ESC201A Assignment 2

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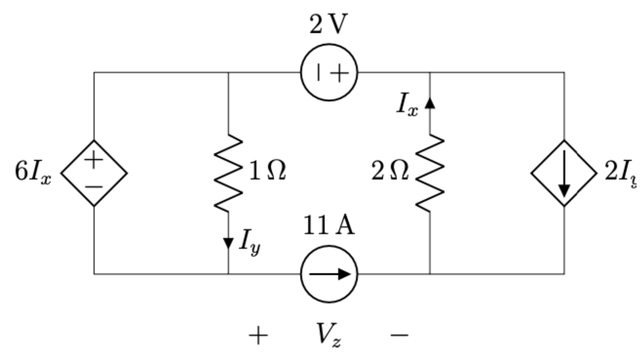
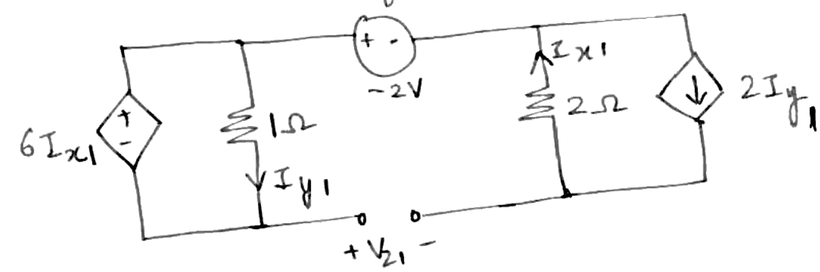
2023-2024 Semester I

Que 1.

Determine I_x, I_y and V_z using superposition:



Ans4. (i) Contribution of −2V source:



$$6I_{x1} = 1 \times I_{y1} \quad -(1)$$

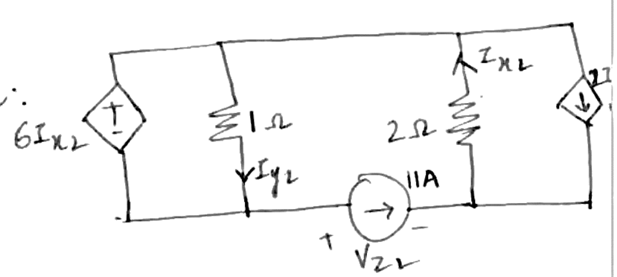
$$2I_{y1} = I_{x1} \quad -(2)$$

$$\Rightarrow I_{x1} = I_{y1} = 0$$

Also, $-V_{z1} - 1 \times I_{y1} + (-2V) - 2 \times I_{x1} = 0$

$\therefore \quad V_{z1} = -2\,V$

(ii) Contribution of 11A source:



$V_{1\Omega} = 6I_{x2}$

$V_{1\Omega} = 1 \times I_{y2}$

$\Rightarrow 6I_{x2} = I_{y2}$

$11 = I_{x2} - 2I_{y2}$

$\therefore \quad I_{x2} = -1A, \quad I_{y2} = -6A$

Also, $\quad 2I_{x2} + I_{y2} + V_{z2} = 0$

$\Rightarrow V_{z2} = 8V$

$\therefore \; I_x = I_{x1} + I_{x2} = -1A$

$I_y = I_{y1} + I_{y2} = -6A$

$V_z = V_{z1} + V_{z2} = 6V$

Que 2

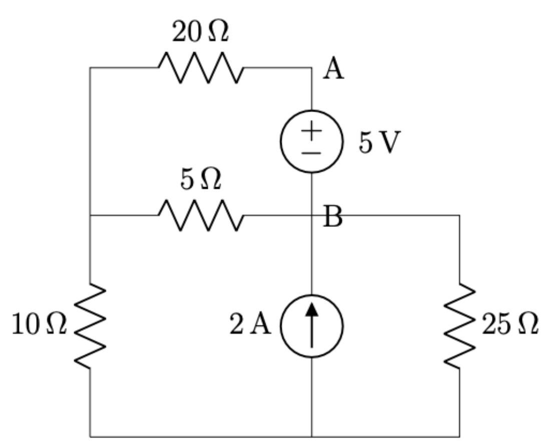
Determine the power supplied by the 5V source using

