Problem 1

Design an RC low pass filter with a cut-off frequency of 8 KHz. You have to use a resistance of 10 KΩ.

$\omega_c = \frac{1}{RC}$

$\omega_c = 2\pi \times 8000$ rad/s

$R = 10 \times 10^3 \, \Omega$

So, $C = \frac{1}{R\omega_c} = \frac{1}{10\times10^3 \times 2\pi \times 8000}$

$= 1.9894 \times 10^{-9}$ F $= 1.9894$ nF

Problem 2

Find the Thevenin equivalent circuit with respect to terminal AB

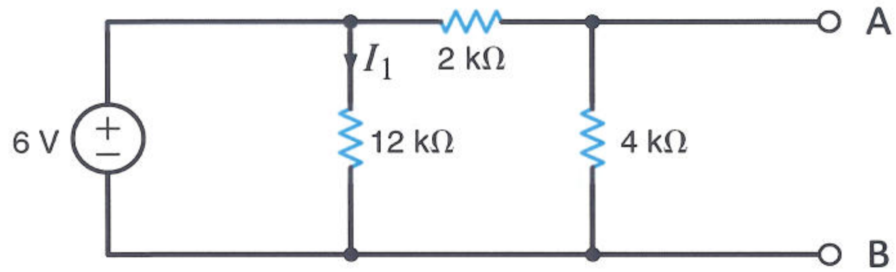
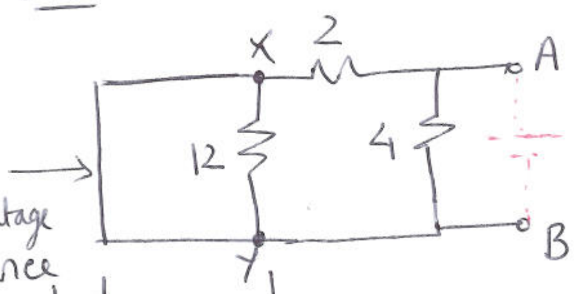
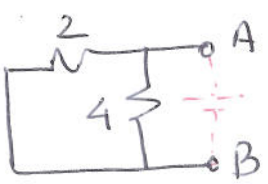


Figure 1: Circuit for problem 2

$\underline{\underline{R_{Th}}}$



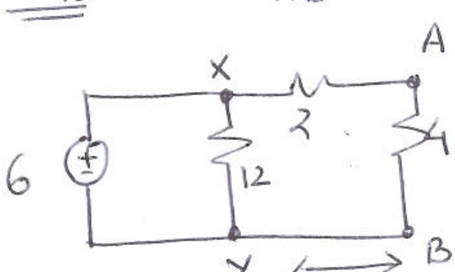
voltage source shorted



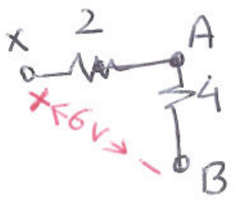
$2 \| 4 = \frac{2\times4}{6} = 1.33$ KΩ

12KΩ is shorted out
X, Y same point

$\underline{\underline{V_{Th}}}$ is V_{AB}



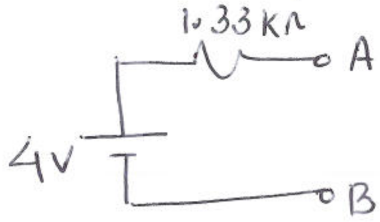
$V_{xy} = 6$ V ← 12 K is connected across the source



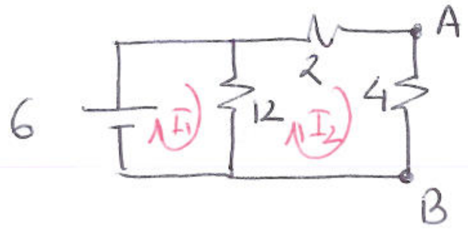
2 & 4 K resistances in series.
So apply voltage division.

$V_{AB} = 6 \times \frac{4}{2+4} = 4$ volt ← V_{Th}

So Thevenin equivalent circuit :



Alternate way of finding V_{Th}



$V_{AB} = 4I_2$

$12I_1 - 12I_2 = 6$ — (1)

$-12I_1 + 18I_2 = 0$ — (2)

