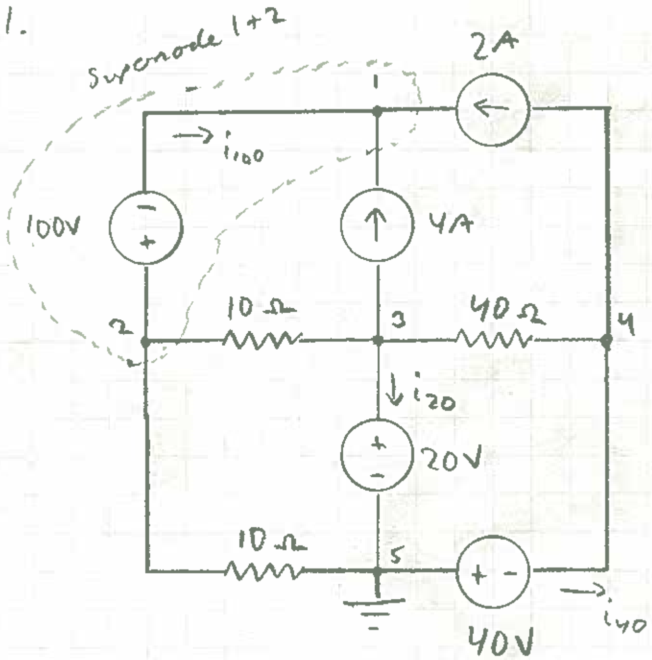
1.



a) Find node voltages

b) Find power in all voltage sources

a) Reference node: 5

Note: $V_3 = 20\,V$

$V_4 = -40\,V$

Use supernode 1+2:

$V_2 = V_1 + 100$ (1) (supernode constraint)

$$KCL_{1+2}: \quad 2 + 4 - \frac{V_2}{10} - \frac{V_2 - 20}{10} = 0$$

$$60 - V_2 - V_2 + 20 = 0$$

$$V_2 = 40\,V$$

(1) $\Rightarrow$ $V_1 = V_2 - 100 = -60\,V$

b) <u>100V source:</u>

$KCL_1: \quad i_{100} + 2 + 4 = 0 \;, \quad i_{100} = -6\,A$

$p_{100} = 100 \cdot i_{100} = 100 \cdot (-6) = \underline{-600\,W}$ (600 W supplied)

<u>20V source:</u>

$$KCL_2: \quad \frac{V_2 - V_3}{10} - 4 - \frac{V_3 - V_4}{40} - i_{20} = 0$$

$$i_{20} = \frac{40-20}{10} - 4 - \frac{20-(-40)}{40} = -3.5\,A$$

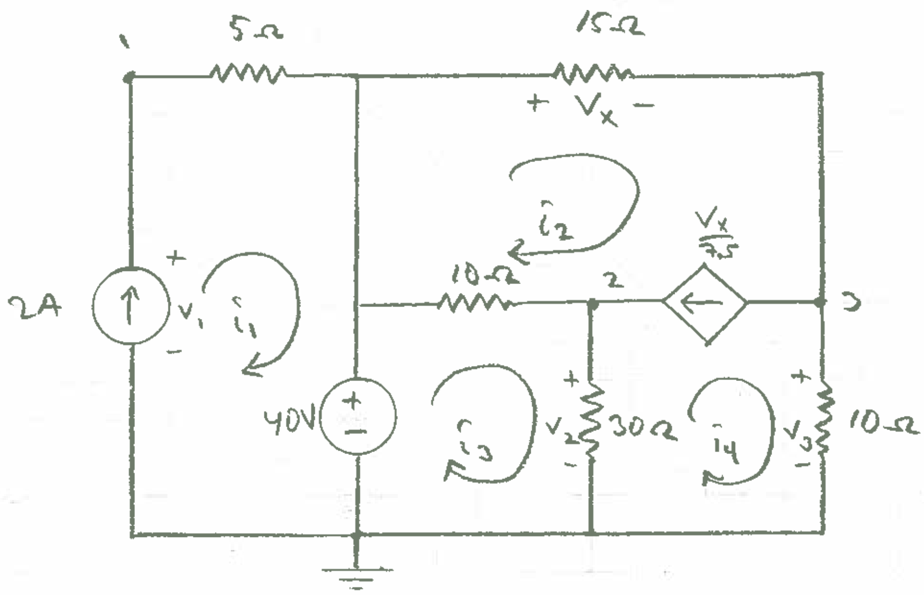
$p_{20} = 20 \cdot i_{20} = 20 \cdot (-3.5) = -70\,W$ (70 W supplied)