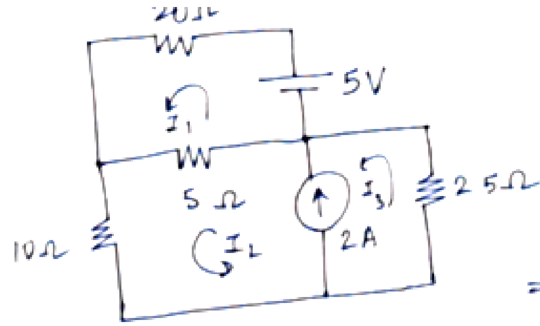
(a) Mesh analysis

(b) Nodal analysis

(c) Superposition principle

(d) Thevenin's equivalent circuit between terminals A and B.





$$20I_1 + 10I_2 + 25I_3 = 5$$

$$I_2 - I_3 = 2$$

$$\therefore 20I_1 + 10I_2 + 25I_2 = 55$$

$$\Rightarrow 20I_1 + 35I_2 = 55$$

$$\Rightarrow 4I_1 + 7I_2 = 11 \quad \text{—— (1)}$$

$$20I_1 + 5(I_1 - I_2) = 5$$

$$\Rightarrow 25I_1 - \frac{5}{7}(11 - 4I_1) = 5$$

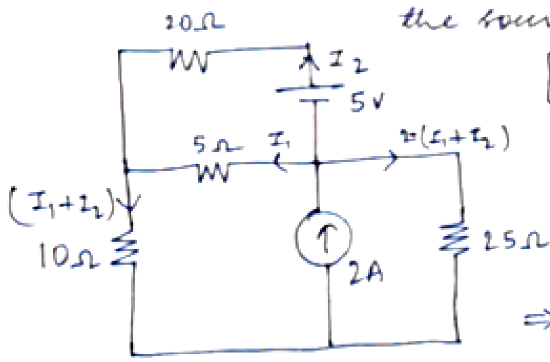
$$\Rightarrow 25I_1 - \frac{55}{7} + \frac{20}{7}I_1 = 5$$

$$\Rightarrow I_1 = \frac{\left(5 + \frac{55}{7}\right)}{\left(25 + \frac{20}{7}\right)} = 0.46\text{A}$$

$$\therefore P_{5V} = -0.46 \times 5 \text{ W} = -2.31\text{W}$$

Shows that power is supplied by the source

(b)



$$[10(I_1 + I_2) + 20I_2] - [25(2 - I_1 - I_2)] = 5$$

$$\Rightarrow 10I_1 + 30I_2 - 50 + 25I_1 + 25I_2 = 5$$

$$\Rightarrow 11I_2 + 7I_1 = 11 \quad \text{—— (1)}$$

$$10(I_1 + I_2) + 5I_1 = (2 - I_1 - I_2)25$$

$$\Rightarrow 15I_1 + 10I_2 = 50 - 25I_1 - 25I_2$$

$$\Rightarrow 40I_1 + 35I_2 = 50$$

$$\Rightarrow 8I_1 + 7I_2 = 10 \quad \text{—— (2)}$$

From (1) and (2),

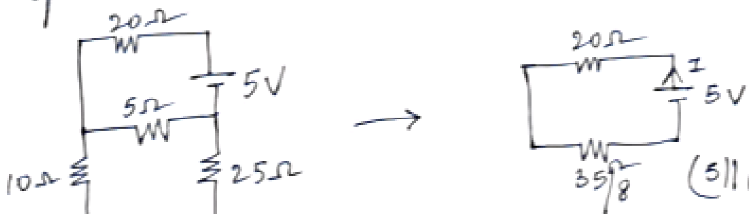
$$11I_2 + \frac{7}{8}\left(10 - 7I_2\right) = 11$$

$$\Rightarrow \left(11 - \frac{49}{8}\right) I_2 = 11 - \frac{70}{8}$$

$$\Rightarrow I_2 = 0.46A$$

$$\therefore P_{5V} = -0.46 \times 5W = -2.31W$$

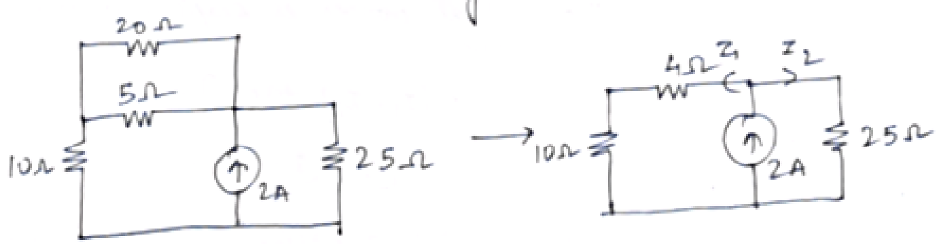
(c) Open circuit current source:



$(5 \| (10+25))$

$$\therefore I = \frac{5}{20 + \frac{35}{8}} A = 0.2A$$

Short circuit voltage source:



$I_2 = 2 - I_1$

$$25\left(2 - I_1\right) = I_1\left(10+4\right) \Rightarrow I_1 = 1.28A$$

$\cancel{5(1.28)}\ 5i_A = 20(I_1 - i_A)$

$$\Rightarrow i_A\left(5+20\right) = 20I_1$$

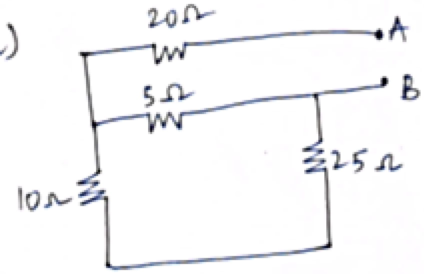
$$\Rightarrow i_A = \frac{4}{5} I_1$$

$$\Rightarrow I_1 - i_A = \frac{I_1}{5} = 0.26A$$

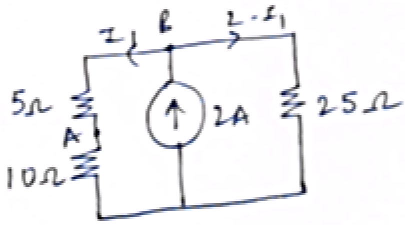
$\therefore I = 0.2A + 0.26A = 0.46A$

$P_{5V} = -0.46A \times 5V = -2.31W$

(d)

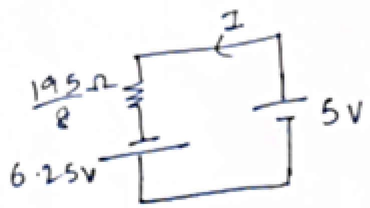


$\rightarrow R_{TH} = 20 + (5 \parallel (10+25)) = \frac{195}{8}\,\Omega$



$I_1 = \frac{2 \times 25}{25+10+5}\,A = 1.25\,A$

$\therefore V_{AB} = -5I_1 = -6.25V = V_{TH}$



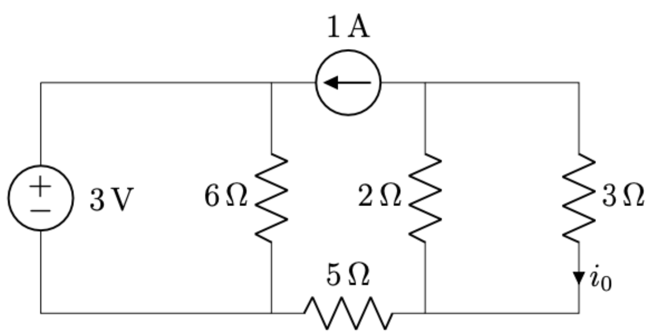
$(6.25 + 5) = I\left(\frac{195}{8}\right)$

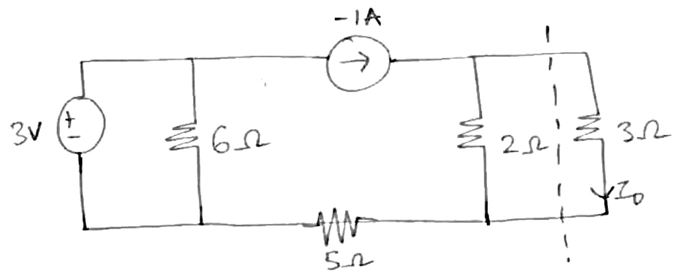
$\Rightarrow I = 0.46\,A$

$\therefore P_{5V} = -0.46 \times 5W = -2.31W$

Que 3

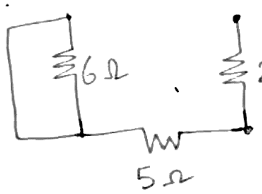
Use Thevenin's theorem to determine i_o.



