3.71) Firstly, find our ranges

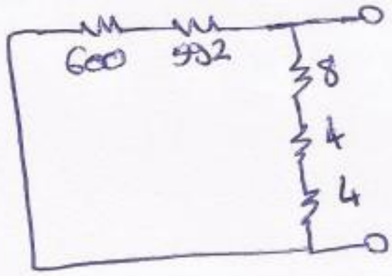
R_{in}: $[588, 612]$ R_{out}: $[3.92, 4.08]$

$[7.84, 8.16]$

$[15.68, 16.32]$

Let's check R_{IN} and R_{out} for '16'. Note voltage source does not affect resistance so we ignore it for the analysis

R_{out}



600 and 592 are series

8, 4, 4 are series

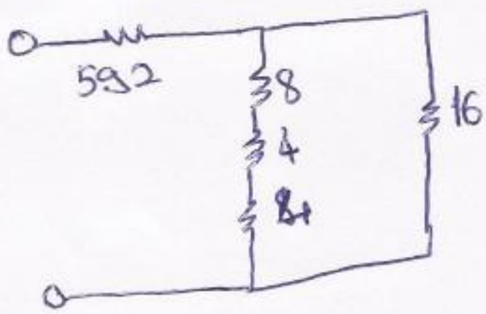
They are parallel to eachother

so $R_{OUT} = \left(\frac{1}{600+592} + \frac{1}{8+4+4} \right)^{-1}$

$= 15.7881$ ✓ (in the range)

3.71) cont.)

R_{in}

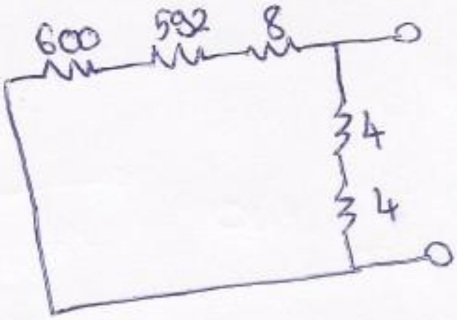


$$R_{in} = 592 + \left(\frac{1}{8+4+4} + \frac{1}{16}\right)^{-1}$$

$$= 600\,\Omega \checkmark$$

Now for "8"

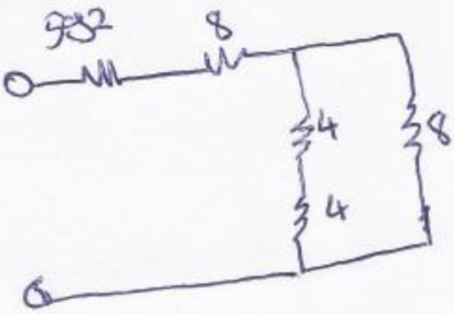
R_{out}



$$R_{out} \left(\frac{1}{600+592+8} + \frac{1}{4+4}\right)^{-1}$$

$$= 7.9470 \checkmark$$

R_{in}



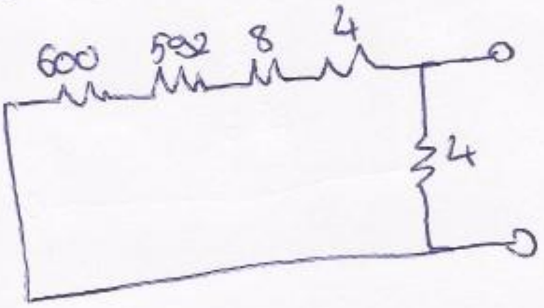
$$R_{in} = 592+8+\left(\frac{1}{4+4}+\frac{1}{8}\right)^{-1}$$

$$= 604\,\Omega \checkmark$$

3.71) cont.

for "4"

