$$

At $t=\infty$



$$i(\infty)=\frac{18}{9}=2\text{ A}$$

$$\tau = \frac{L}{R_{eq}}$$



$$R_{eq} = 72 // (6+3) = 8\Omega$$

$$\tau = \frac{0.5}{8} = \frac{1}{16} s$$

$$i(t) = 2 + [-6-2]e^{-16t} \text{ A}$$

$$\boxed{i(t) = 2 - 8e^{-16t} \text{ A for } t > 0}$$