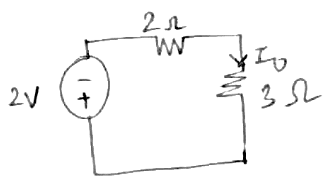


$$I_{2\Omega} = -1\text{A} \quad \Rightarrow V_{TH} = 2 \times -1\text{V} = -2\text{V}$$

R_{TH}:



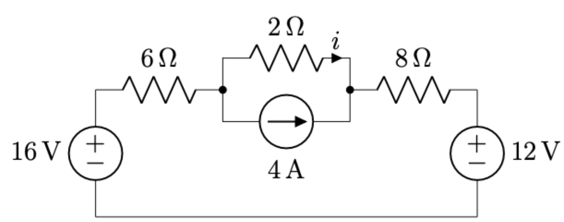
$$\Rightarrow R_{TH} = 2\Omega$$

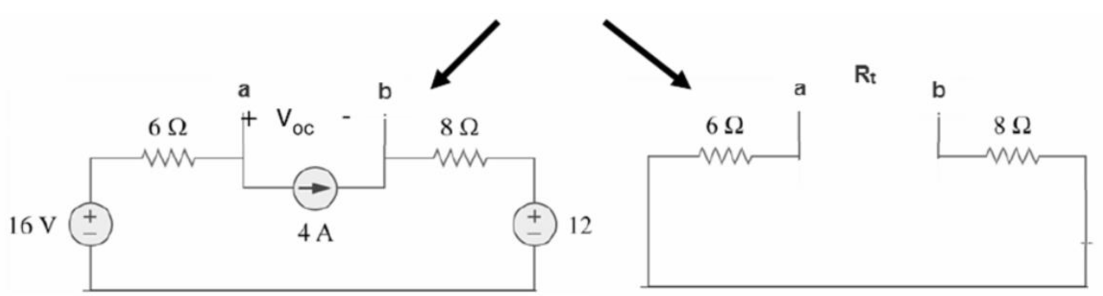


$$\therefore \quad I_0 = \frac{-2}{2+3}\text{A} = -\frac{2}{5}\text{A}$$

Que 4

Determine current i through 2Ω resistor by building Thevenin's equivalent for the rest of the circuit.



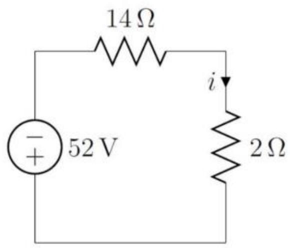


$$-16 + 4 \times 6 + v_{OC} + 4 \times 8 + 12 = 0$$

$$R_t = 14\Omega$$

$$v_{OC} = -52V$$

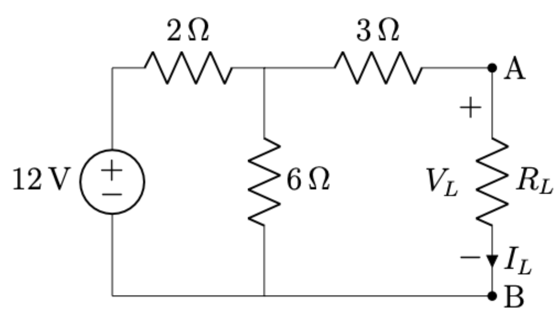
Now, the original circuit can be represented as,



Clearly $i = -3.25A$.

Que 5.

Find Voltage V_L across the load resister R_L, and the current I_L flowing through the load resistor R_L, in the below circuit, by using Norton's Theorem. Where $R_L = 1.5\Omega$.



To compute I_N, we will short circuit terminal AB. Then the current supplied from 12V source is

$$I = \frac{12\text{V}}{2 + 6||3} = 3\text{A}$$

From current division, the current in AB is 2A. Hence, $I_N = 2\text{A}$,

To calculate the R_N, we will short circuit the voltage source. Looking from terminal A-B, the resistance is (2||6 +3)= 4.5 ohm.

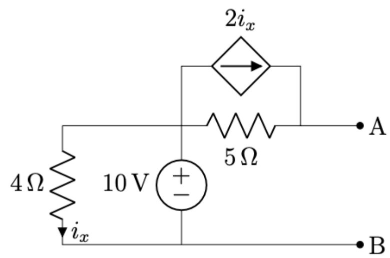
Now, from current division, the current in R_L will be

$$I_l = I_N \frac{4.5}{4.5 + 1.5} = 1.5A$$

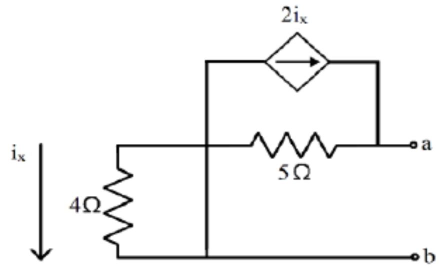
Voltage across R_L is $V_L = I_l R_L = 2.25V$.