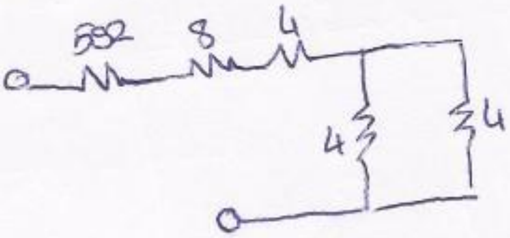
Rout



$$R_{out} = \left(\frac{1}{600+592+8+4} + \frac{1}{4} \right)^{-1}$$

$= 3.9868$ ✓

Rin

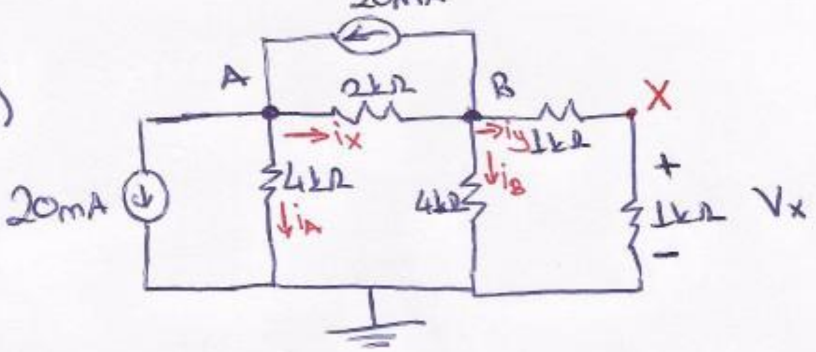


$$R_{in} = 592 + 8 + 4 + \left(\frac{1}{4} + \frac{1}{4} \right)^{-1}$$

$= 606$ ✓

Yes! Their claim is correct.

3.3)



a) Node A , KCL

$20mA - 20mA - i_x - i_A = 0$

Node B , KCL

$i_x - i_y - i_B - 20mA = 0$

$i_A = \dfrac{V_A}{4k\Omega}$ $\quad i_B = \dfrac{V_B}{4k\Omega}$, $i_y = \dfrac{V_B}{(2k\Omega)}$

↳ to get rid of V_x (we will find it at part c), total of series resistance is used ($1k\Omega + 1k\Omega$)

$i_x = \dfrac{V_A - V_B}{2k\Omega}$

Let's substitute currents into the equation we found by KCL

$3V_A = 2V_B$ → from node A

$2V_A - 5V_B = 80$ → from node B

3.3) cont.

b) Substituting $V_A = \frac{2}{3} V_B$ into second equation, we get

$$-\frac{11}{3} V_B = 80 \Rightarrow \boxed{V_B = -21.81\,V}$$

$$V_A = \frac{2}{3}(-21.81)$$

$$\boxed{V_A = -14.54\,V}$$

c) To find i_x, we can use the equation we have already had at part a

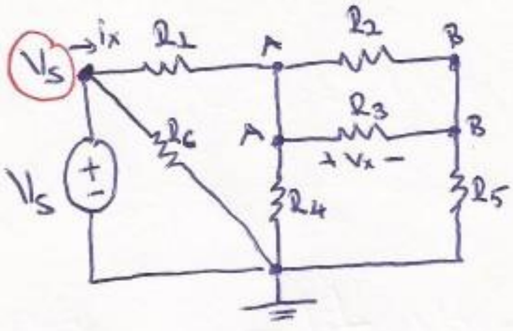
$$\boxed{i_x = \frac{V_A - V_B}{2k\Omega} = \frac{-14.54 + 21.81}{2k\Omega} = 3.635\,mA}$$

Using $V = I\Omega$ formula, we get

$V_x = i_y \cdot (1k\Omega)$, substituting i_y

$$\boxed{V_x = \frac{V_B}{2k\Omega}\,1k\Omega = -10.9\,V}$$

3.6)



a) KCL @ node A

$$\frac{V_s - V_A}{R_1} - \frac{V_A}{R_4} - \frac{V_A - V_B}{R_2} - \frac{V_A - V_B}{R_3} = 0$$

$$\Rightarrow \boxed{V_A\left(-\frac{1}{R_1} - \frac{1}{R_2} - \frac{1}{R_3} - \frac{1}{R_4}\right) - V_B\left(-\frac{1}{R_2} - \frac{1}{R_3}\right) = -\frac{V_s}{R_1}}$$

