19/06/2022

K. SREE INDIRA SIVANI
1602-21-733-052
CSE-A

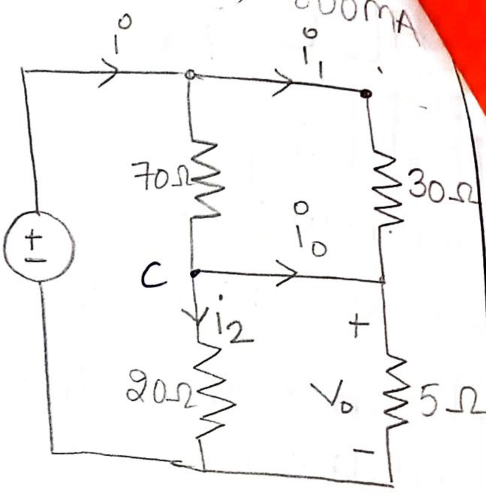
BEE ASSIGNMENT-1

1) Following the voltmeter setup of Fig: 2.6; design a voltmeter for the following multiple ranges:

(a) 0-1 V (b) 0-5 V (c) 0-50 V. (d) 0-100 V.

Assume that the internal resistance $R_m = 2k\Omega$ and the full scale current $I_{fs} = 100\mu A$

2) Calculate V_o and I_o in the circuit. 32V, 800mA



* 70Ω ||el 30Ω

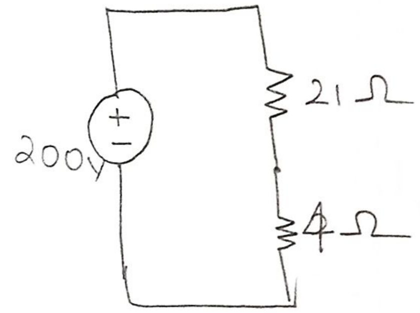
let $R_1 = \frac{7\cancel{0} \times 3\cancel{0}}{10\cancel{0}} = 21\Omega$

Voltage across $R_1 \Rightarrow V_1$

* ∵ Resistors 5Ω & 20Ω are ||el.

$R_2 = \frac{5 \times 20}{25} = 4\Omega$

∴ Voltage across R_2 is $\underline{\underline{V_o}}$



Total current $i = \frac{200}{21+4} = 8A$

current across '70Ω' is i_1

current across 20Ω is i_2.

$V_1 = 21i = 21 \times 8 = 168V$

$V_2 = 4i = 4 \times 8 = 32V$

$i_2 = \frac{32}{20} = 1.6A$

$i_1 = \frac{V_1}{70} = \frac{168}{70} = \frac{84}{35} = \frac{12}{5}$

$\boxed{i_1 = 2.4A}$

at C:

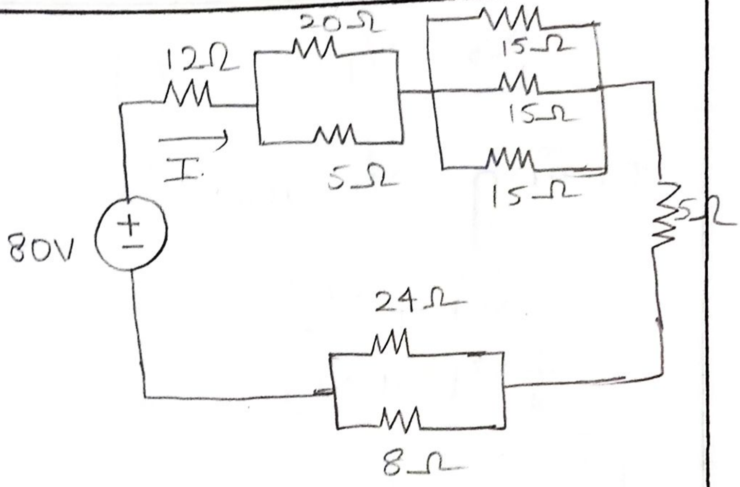
$i_1 = i_o + i_2$

$i_o = 2.4 - 1.6 = \underline{0.8A} = 800mA.$

∴ Current flowing through 5Ω resistor $= 800mA$

Voltage across 5Ω is $32V$.