<u>40V source:</u>

$$KCL_5: \quad \frac{V_2}{10} + i_{20} - i_{40} = 0$$

$$i_{40} = \frac{40}{10} - 3.5 = 0.5\,A$$

$p_{40} = 40 \cdot i_{40} = 40 \cdot 0.5 = 20\,W$ (20 W absorbed)



a) Find mesh currents

b) Find node voltages V_1, V_2, V_3

a) Mesh-current method:

Note: $i_1 = 2A$

$$V_x = 15 \cdot i_2 \Rightarrow \frac{V_x}{7.5} = 2 i_2$$

Use supermesh 2+4:

$$i_2 - i_4 = \frac{V_x}{7.5} = 2 i_2 \Rightarrow i_2 = -i_4 \quad (1) \quad \text{(Supermesh constraint)}$$

$$KVL_{2+4}: \quad 15 i_2 + 10 i_4 + 30(i_4 - i_3) + 10(i_2 - i_3) = 0$$

$$(1) \Rightarrow \quad 15 i_2 - 10 i_2 - 30 i_2 - 30 i_3 + 10 i_2 - 10 i_3 = 0$$

$$-15 i_2 - 40 i_3 = 0 \quad (2)$$

$$KVL_3: \quad -40 + 10(i_3 - i_2) + 30(i_3 - i_4) = 0$$

$$(1) \Rightarrow \quad -40 + 10 i_3 - 10 i_2 + 30 i_3 + 30 i_2 = 0$$

$$20 i_2 + 40 i_3 = 40 \quad (3)$$

$(2) + (3) \Rightarrow \quad 5 i_2 = 40$

$i_2 = \underline{8A}$

$(1) \Rightarrow i_4 = \underline{-8A}$

$(2) \Rightarrow -15 \cdot 8 - 40 i_3 = 0$

$i_3 = \underline{-3A}$

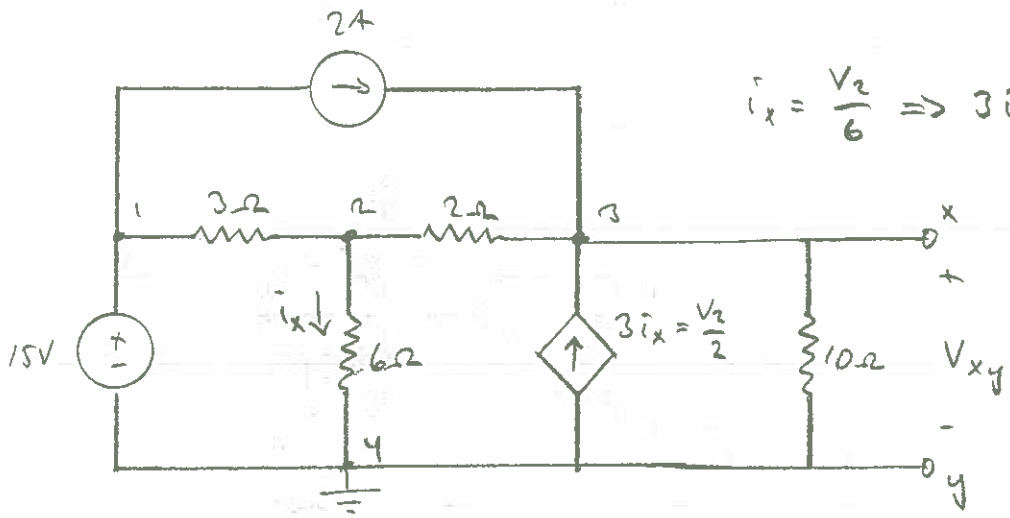
b) KVL₁: $-V_1 + 5 i_1 + 40 = 0$

$V_1 = 5 \cdot 2 + 40 = \underline{50V}$

$V_2 = 30(i_3 - i_4) = 30 \cdot (-3 + 8) = \underline{150V}$

$V_3 = 10 \cdot i_4 = 10 \cdot (-8) = \underline{-80V}$

3)



$i_x = \frac{V_2}{6} \Rightarrow 3i_x = \frac{V_2}{2}$

a) Thévenin equivalent?

b) V_{xy} for load consisting of $R = 10\,\Omega$ in series with 2A source?