KCL @ node B

$$\frac{V_A - V_B}{R_2} + \frac{V_A - V_B}{R_3} - \frac{V_B}{R_5} = 0$$

$$\Rightarrow \boxed{V_A\left(\frac{1}{R_2} + \frac{1}{R_3}\right) - V_B\left(\frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_5}\right) = 0}$$

b) $\boxed{i_x = \frac{V_s - V_A}{R_1}}$ $\boxed{V_x = V_A - V_B}$

3.6) b) cont.

$$R_1 = R_2 = R_3 = R_4 = R_5 = R_6 = 10k\Omega$$

$$V_S = 24V$$

Substituting values into the equations for nodes A and B,

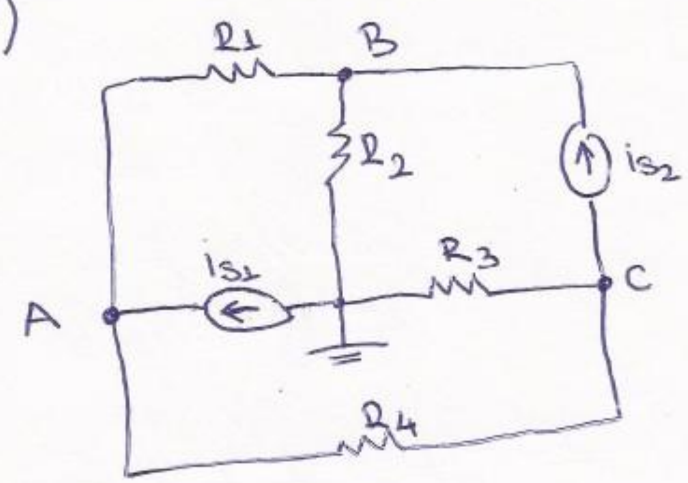
$$-\frac{2}{5}V_A + \frac{1}{5}V_B = -\frac{24}{10}$$

$$\frac{1}{5}V_A - \frac{3}{10}V_B = 0$$

$$\boxed{\begin{array}{l} V_A = 9V \\ V_B = 6V \end{array}}$$

$$\boxed{\begin{array}{l} i_x = \dfrac{24-9}{10k\Omega} = 1.5mA \\ V_x = 9-6 = 3V \end{array}}$$

3.7)



a) KCL @ node A

$$i_{s1} + \frac{V_B - V_A}{R_1} + \frac{V_C - V_A}{R_4} = 0$$

$$\boxed{V_B\left(\frac{1}{R_1}\right) + V_C\left(\frac{1}{R_4}\right) - V_A\left(\frac{1}{R_1} + \frac{1}{R_4}\right) = -i_{s1}}$$

KCL @ node B

$$i_{s2} - \frac{V_B}{R_2} - \frac{V_B - V_A}{R_1} = 0$$

$$\boxed{V_A\left(\frac{1}{R_1}\right) - V_B\left(\frac{1}{R_1} + \frac{1}{R_2}\right) = -i_{s2}}$$

3.7) a) cont.

KCL @ node C

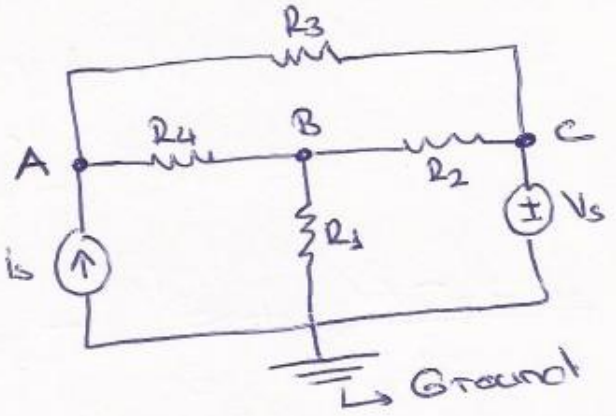
$$-i_{s2} - \frac{V_C}{R_3} + \frac{V_A - V_C}{R_4} = 0$$

$$\boxed{V_A\left(\frac{1}{R_4}\right) - V_C\left(\frac{1}{R_3} + \frac{1}{R_4}\right) = i_{s2}}$$

c) Solving three equation for three uknowns with given values, we get

$$\boxed{V_A = 5.98 \quad , \quad V_B = 5.34 \quad , \quad V_C = -1.41}$$

3.5)



a) Nodal Analysis

KCL @ node A

$$i_s - \frac{V_A - V_B}{R_4} - \frac{V_A - V_C}{R_3} = 0$$

$$\boxed{V_A\left(-\frac{1}{R_4} - \frac{1}{R_3}\right) + V_B\left(\frac{1}{R_4}\right) + V_C\left(\frac{1}{R_3}\right) = -i_s}$$