3) Find I in the circuit:



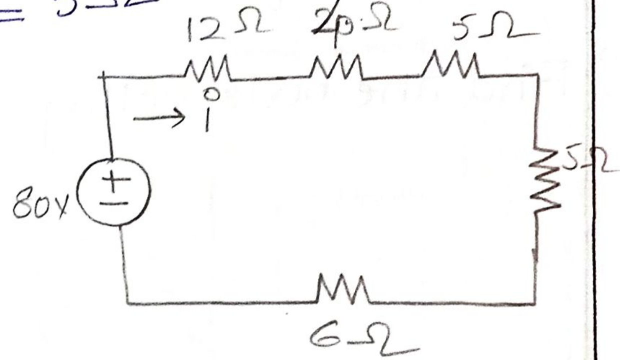
∴ $R_1 = 12\,\Omega$

$$R_2 = \frac{20\times5}{20+5} = 4\,\Omega$$

$$R_3 = 15 \parallel (15\parallel15)$$

$$= 15 \parallel \left(\frac{\cancel{15}\times15}{\cancel{30}_{2}}\right)$$

$$= 15 \parallel \frac{15}{2} \Rightarrow \frac{15\times15/\cancel{2}}{\frac{45}{\cancel{2}}} = 5\,\Omega$$



$R_4 = 5\,\Omega$

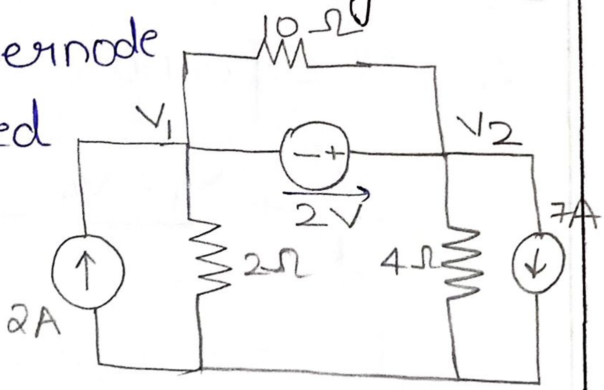
$$R_5 = \frac{\cancel{24}^{3}\times\cancel{8}^{2}}{\cancel{32}_{4}} = 6\,\Omega$$

$$R_{eq} = 12+4+5+5+6 = 32\,\Omega$$

$$i = \frac{80}{32} = \frac{5}{2} = 2{\cdot}5\,A$$

4) For the circuit shown; find the node voltages:

∴ V_1, 2V, V_2 become a supernode and 10 Ω resistor is included



∴ At super node.

Apply KCL

$$2 = \frac{V_1-0}{2} + \frac{V_2-0}{4} + 7$$

$$-5 = \frac{2V_1+V_2}{4}$$

$$\boxed{2V_1+V_2 = -20} \quad \text{— (1)}$$

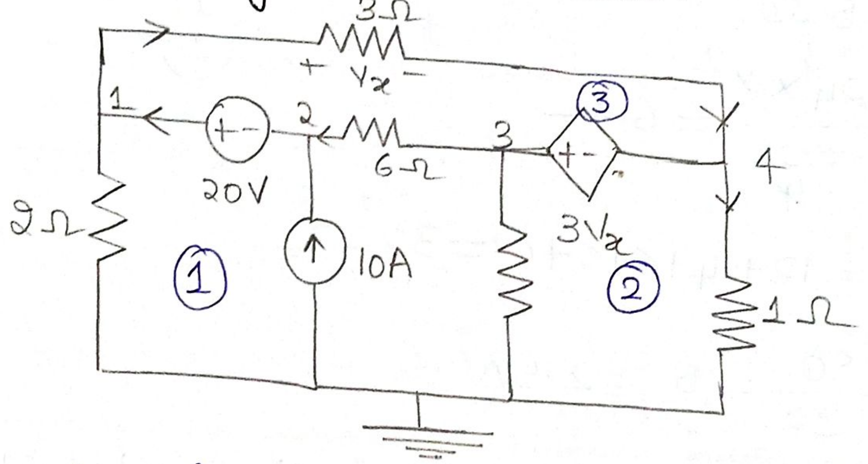
$$\boxed{V_2 - V_1 = 2V} \quad \text{— (2)}$$