Que 6.

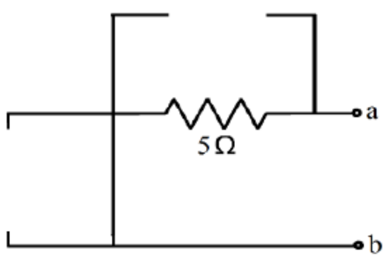
Find the Norton resistance R_N, and the Norton current I_N, at the terminals $A - B$.



Solution: Short the independent voltage source as shown below.

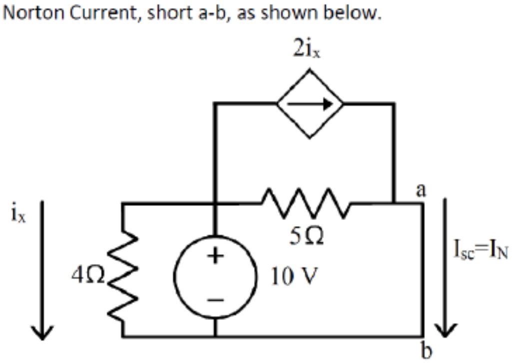


Now, $i_x = 0 \Rightarrow 2i_x = 0$, i.e. the dependent current source is open.



Therefore, $\boldsymbol{R_N = 5\Omega}$

To find the Norton Current, short a-b, as shown below.



All the branches are in parallel. Therefore,

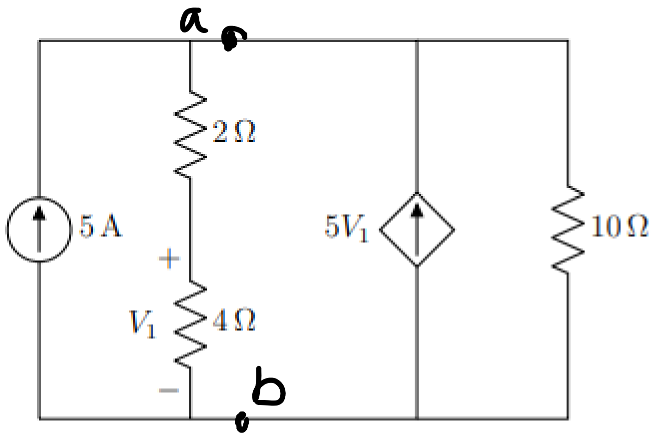
$$i_x = \frac{10}{4} = 2.5A$$

Applying KCL at node a,

$$I_{sc} = I_N = \frac{10}{5} + 2i_x = \boldsymbol{7A}$$

Que 7.

Determine the power dissipated in the 10Ω resistor in the following circuit



tage at node a be V and let b be reference node. Applying KCL at node a,

$$-5 + \frac{V}{6} - 5v_1 + \frac{V}{10} = 0 \quad \text{——(1)}$$

Also, by voltage division,

$$v_1 = \frac{V \times 4}{2+4} = \frac{4V}{6} = \frac{2V}{3} \quad \text{—(2)}$$

From (1) and (2),

$$-5 + \frac{V}{6} - 5\left(\frac{2V}{3}\right) + \frac{V}{10} = 0$$

$$\Rightarrow \frac{V}{6} - \frac{10V}{3} + \frac{V}{10} = 5$$

$$\Rightarrow \frac{5V - 100V + 3V}{30} = 5$$

$$\Rightarrow -92V = 5 \times 30$$

$$\Rightarrow V = -\frac{5 \times 30}{92} \text{ V}$$

$\therefore$ Power across 10Ω $= \left(\frac{5 \times 30}{92}\right)^2 \times \frac{1}{10}$ W

$= \frac{25 \times 900}{920 \times 92}$ W $= 265.83$ mW

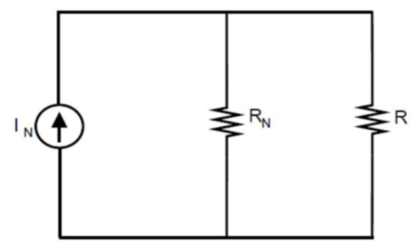
Que 8.