KCL @ node B

$$\frac{V_A - V_B}{R_4} - V_B\left(\frac{1}{R_1}\right) - \frac{V_B - V_C}{R_2} = 0$$

$$\boxed{V_A\left(\frac{1}{R_4}\right) - V_B\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_4}\right) + V_C\left(\frac{1}{R_2}\right) = 0}$$

3.5) a) cont.

Since we chose reference as shown on the figure, V_c can be easily found as V_s. $\boxed{V_c = V_s}$. Then we have two equations and two unknowns. Substituting the values which are given at part b, we get

$$-2V_A + V_B = -21 \qquad V_B = \frac{61}{5}$$

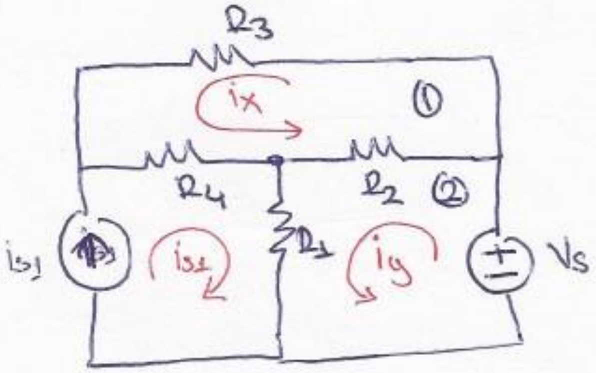
$$V_A - 3V_B = -20 \qquad V_A = \frac{83}{5}$$

$$V_x = V_B - V_s = \frac{61}{5} - 20 = -\frac{39}{5}\,V$$

$$i_x = \frac{V_s - V_A}{R_3} = \left(20 - \frac{83}{5}\right) mA = \frac{17}{5}\,mA$$

3.5) Mesh Analysis

b)



KVL @ mesh 1

$$R_3 i_x + R_4(i_x + i_{s1}) + R_2(i_x - i_y) = 0$$

$$\Rightarrow \boxed{i_x(R_3 + R_4 + R_2) - i_y(R_2) = -i_{s1}(R_4)}$$

KVL @ mesh 2

$$R_2(i_y - i_x) + R_1(i_y + i_{s1}) - V_s = 0$$

$$\Rightarrow \boxed{-i_x(R_2) + i_y(R_1 + R_2) = V_s - R_1 i_{s1}}$$

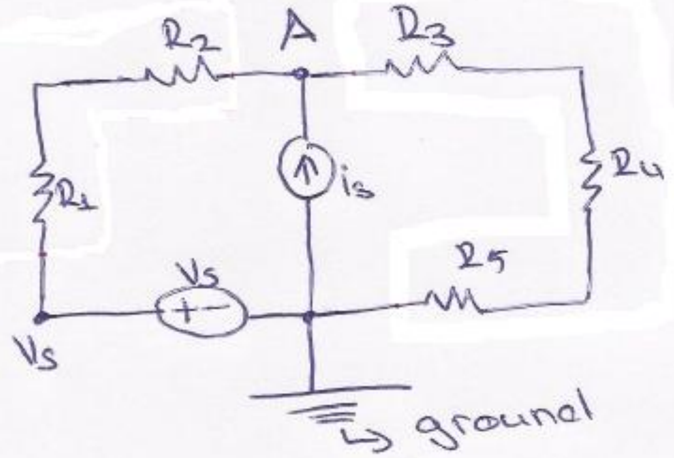
3.5) b) cont. Substituting the given values

$$3i_x - i_y = -1$$
$$-i_x + 2i_y = 19$$

$$\boxed{i_x = \frac{17}{5} \text{ mA} \qquad i_y = \frac{112}{10} \text{ mA}}$$

$$\boxed{V_x = (i_x - i_y) R_2 = \left(\frac{34 - 112}{10}\right) 1 = \frac{-39}{5} \text{ V}}$$