a) 1) Find no-load voltage V_{xy}

Use node-voltage method with node 4 as reference

$V_1 = 15\,V$, solve for V_2 and $V_3 = V_{xy}$

KCL$_2$: $$\frac{15 - V_2}{3} - \frac{V_2}{6} - \frac{V_2 - V_3}{2} = 0$$

$$30 - 2V_2 - V_2 - 3V_2 + 3V_3 = 0$$

$$-6V_2 + 3V_3 = -30 \quad (1)$$

KCL$_3$: $$2 + \frac{V_2 - V_3}{2} + \frac{V_2}{2} - \frac{V_3}{10} = 0$$

$$20 + 5V_2 - 5V_3 + 5V_2 - V_3 = 0$$

$$10V_2 - 6V_3 = -20 \quad (2)$$

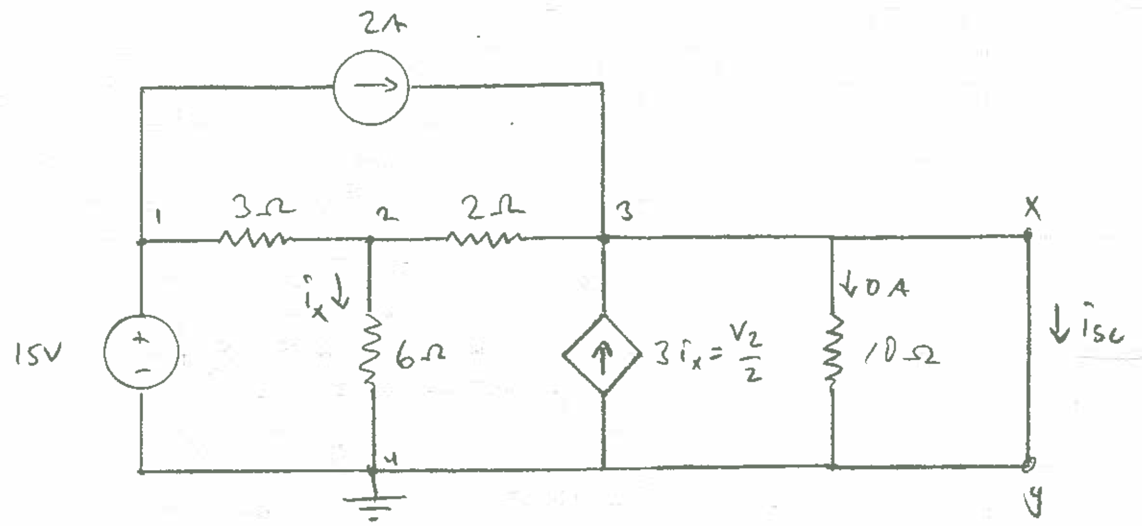
$2 \times (1) + (2) \Rightarrow$ $-2V_2 = -80$

$$V_2 = 40\,V$$

(1) ⇒ $-6 \cdot 40 + 3V_3 = -30$

$$V_3 = \underline{70\,V} = V_{TH}$$

2) Find short-circuit current i_{sc}



<u>Note</u> $V_1 = 15V$

$V_3 = 0\,V$ (due to short-circuit)