Solving V_1 and V_2

$$2V_1 + \cancel{V_2} = -20$$
$$\mp V_1 \pm \cancel{V_2} = 2$$
$$3V_1 = -22$$
$$\boxed{V_1 = -7.33V}$$

$$V_2 = 2 + V_1$$
$$= 2 - 7.33V$$
$$\boxed{V_2 = -5.33V}$$

5) Find the node voltages in the circuit:



1 and 2 nodes forms a super node.

∴ at super node apply KCL

$$\frac{V_1}{2} + \frac{V_1 - V_4}{3} = 10 + \frac{V_3 - V_2}{6}$$

$$3V_1 + 2V_1 - 2V_4 = 60 + V_3 - V_2$$

$$\boxed{5V_1 + V_2 - V_3 - 2V_4 = 60} \quad \text{— (1)}$$

$$\boxed{V_1 - V_2 = 20} \quad \text{— (2)} \qquad V_1 = 20 + V_2$$

* 3 and 4 form a supernode

at super node ; apply KCL

$$\frac{V_3}{4} + \frac{V_3 - V_2}{6} + \frac{V_4}{1} = \frac{V_1 - V_4}{3}$$

$$3V_3 + 2V_3 - 2V_2 + 12V_4 = 4V_1 - 4V_4$$

$$\boxed{4V_1 - 5V_3 + 2V_2 - 16V_4 = 0} \quad -(3)$$

$$\boxed{V_3 - V_4 = 3V_x} \quad -(4)$$

~~Apply KVL in each loop~~

(1)

$$V_x = V_1 - V_4$$

$$V_3 - V_4 = 3V_1 - 3V_4$$

$$\boxed{3V_1 - V_3 - 2V_4 = 0}$$

$$V_1 = V_2 + 20$$

$$\boxed{3V_2 - V_3 - 2V_4 = -60} \quad -(6)$$

$$\boxed{6V_2 - 5V_3 - 16V_4 = -80} \quad -(7)$$

(1) becomes

$$100 + 5V_2 + V_2 - V_3 - 2V_4 = 0$$

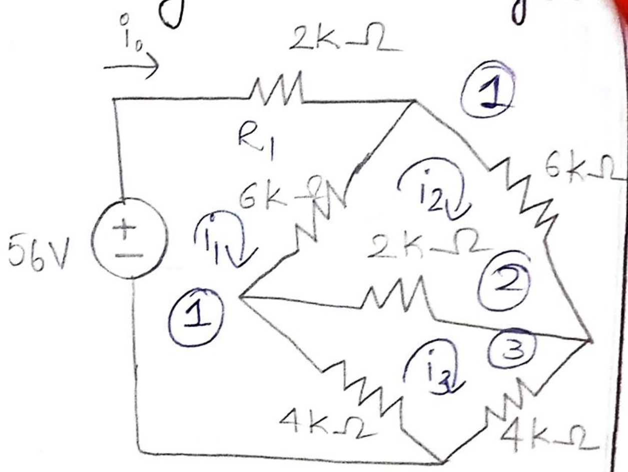
$$\boxed{6V_2 - V_3 - 2V_4 = -40} \quad -(5)$$

Solve (5), (6), (7) to get V_2, V_3, V_4.

$V_2 = +6.67V$ $\quad$ $V_3 = 173.33V$ $\quad$ $V_4 = -46.66V$

$V_1 = 26.67V$

5) For the bridge network; find i_o using mesh analysis.



∵ 1 forms a Wheat-stone bridge

∴ 2kΩ resistor can be ignored.

