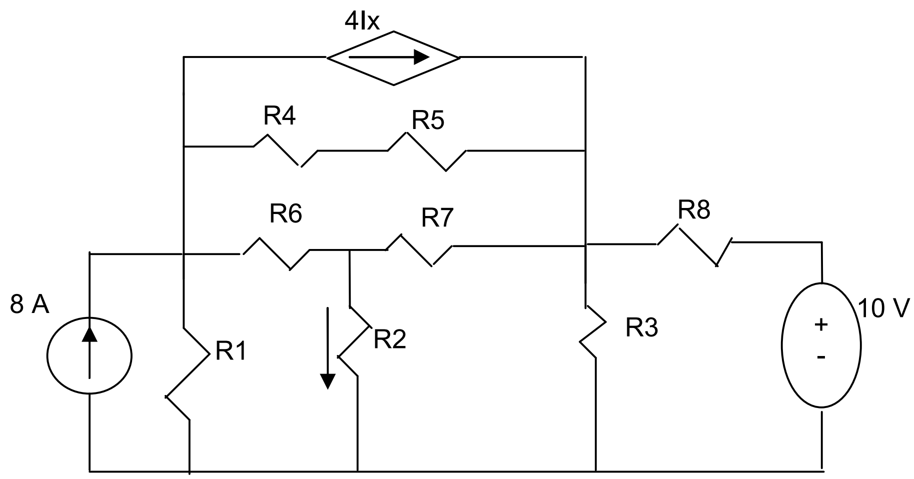
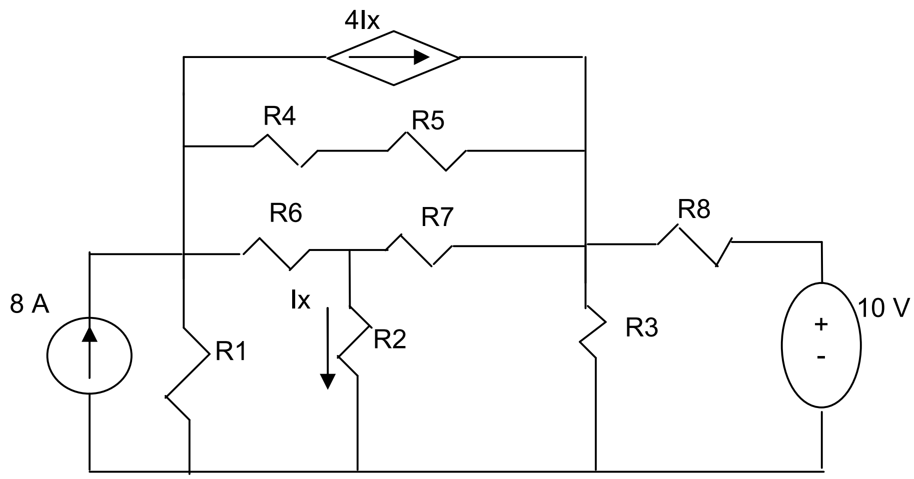
Fundamentals of Electrical Circuits - Chapter 4

1S. For the following circuit find:
a) Number of Branches
b) Number of Branches with unknown current
c) Number of Essential Branches
d) Number of Essential Branches with unknown current
e) Number of Nodes
f) Number of Essential Nodes
g) Number of Meshes



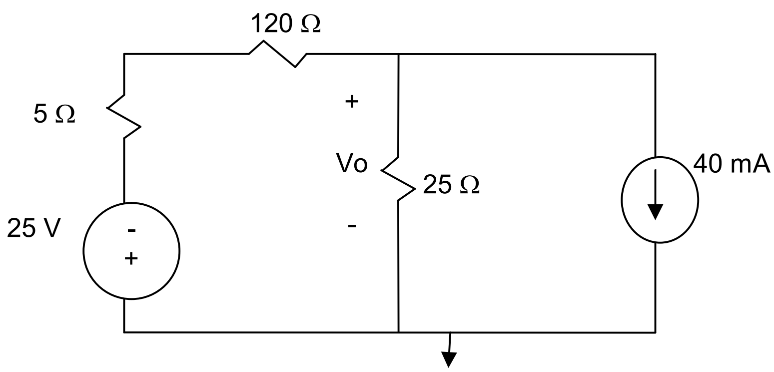
Solution:
a) Number of Branches = 11
b) Number of Branches with unknown current = 9
c) Number of Essential Branches = 9
d) Number of Essential Branches with unknown current = 7
e) Number of Nodes = 6
f) Number of Essential Nodes = 4
g) Number of Meshes = 6

1U. For the following circuit:
a) How many independent equations can be derived using Kirchhoff's Current Law (KCL)?
b) How many independent equations can be derived using Kirchhoff's Voltage Law (KVL)?
c) What two meshes should be avoided in applying Kirchhoff's Voltage Law (KVL)?



Solution:

2S. Use the node-voltage method to find Vo in the circuit shown below.