$6I_2 = 6 \Rightarrow I_2 = 1\ mA$

So $V_{AB} = 4 \times 1 = 4$ volts

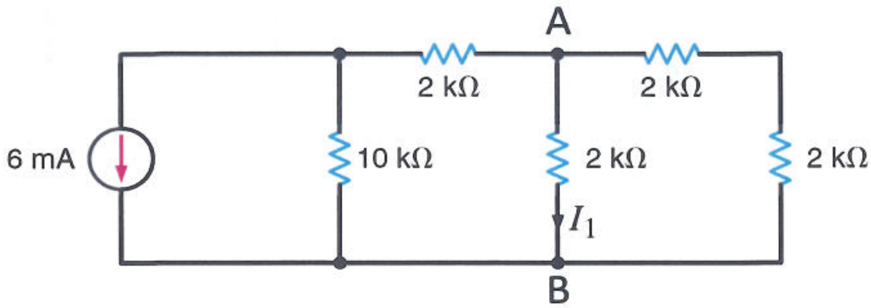
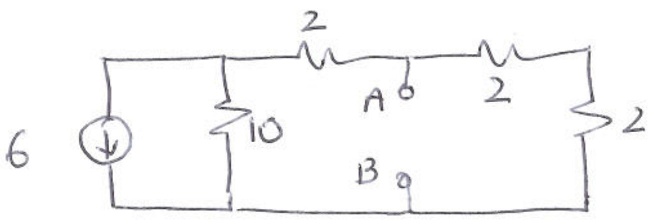
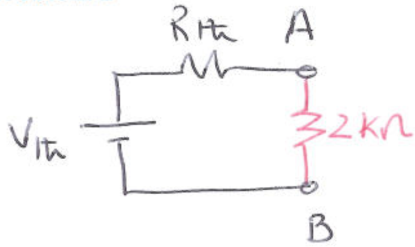
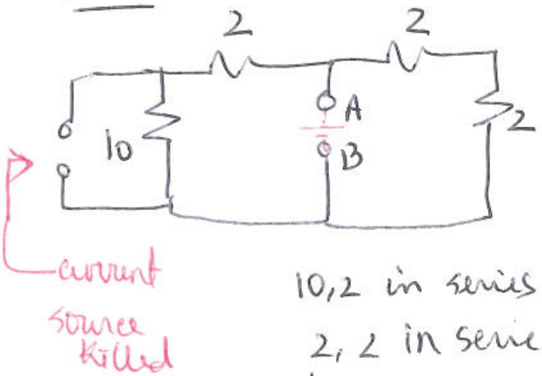


Figure 2 Circuit for problem 2

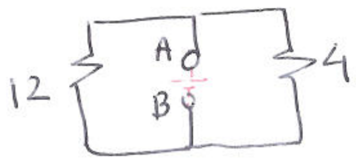




R_{th}

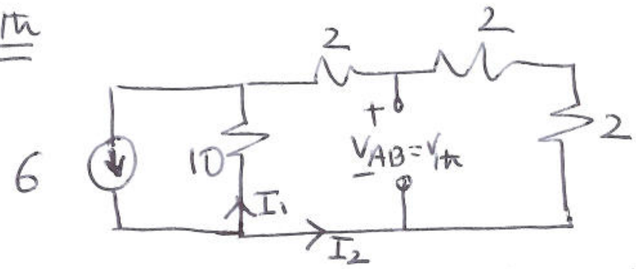


10, 2 in series
2, 2 in series

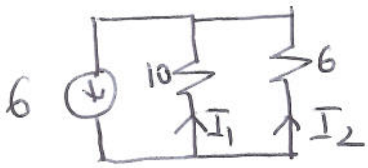


$$12 \| 4 = \frac{12 \times 4}{12+4} = 3\ K\Omega$$

V_{th}

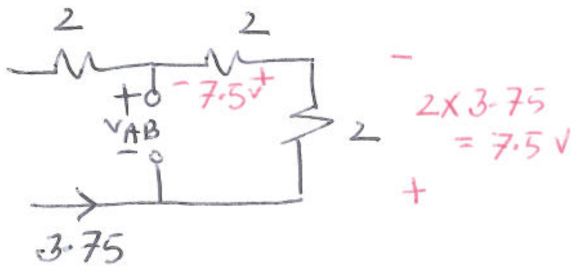


The three 2 kΩ resistances are in series.



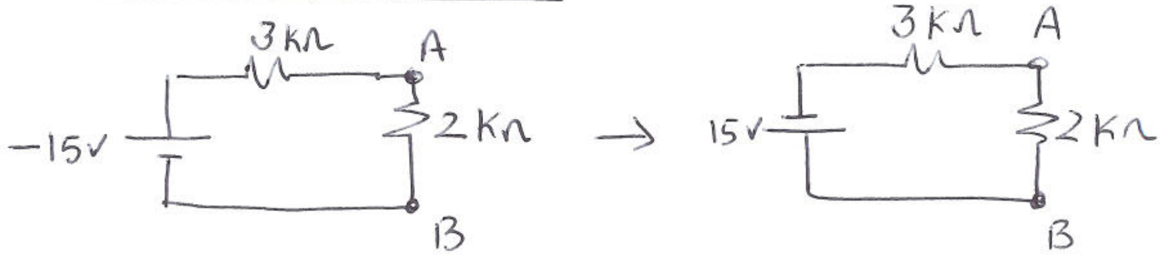
$$I_2 = 6 \times \frac{10}{10+6} \quad \text{current division}$$

$$= 3.75\ mA$$



$V_{AB} = -7.5 - 7.5 = -15\ V$

So Thevenin equivalent ckt:



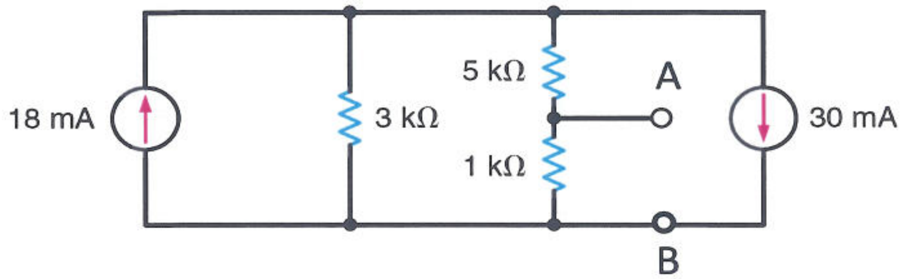
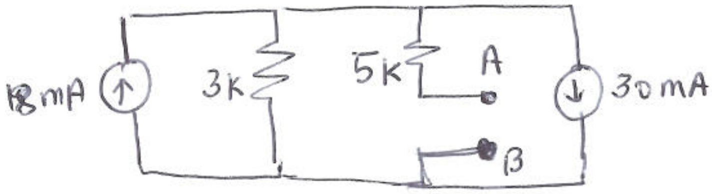
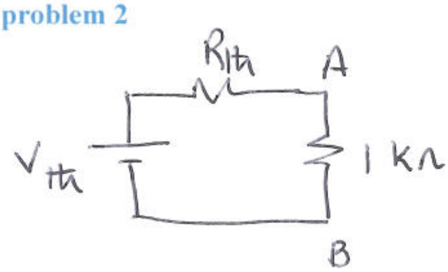
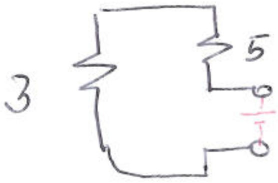


Figure 3 Circuit for problem 2





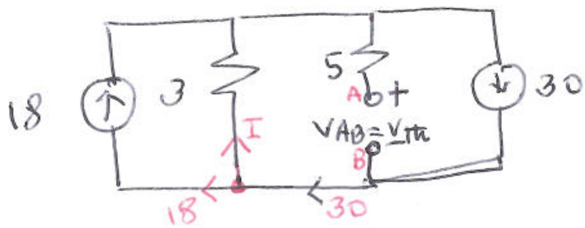
Rth



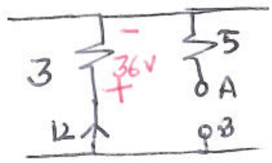
$R_{th} = 3 + 5$

$= 8\,K\Omega$

Vth



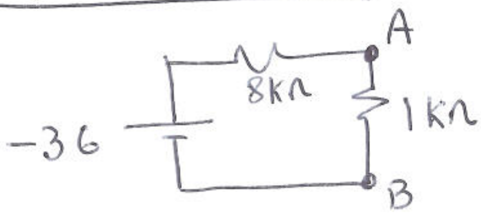
$I = 30 - 18 = 12\ mA$



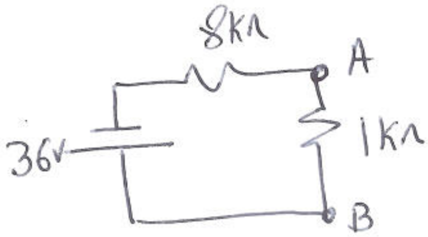
$V_{AB} = -36\ V$

→ no drop in the 5K resistance as no current.

Equivalent ckt



→



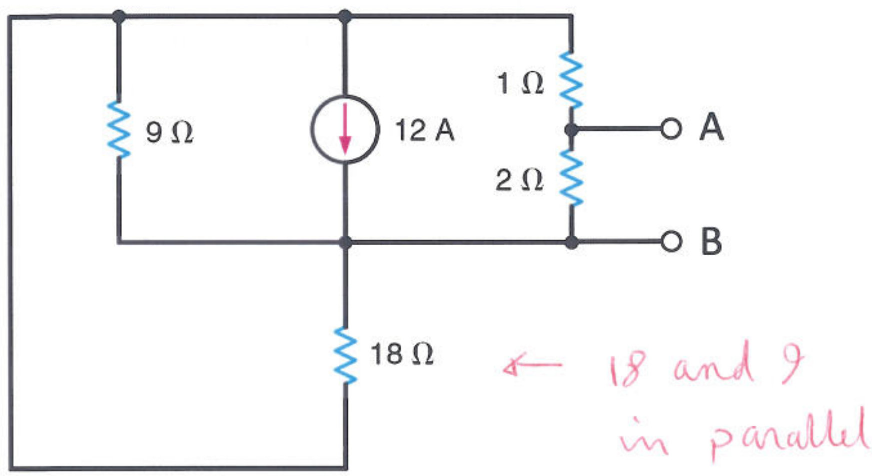
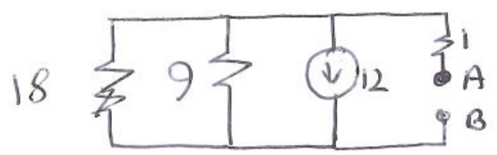
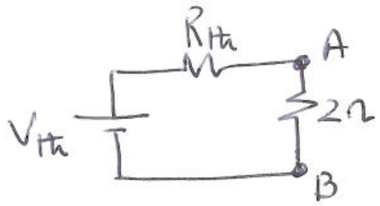
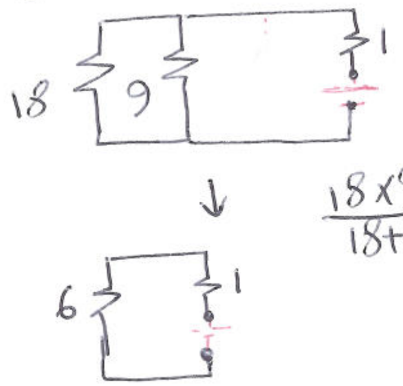