3.12)



a-b)

Nodal Analysis

KCL @ node A

$$i_S + \frac{(V_S - V_A)}{(R_1 + R_2)} - \frac{V_A}{(R_3 + R_4 + R_5)} = 0$$

$$V_A \left(\frac{1}{R_1 + R_2} + \frac{1}{R_3 + R_4 + R_5} \right) = i_S + \frac{V_S}{R_1 + R_2}$$

Solving for VA with given values

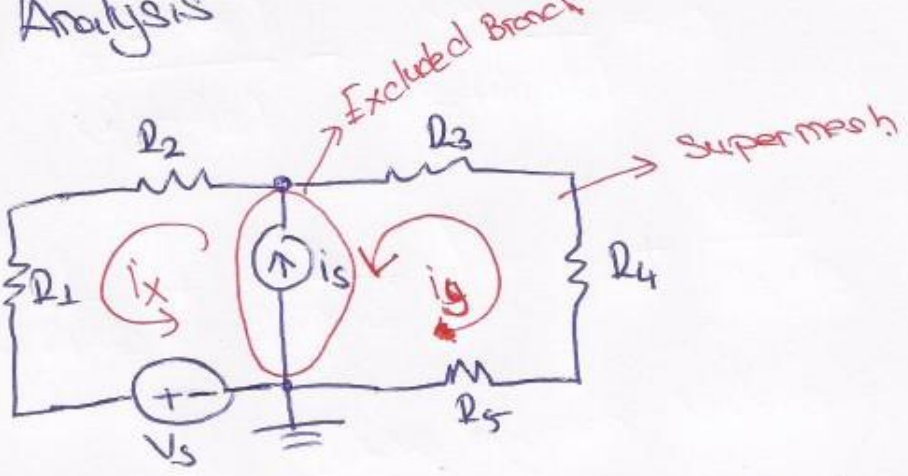
$$\boxed{V_A = \frac{75}{2} \text{ V}}$$

3.12) cont.

$$\boxed{\begin{aligned} i_x &= \frac{V_A - V_S}{R_1+R_2} = 25\,mA \\ V_x &= \underbrace{R_4 \frac{V_A}{(R_3+R_4+R_5)}}_{\text{Current division}} = \frac{75}{4}\,V \end{aligned}}$$

Mesh Analysis

a-b)



$$R_2 i_x + R_1 i_x + V_S + R_3 i_y + R_4 i_y + R_5 i_y = 0$$

$$i_x - i_y = i_s$$

$$\Rightarrow \boxed{i_x (R_1+R_2+R_3+R_4+R_5) = (R_3+R_4+R_5)\, i_s - V_s}$$

3.12) Mesh Analysis cont.

Using the given values, we get

$$\boxed{i_x = 25\text{ mA}}$$

$$i_y = i_x - i_s = 25 - 100 = -75\text{mA}$$

$$V_x = -i_y \cdot R_4 = \frac{75}{4}\text{ V}$$

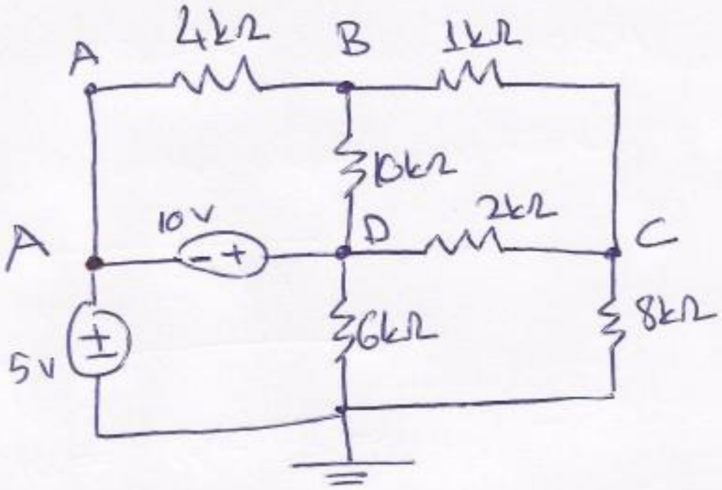
Because of the direction.