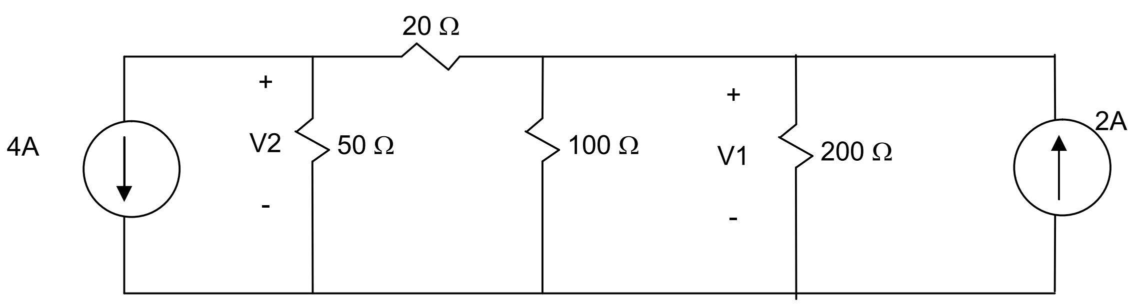
Solution:

$$\frac{V_0-(-25)}{125}+\frac{V_0}{25}+40*10^{-3}=0$$

$$6V_0=-30$$

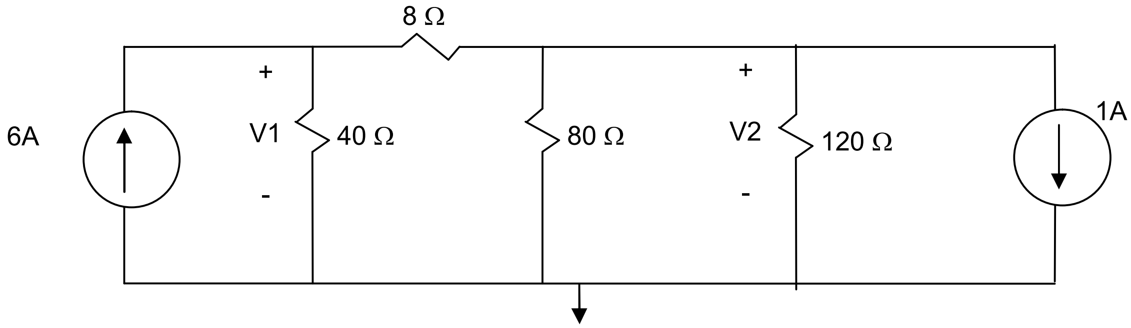
$$V_0=-5$$

2U. Use the node-Voltage method to find V_1 and V_2 in the following circuit.



Solution:

2Sb. Use the node-Voltage method to find V1 and V2 in the following circuit.



Solution:

Three Nodes so we need to write two Node-Voltage equations:

Node V_1 → $-6 + V_1/40 + (V_1 - V_2)/8 = 0$

Node V_2 → $1 + V_2/120 + V_2/80 + (V_2 - V_1)/8 = 0$

Solve two unknowns, two equations

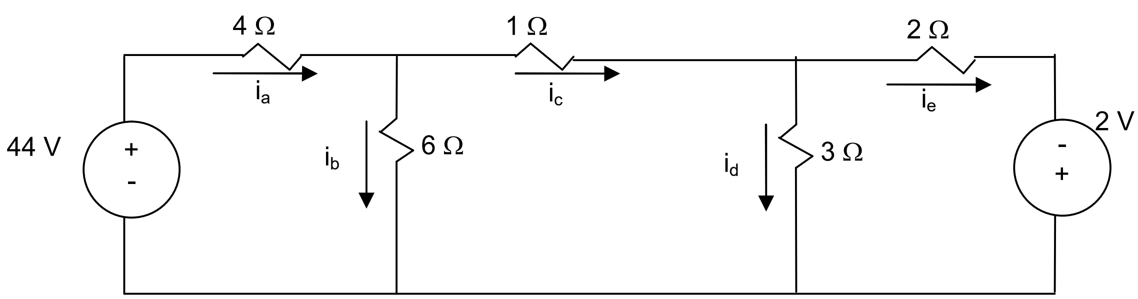
$6V_1 - 5V_2 = 240$

$-30\,V_1 + 35\,V_2 = -240$

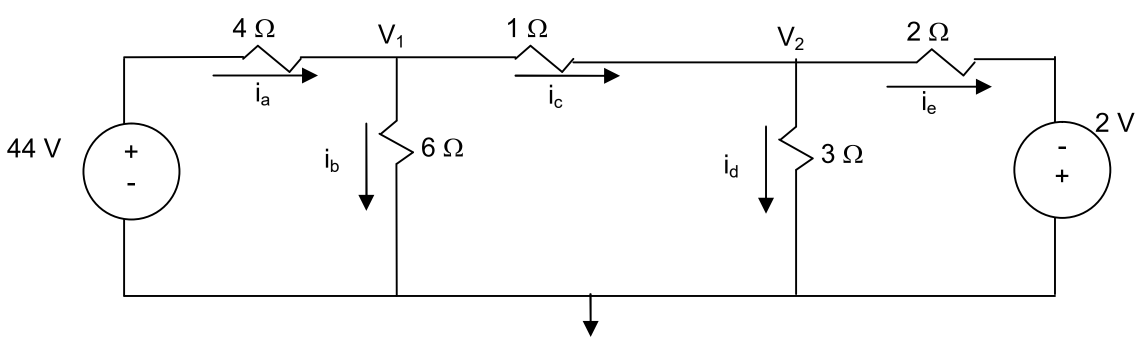
$V_1 = 120$ V and $V_2 = 96$ V

2Sc. a) Use the node-voltage method to find the branch currents ($i_a - i_e$) in the circuit shown below.

b) Find the total power developed in the circuit.