∴ $R_1 = 2k\Omega$

~~R2~~

For mesh 1

$$+56 - 2i_1 - 6(i_1 - i_2) - 4(i_1 - i_3) = 0$$

$$56 = 12i_1 - 6i_2 - 4i_3 \Rightarrow \boxed{6i_1 - 3i_2 - 2i_3 = 28} \quad -1$$

For mesh 2

$$-6(i_2 - i_1) - 6i_2 - 2(i_2 - i_3) = 0$$

$$-14i_2 + 6i_1 + 2i_3 = 0$$

$$\boxed{3i_1 - 7i_2 + i_3 = 0} \quad -2$$

For mesh 3

$$-2(i_3 - i_2) - 4i_3 - 4(i_3 - i_1) = 0$$

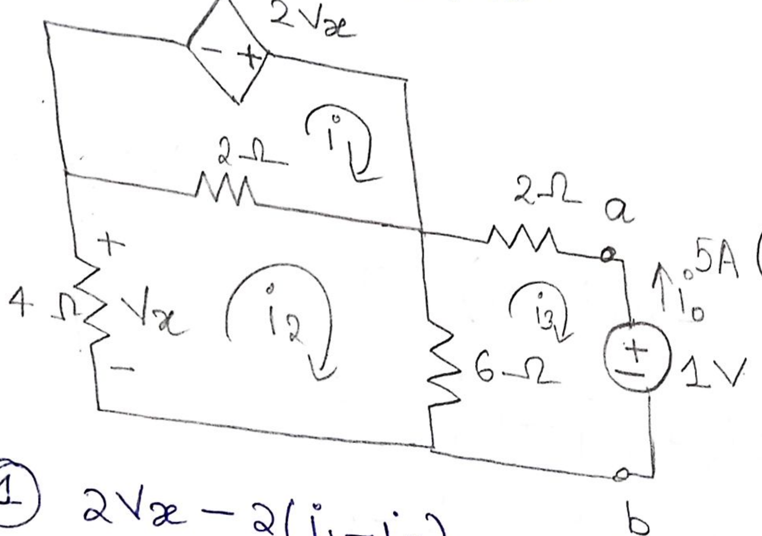
$$-10i_3 + 2i_2 + 4i_1 = 0$$

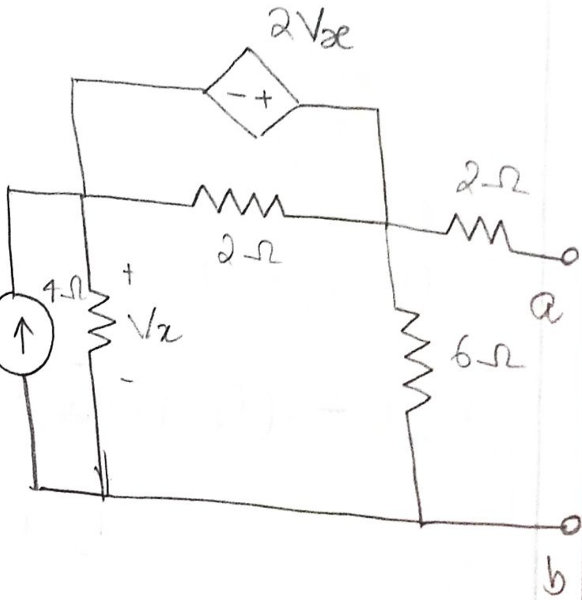
$$\boxed{2i_1 + i_2 - 5i_3 = 0} \quad -3$$

$$\boxed{\begin{aligned} i_1 &= i_o = 8mA \\ i_2 &= i_3 = 4mA \end{aligned}}$$

) Find the Thevenin equivalent of the circuit at terminals a and b.

i) Remove current source:





(1) $2V_x - 2(i_1 - i_2) = 0$

$\boxed{V_x = i_1 - i_2} = -4i_2.$

$\boxed{i_1 = -3i_2}$

(2) $-4i_2 - 2(i_2 - i_1) - 6(i_2 - i_3) = 0$

$-12i_2 + 2i_1 + 6i_3 = 0.$

$6i_2 - i_1 - 3i_3 = 0.$

$6i_2 + 3i_2 - 3i_3 = 0$

$9i_2 = 3i_3$

$i_3 = 3i_2.$

(3) $-6(i_3 - i_2) - 2i_3 - 1 = 0$

$-8i_3 + 6i_2 - 1 = 0.$

$8i_3 - 6i_2 + 1 = 0.$

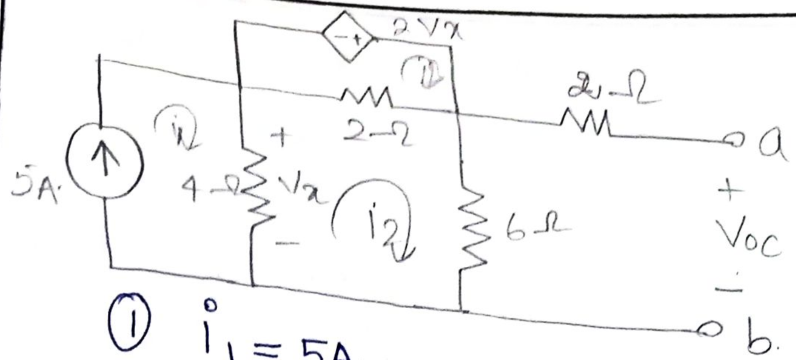
$24i_2 - 6i_2 + 1 = 0$

$i_2 = -1/18\ A$

$\boxed{i_3 = \frac{-1}{6}\ A}$

$\boxed{i_1 = +\frac{1}{6}\ A}$

$R_{Th} = \frac{1V}{-1/6} = 6\Omega$



① $i_1 = 5A$

② $-2(i_2-i_3) - V_{oc} - 4(i_2-i_1) = 0$ $\qquad V_{oc} = 6i_2$

$-6i_2 + 2i_3 + 4i_1 - 6i_2 = 0$

$6i_2 - 2i_3 - 4i_1 + 6i_2 = 0$

$6i_2 - i_3 - 2i_1 = 0$

$\boxed{6i_2 - i_3 = 10}$

③ $-2V_x + 2(i_3 - i_2) = 0$ $\qquad 4(i_1 - i_2) = V_x$

$i_3 - i_2 = V_x$ $\qquad 4(5 - i_2) = V_x$

$i_3 - i_2 = 20 - 4i_2$

$3i_2 + i_3 = 20$

$6i_2 - i_3 = 10$

$9i_2 = 30$

$\boxed{i_2 = \frac{10}{3} A}$

$\therefore V_{oc} = 6i_2$

$= 6 \times \frac{10}{3}$