Figure 4 Circuit for problem 2





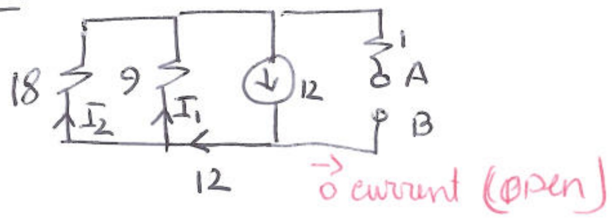
R_{Th}



$$\frac{18 \times 9}{18+9} = 6\Omega$$

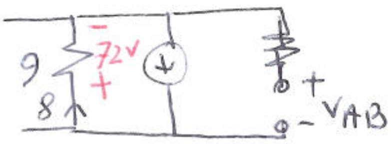
$R_{Th} = 6 + 1 = 7\Omega$

V_{Th}



$$I_1 = 12 \times \frac{18}{9+18}$$ ← current division

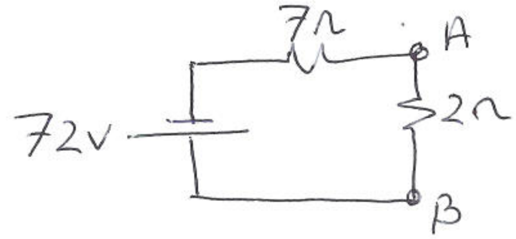
$= 8$ Amp



$V_{AB} = -72\ V = V_{Th}$

Equivalent ckt

Equivalent ekt



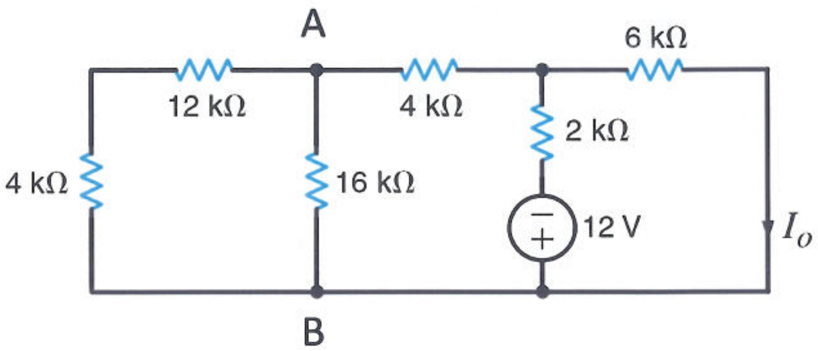
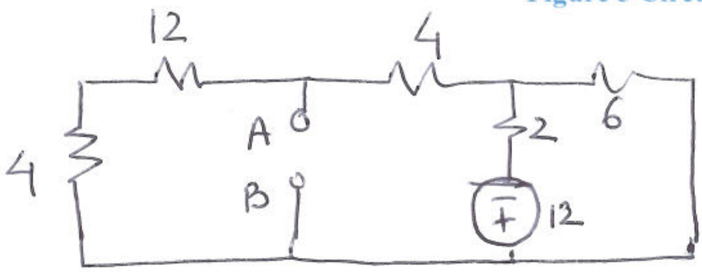
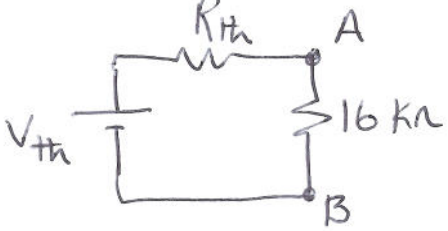
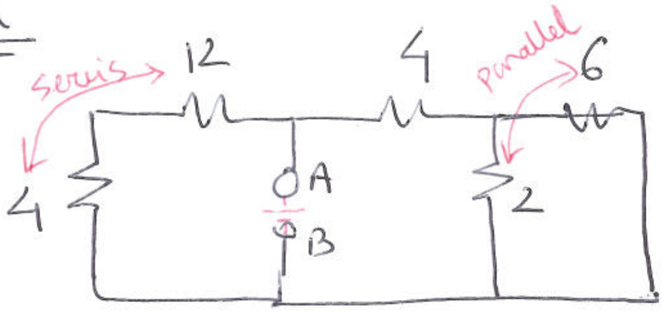