A practical current source provides $10W$ to 250Ω load and, $20W$ to 80Ω load. A resistance R_L with voltage v_L across it, and with current i_L through it, is connected to the source. Find the values of R_L, v_L, and i_L if,

(a) $v_L.i_L$ is maximum.

(b) v_L is maximum.

(c) i_L is maximum.



10 W to 250 Ω corresponds to 200mA. Similarly, 20W to 80 Ω corresponds to 500 mA. By Voltage division, we have

$$I_R = I_N \frac{R_N}{R + R_N}$$

So, we have

$$0.2 = I_N \frac{R_N}{250 + R_N}$$

$$0.5 = I_N \frac{R_N}{80 + R_N}$$

Solving, we get I_N=1.7 A and R_N= 33.33 Ω.

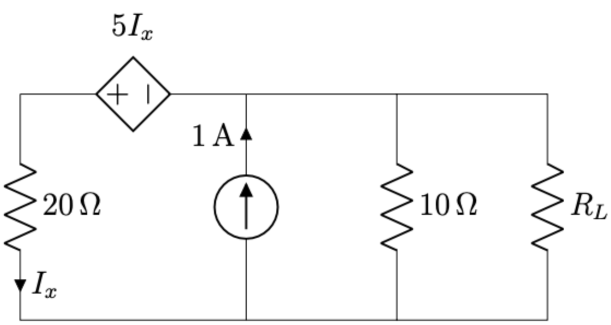
(a) If $v_L i_L$ is a maximum, then we have $R_L = R_N = 33.33\ \Omega, i_L = 1.7 \times \frac{33.33}{33.33+33.33} = 850$ mA, v_L= 33.33 i_L = 28.33 V

(b) If v_L is a maximum, then $v_L = I_N(R_N||R_L)$. Then v_L is a maximum when $R_N||R_L$ is a maximum, which occurs at $R_L = \infty$. Then $i_L = 0$ and $v_L = 1.7 \times R_N = 56.66$ V.

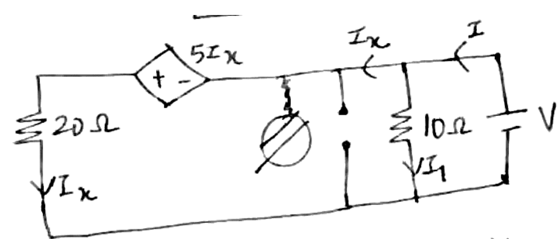
(c) If i_L is a maximum, then $i_L = i_N \frac{R_N}{R_N+R_L}$ is maximum when $R_L = 0\ \Omega$. So, $i_L = 1.7A$, and $v_L = 0\ V$.

Que 9.

Determine the value of R_L in the below circuit, such that maximum power is delivered into R_L. Calculate the value of the maximum power.



For maximum power transfer, $R_L = R_{TH}$.

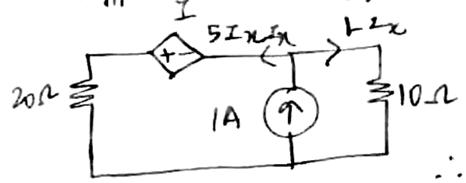


$$\frac{V+5I_x}{20} = I_x$$

$$\Rightarrow V = 15 I_x \quad —(1)$$

$$\frac{V}{10} = I_1 \Rightarrow I = I_1 + I_x = \frac{V}{10} + \frac{V}{15} = \frac{V}{6}$$

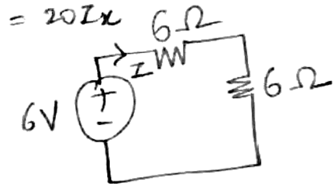
$$\therefore R_{TH} = \frac{V}{I} = V/V\left(\frac{1}{6}\right) = 6\Omega$$



KVL: $10(1-I_x) + 5I_x = 20I_x$

$$\Rightarrow I_x = \frac{2}{5}\text{ A}$$

$$\therefore V_{oc} = \left(1-\frac{2}{5}\right) \times 10 = 6V$$



$$I = \frac{6}{12}A = 0.5A$$

$$\therefore P_{max} = (0.5)^2 \times 6\,W = 1.5W$$