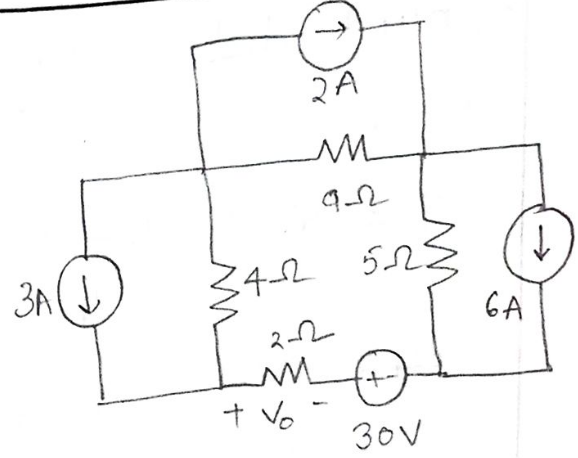
$\boxed{V_{oc} = 20V}$

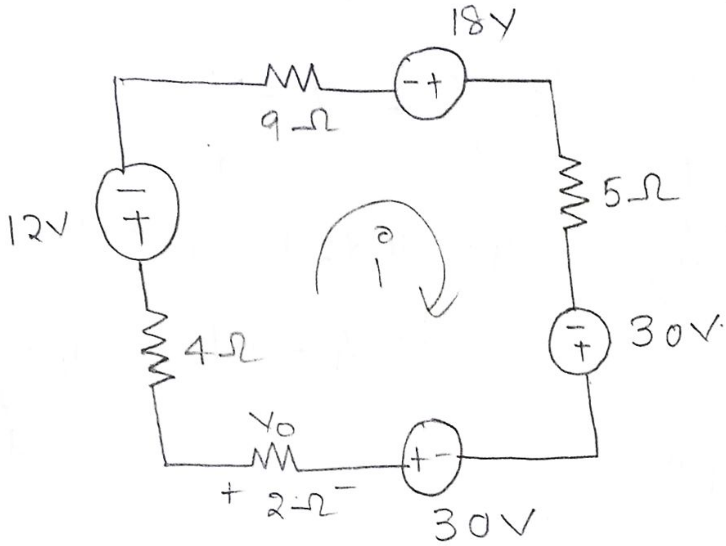
7) Obtain V_o in the circuit using source transformation. Convert current sources 3A, 2A and 5A into voltage source forming single mesh.

$\Rightarrow V_1 = 3 \times 4 = 12V$

$V_2 = 5 \times 6 = 30V$

$V_3 = 9 \times 2 = 18V$





Applying KVL

$$-4i - 12 - 9i + 18 - 5i + 30 + 30 - 2i = 0$$

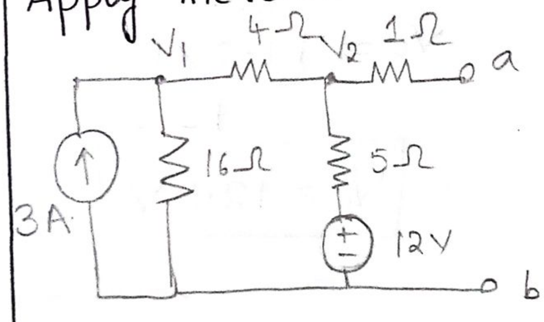
$$-i(20) + 66 = 0$$

$$i = \frac{66}{20} = \frac{33}{10}$$

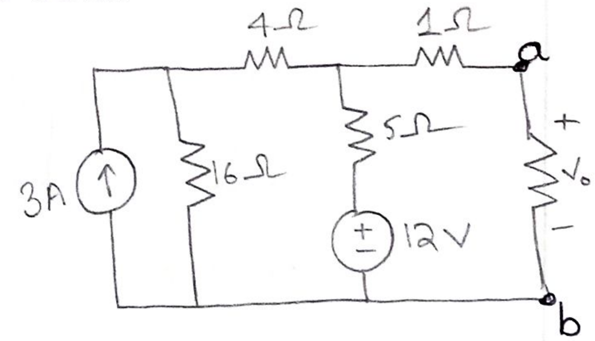
$$i = 3.3A$$

$$\boxed{V_o = 2i = 6.6V}$$

8) Apply Thevenin's theorem to find V_o in the circuit



$\Leftarrow$



Apply Nodal analysis:

at V_1

$$3 = \frac{V_1}{16} + \frac{V_1 - V_2}{4}$$

$$48 = V_1 + 4V_1 - 4V_2$$

$$\boxed{5V_1 - 4V_2 = 48} \quad -(1)$$

at V_2:

$$\cancel{-\frac{V_2 - 12}{5} - \frac{V_2 - V_1}{}}$$

$$\frac{12 - V_2}{5} + \frac{V_1 - V_2}{4} = 0$$

$$48 - 4V_2 + 5V_1 - 5V_2 = 0$$

$$\boxed{5V_1 - 9V_2 = -48} \quad -(2)$$

Solve (1) & (2)