KCL_2: $\frac{15 - V_2}{3} - \frac{V_2}{6} - \frac{V_2}{2} = 0$

$$30 - 2V_2 - V_2 - 3V_2 = 0$$

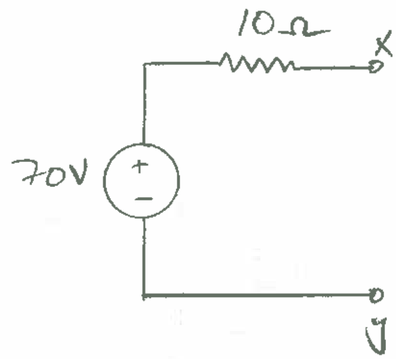
$$V_2 = 5V$$

KCL_3: $2 + \frac{V_2 - 0}{2} + \frac{V_2}{2} - i_{sc} = 0$

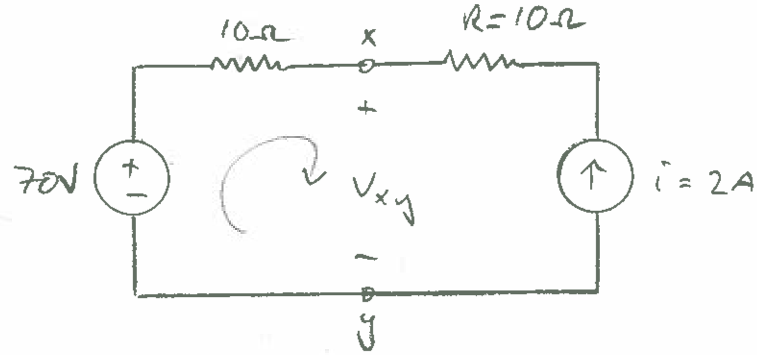
$$i_{sc} = 2 + \frac{5}{2} + \frac{5}{2} = 7\,A$$

$$R_{Th} = \frac{V_{TH}}{i_{sc}} = \frac{70}{7} = \underline{10\,\Omega}$$

Thevenin equivalent:



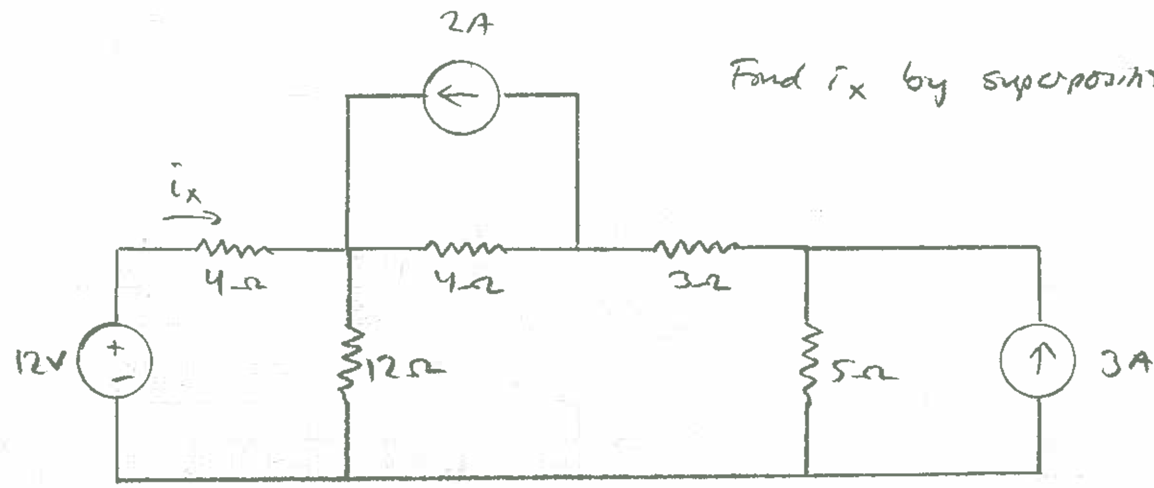
b)



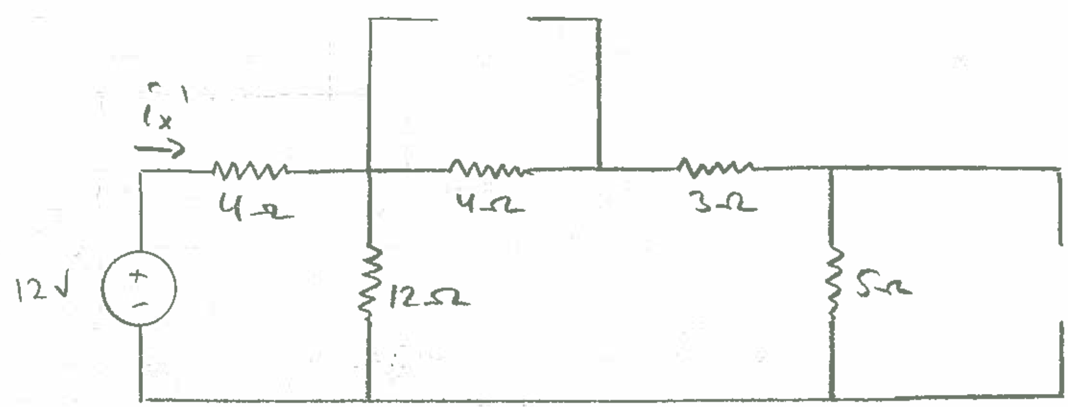
KVL: $-70 - 10 \cdot 2 + V_{xy} = 0$

$V_{xy} = \underline{90\ V}$

4. Find i_x by superposition



a) i_x due to 12 V source, i_x'