c) Power can be found by using $P=VI$ and $P=I^2 \cdot R$ formulas for voltage source and resistors respectively

$$P = i_x^2(R_1+R_2) + i_y^2(R_3+R_4+R_5) + V_s \cdot i_x$$

$$= 3.75\text{ W}$$

3.20)



Nodal Analysis

We can easily find $\boxed{V_A = 5V}$ from the figure and $\boxed{V_D = 15V}$

KCL @ node B

$$\frac{(5V - V_B)}{4k\Omega} - \frac{V_B - 15}{10k\Omega} - \frac{V_B - V_C}{1} = 0$$

$$V_B\left(-\frac{1}{4} - \frac{1}{10} - 1\right) + V_C = -\frac{5}{4} - \frac{15}{10}$$

$$\boxed{-\frac{27}{20} V_B + V_C = \frac{-55}{20}}$$

3.20) cont

KCL @ node C

$$-\frac{V_C}{8} + \frac{V_B - V_C}{1} - \frac{V_C - 15}{2} = 0$$

$$V_B - V_C\left(\frac{1}{8} + 1 + \frac{1}{2}\right) = -\frac{15}{2}$$

$$\boxed{V_B - V_C\,\frac{13}{8} = -\frac{15}{2}}$$

Solving equations for V_A and V_B, we get

$V_B = 10.03$
$V_C = 10.79$

$$i_A = \frac{V_A - V_B}{4k\Omega} = \frac{5 - 10.03}{4} \cong -1.25\,mA$$

$$i_B = \frac{V_B - V_C}{1} = \frac{10.03 - 10.79}{1} = -.76\,mA$$

$$i_C = \frac{V_C}{8} = \frac{10.79}{8} = 1.37\,mA$$

$$i_D = \frac{V_D}{6} + i_C = \frac{15}{6} + 1.37 = 3.87\,mA$$

3.20) (cont) Mesh Analysis

KVL @ mesh A

$4i_A + 10(i_A - i_B) + 10 = 0$

$\Rightarrow i_A(4+10) - i_B(10) = -10$

KVL @ mesh B

$10(i_B - i_A) + 1 i_B + 2(i_B - i_C) = 0$

$\Rightarrow i_A(-10) + i_B(10+1+2) + i_C(-2) = 0$

KVL @ mesh C

$2(i_C - i_B) + 8 i_C + 6(i_C - i_D) = 0$

$\Rightarrow i_B(-2) + i_C(2+8+6) + i_D(-6) = 0$

KVL @ mesh D

$-5 - 10 + 6(i_D - i_C) = 0$

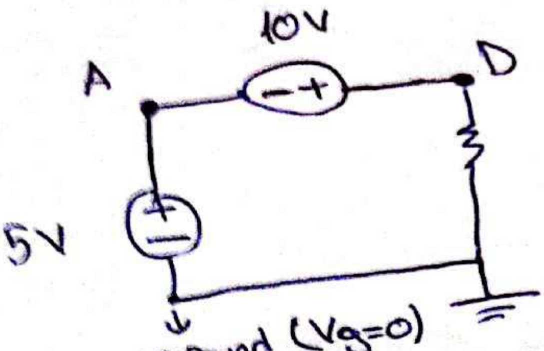
$\Rightarrow i_C(-6) + i_D(6) = 15$

3.20) Solving 4 equations for 4 unknowns,

we obtain

$$\boxed{\begin{aligned} i_A &\cong -1.25 \text{ mA} \\ i_B &\cong -0.76 \text{ mA} \\ i_C &\cong 1.35 \text{ mA} \\ i_D &\cong 3.85 \text{ mA} \end{aligned}}$$

P.S. Explanation about node D: we do not need to use KCL @ node to find V_D since we can justify that by following the potential differences between nodes



$V_A - V_G = 5$ and $V_G = 0$

$\Rightarrow \boxed{V_A = 5}$

Same way

$V_D - V_A = 10$ and $V_A = 5$

$\Rightarrow \boxed{V_D = 15}$