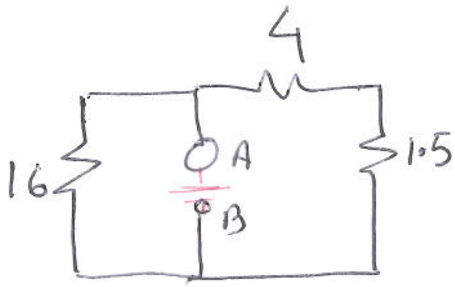
Figure 5 Circuit for problem 2



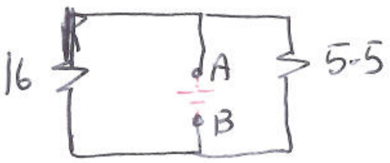


R_{Th}

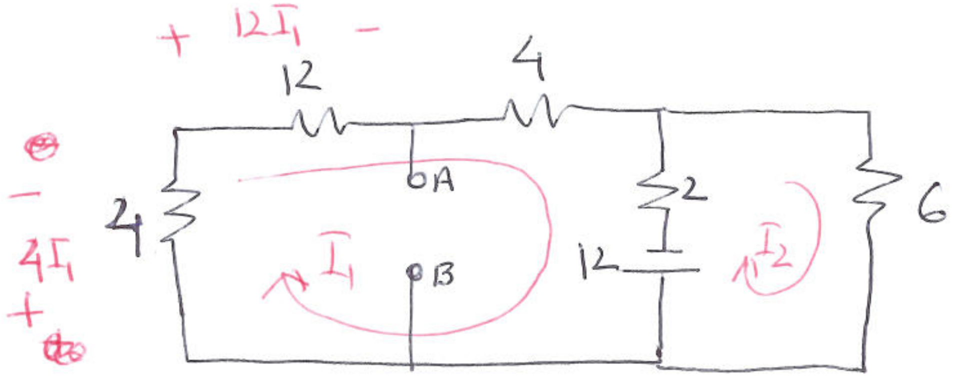




$$\frac{6\times 2}{2+6} = 1.5$$



$$\Rightarrow R_{Th} = 16 \| 5.5 = \frac{16 \times 5.5}{16 + 5.5} = 4.093\ k\Omega$$



Both gains A→B

$V_{AB} = -12 I_1 - 4 I_1$

$= -16 I_1$

$(4+12+4+2)I_1 - 2I_2 = 12$

$\Rightarrow 22I_1 - 2I_2 = 12$ — (1)

$-2I_1 + 8I_2 = -12$ — (2)

4 × (1) + (2)

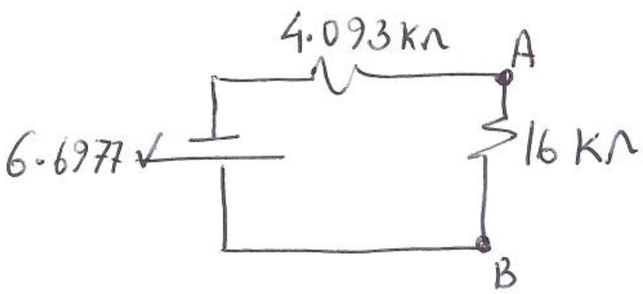
$88I_1 - 8I_2 = 48$

$-2I_1 + 8I_2 = -12$

$86 I_1 = 36 \Rightarrow I_1 = \frac{36}{86}\text{ mA} = 0.4186\text{ mA}$

$\therefore V_{AB} = -16 I_1 = -6.6977$ volt

Equivalent ckt



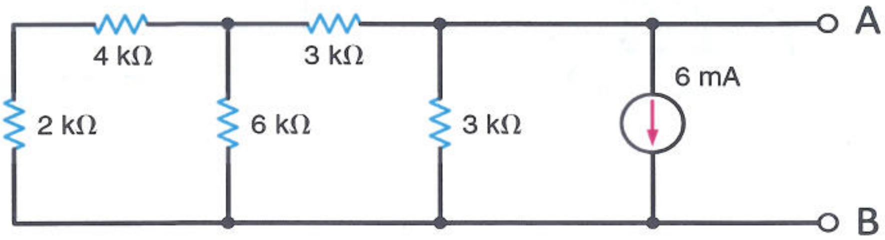
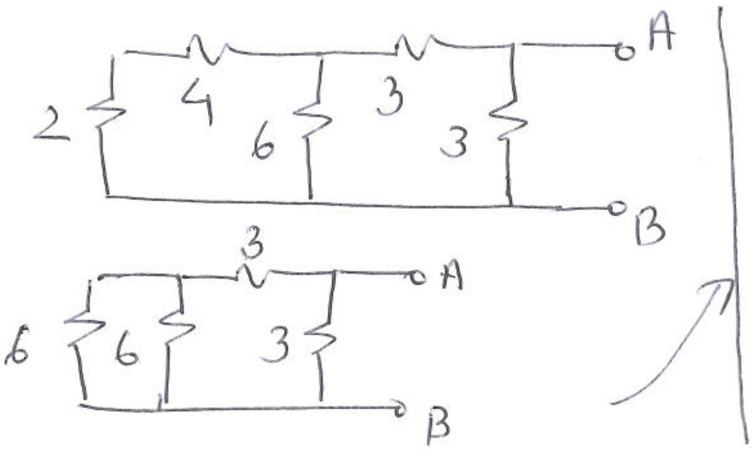
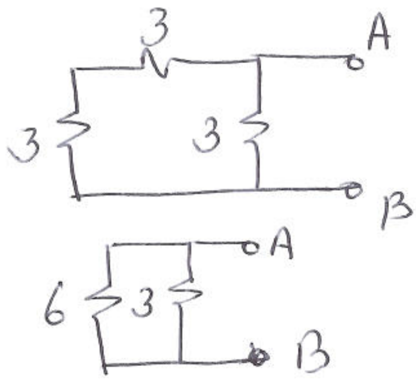