$$\cancel{5V_1} - 4V_2 = 48$$

$$-\cancel{5V_1} \underset{+}{-} 9V_2 = \underset{+}{-}48$$

$$5V_2 = 96$$

$$V_2 = \frac{96}{5} = 19.2\,V$$

$$\boxed{V_2 = V_{Th} = 19.2V}$$

For R_{Th}

$$\cancel{(1+5) \parallel (4+16)}$$

$$\cancel{= 6 \parallel 20}$$

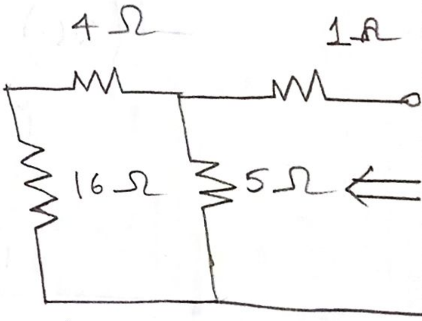
$$\cancel{R_{Th} = \frac{6 \times 20}{26}}$$

For R_{Th}

$$= 1 + (5 \parallel (4+16))$$

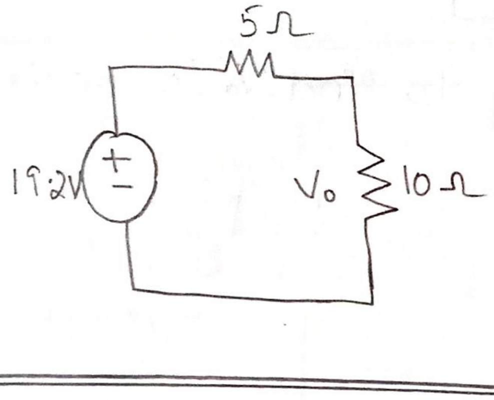
$$= 1 + \frac{5 \times 20}{25}$$

$$= 1 + 4 = 5\Omega$$



$$\boxed{R_{Th} = 5\Omega}$$

$\Rightarrow$

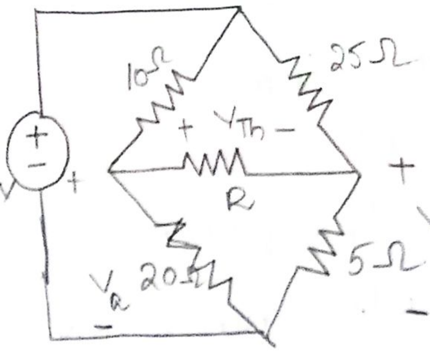


$$V_o = \frac{\overset{6.4}{\cancel{19.2}} \times \overset{3}{\cancel{10}}}{\cancel{+5}\,\cancel{15}}$$

$$\boxed{V_o = 12.8V}$$

7) Determine the maximum power that can be delivered to the variable resistor R.

Thevenin's equivalent at R



$R_{Th} = 10 \| 20 + 25 \| 5$

$= \frac{10 \times 2\cancel{0}}{3\cancel{0}} + \frac{25 \times \cancel{5}}{\cancel{30}\,6}$

$= \frac{20}{3} + \frac{25}{6}$

$\boxed{R_{Th} = \frac{65}{6}\,\Omega}$

Voltage division Rule:

$V_a = \frac{20}{\cancel{30}} \times \cancel{60}\,2$

$\boxed{V_a = 40V}$

$V_a - V_{Th} - V_b = 0$

$\boxed{V_{Th} = 30V}$

$V_b = \frac{5}{30} \times 60$

$\boxed{V_b = 10V}$

$P_{max} = \frac{V_{Th}^2}{4R_{Th}} = \frac{(30)^2 \times \cancel{6}\,3}{\cancel{4}\,2 \times 65} = \frac{\cancel{900}\,\cancel{180}\,90 \times 3}{\cancel{2} \times \cancel{65}\,13} = \frac{270}{13}$

$\boxed{P_{max} = 20.77W}$

10) The Thevenin equivalent at terminals a-b of the linear network shown is to be determined by measurement. When a 10k-Ω resistor is connected to terminals a-b; the voltage Vab is measured as 6V. When a 30 k-Ω resistor is connected to terminals Vab is measured as 12V. Determine

(a) The Thevenin equivalent at terminals a-b

(b) Vab when a 20k-Ω resistor is connected to terminals a-b.