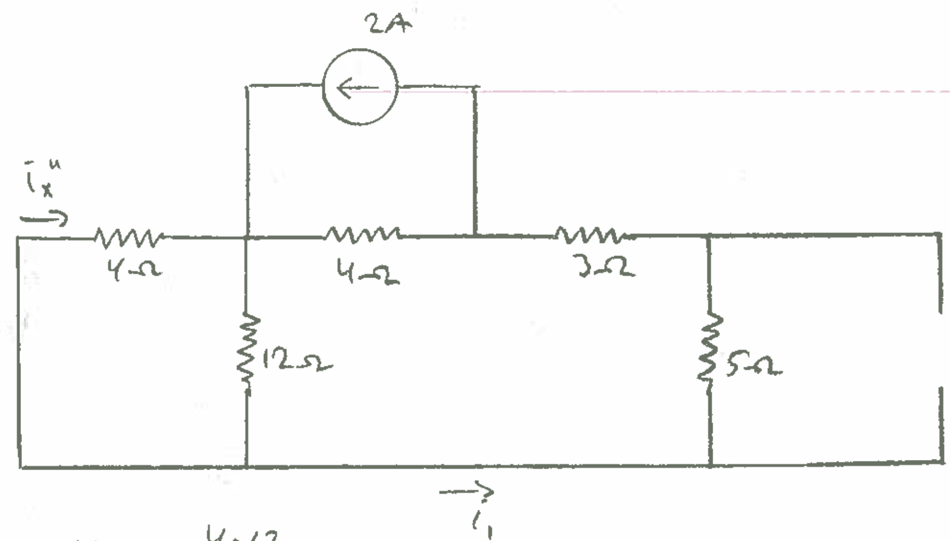


$4 + 3 + 5 = 12\,\Omega$ (in series)

$12 // 12 = 6\,\Omega$

$i_x' = \frac{12}{4+6} = \underline{1.2\,A}$

b) i_x due to 2A source, i_x''



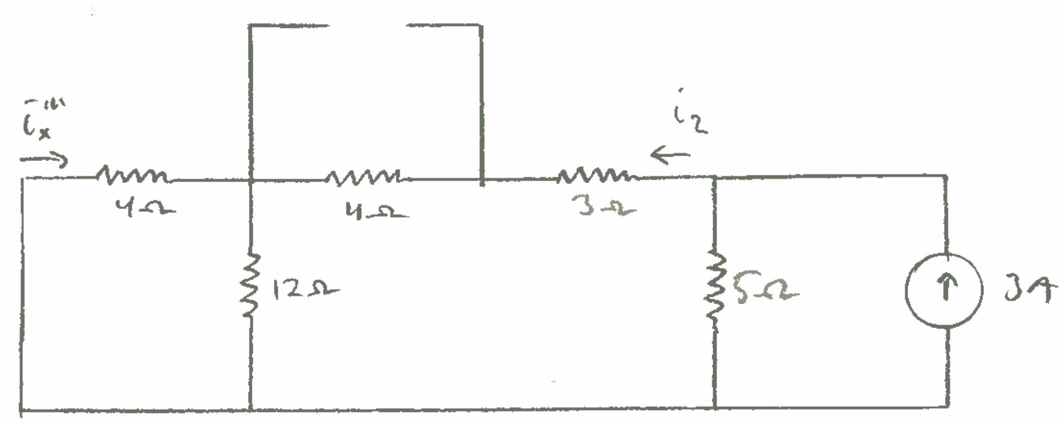
$$4//12 = \frac{4 \cdot 12}{4+12} = 3\,\Omega$$

$$3 + 5 + 3 = 11\,\Omega$$

$$i_1 = 2 \cdot \frac{4}{4+11} = 0.533\text{ A} \quad \text{(current division)}$$

$$i_x'' = -i_1 \cdot \frac{12}{12+4} = -0.4\text{ A}$$

c) i_x due to 3A source, i_x'''



$$4//12 = 3\,\Omega$$

$$3+4+3 = 10\,\Omega$$

$$i_2 = 3 \cdot \frac{5}{5+10} = 1\text{ A}$$

$$i_x''' = -i_2 \cdot \frac{12}{12+4} = -0.75\,A$$

d) Add contributions

$$i_x = i_x' + i_x'' + i_x''' = 1.2 - 0.4 - 0.75 = \underline{0.05\,A}$$