Figure 6 Circuit for problem 2

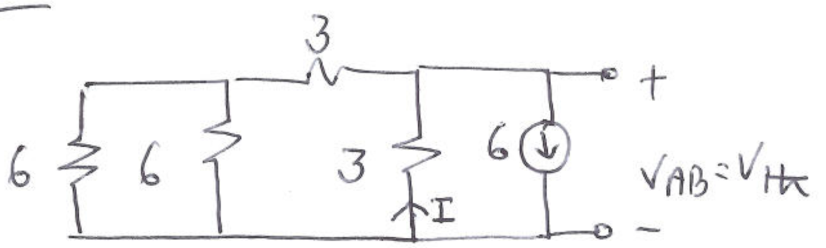
R_{Th} open current source to kill



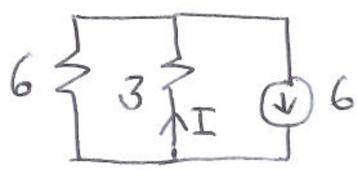


$R_{Th} = 6 \| 3 = 2\ k\Omega$

V_{Th}



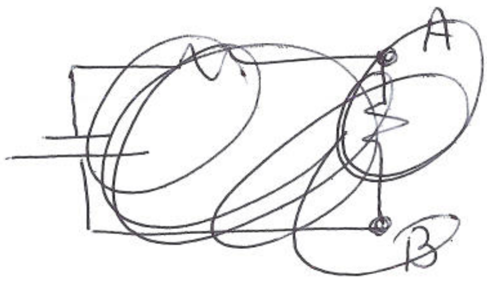
$V_{AB} = -3I$

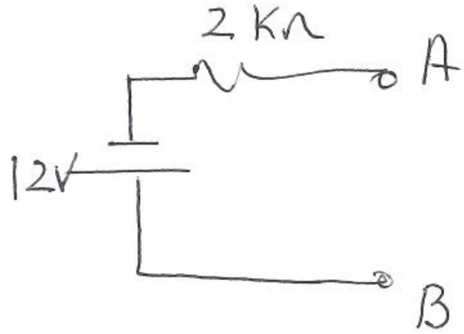


$$I = 6 \times \frac{6}{6+3} = 4\ mA$$

$\therefore V_{AB} = V_{Th} = -3I = -12\ V$

Equivalent ckt





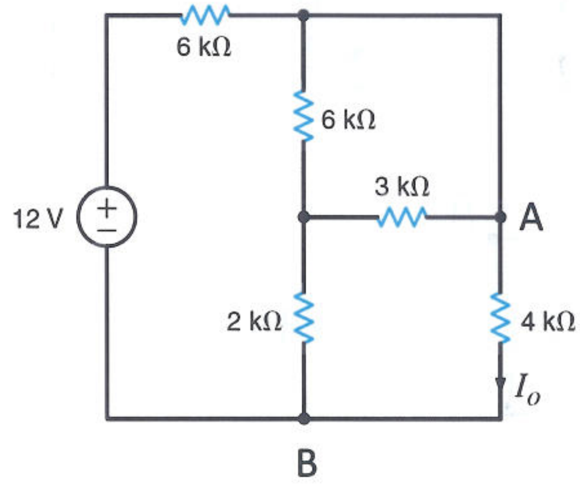
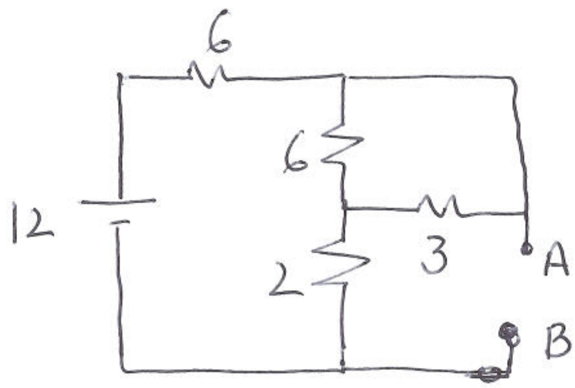
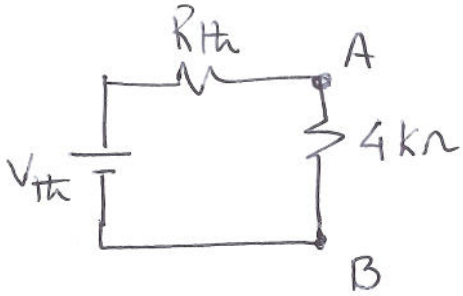
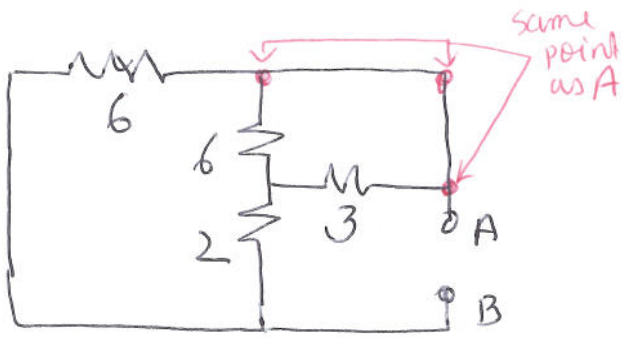


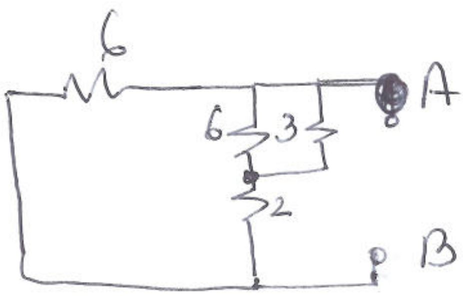
Figure 7 Circuit for problem 2



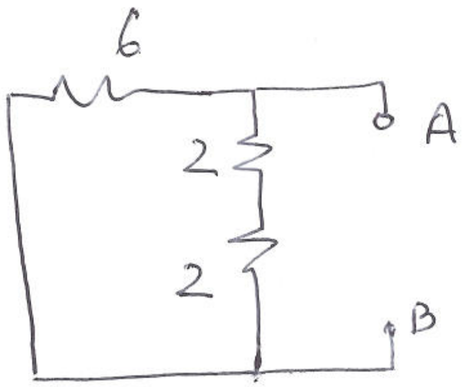


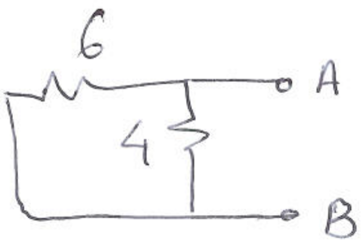
R_{th}





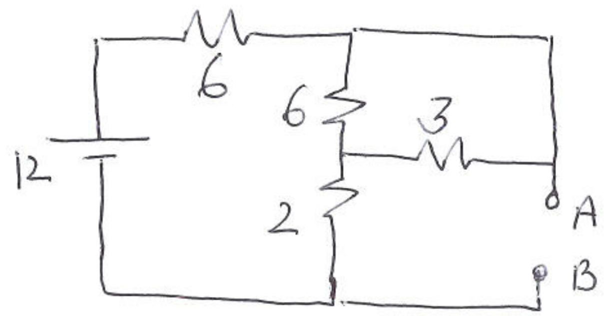
$6 \| 3$
$= 2$

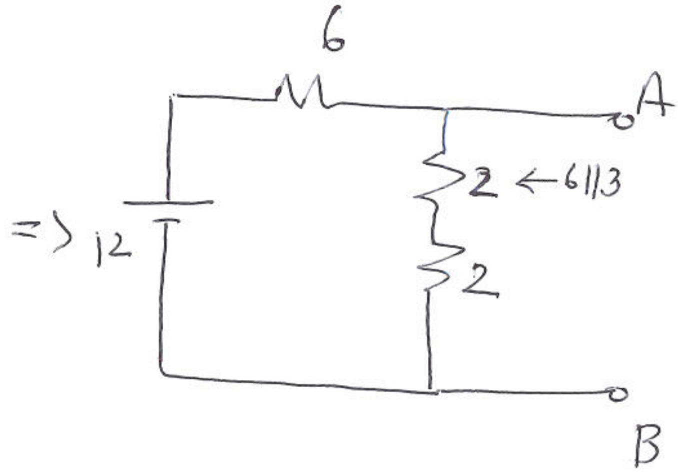


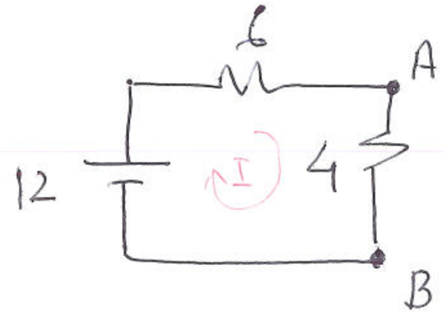


$R_{th} = 6 \| 4 = 2.4\ k\Omega$

V_{th}



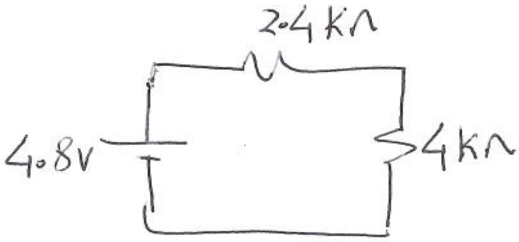




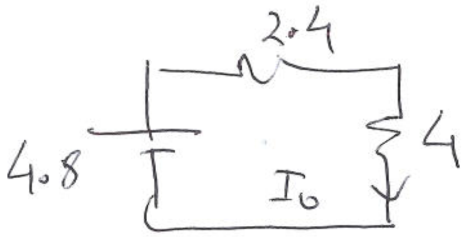
$$V_{AB} = V_{th} = 12 \times \frac{4}{4+6} = 4.8\ V$$

Alternatly $I = \frac{12}{6+4}$, $V_{AB} = 4I$

Equivalent CKT



** If we wanted to find I_o as shown in the ckt!



$$I_o = \frac{4.8}{6.4}\ mA$$

$$= 0.75\ mA$$

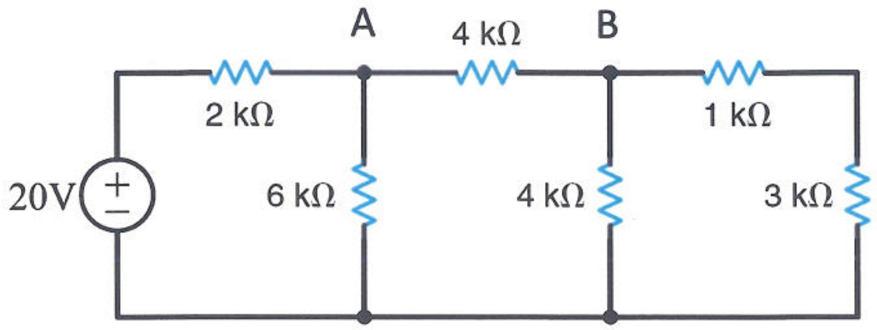
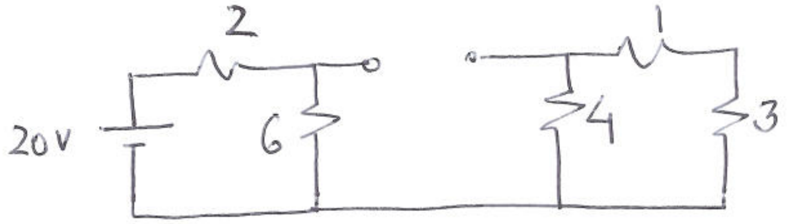
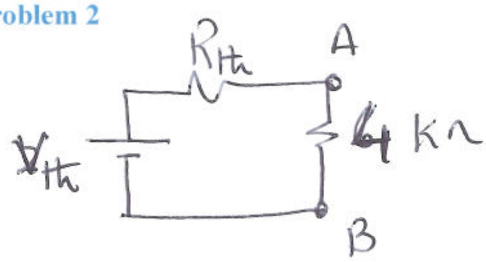
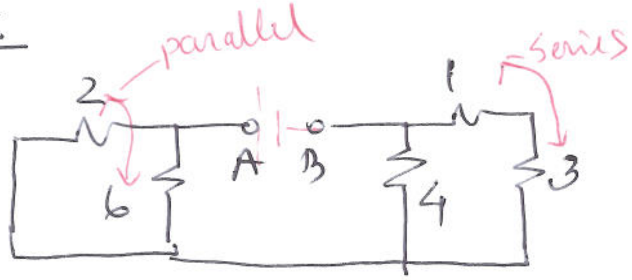


Figure 8 Circuit for problem 2

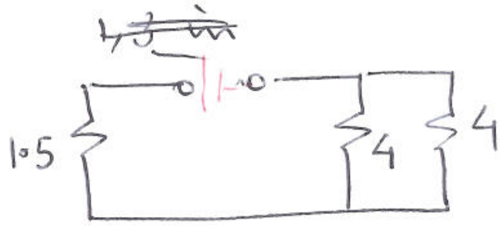


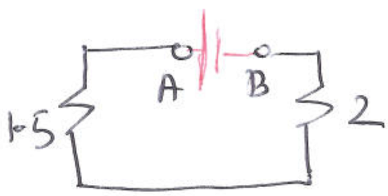


Rth



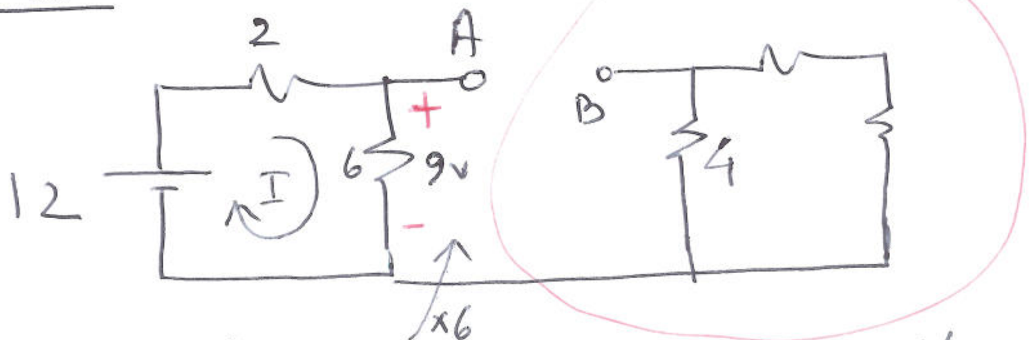
$2 \| 6 = \frac{2\times6}{2+6} = 1.5$





$R_{th} = 2 + 1.5 = 3.5\ k\Omega$

Vth



No current

Zero voltage across these 3 resistances

$I = \frac{12}{8} = 1.5\ mA$

$V_{AB} = 9 + 0 = 9V$

Equivalent ckt