Solution:



a) Three essential nodes so we can write 2 Node-Voltage Equations:

$$\frac{V_1-44}{4}+\frac{V_1}{6}+\frac{V_1-V_2}{1}=0$$

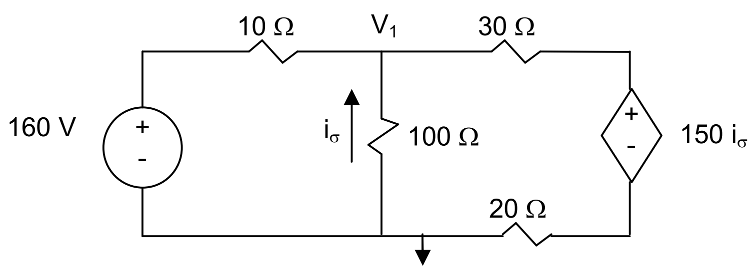
$$\frac{V_2-(-2)}{2}+\frac{V_2}{3}+\frac{V_2-V_1}{1}=0$$

$$17V_1-12V_2=132$$
$$-6V_1+11V_2=-6$$

$$V_1=12 \quad and \quad V_2=6$$
$$\therefore$$
$$i_a=8A; \quad i_b=2A; \quad i_c=6A; \quad i_d=2A; \quad i_e=4A;$$
$$i_a-i_e=8-4=4A$$

b) $P_{total\ develped}$ =?
$P_{total\ develped}$ =-4*(8)^2- 6*(2)^2- 1*(6)^2- 3*(2)^2- 2*(4)^2 = -360W

3S. Use the node-voltage method to calculate the power delivered by the dependent voltage source in the following circuit.



Solution:
There is only one node and one reference node → one node-voltage equation

$$\frac{V_1-160}{10}+\frac{V_1}{100}+\frac{V_1-150i_\sigma}{50}=0 \quad and \quad i_\sigma=-\frac{V_1}{100}$$

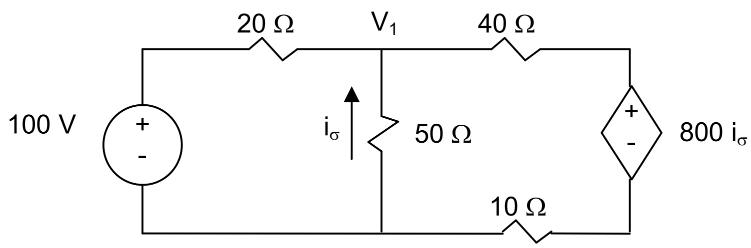
$$\text{Re}\,place\ i_\sigma\ in\ first\ equation \Rightarrow \frac{V_1-160}{10}+\frac{V_1}{100}+\frac{V_1+1.5V_1}{50}=0 \Rightarrow V_1=100\ V$$

$$Dependent\ Voltage=V_d=150i_\sigma=-\frac{150V_1}{100}=-150\ \ V$$

$$50\Omega\ Current=I_{50\Omega}=\frac{V_1-V_d}{50}=\frac{100-(-150)}{50}=5$$

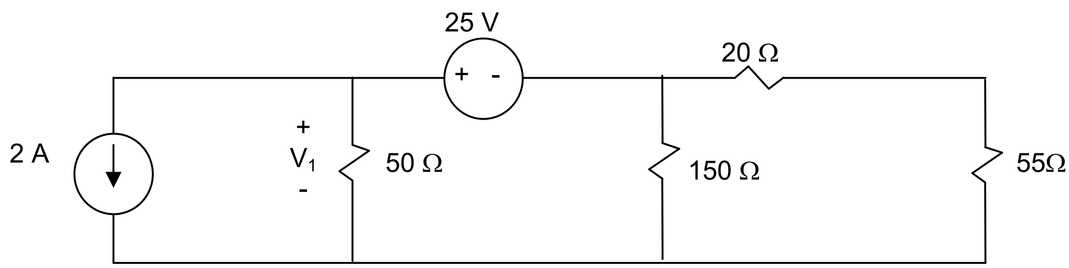
$$P_{Dependent\ Source}=V_d*I_{30\Omega}=(-150)*(5)=-750\,W\ delivered$$

3U. Use the node-voltage method to calculate the power delivered by the dependent voltage source in the following circuit.

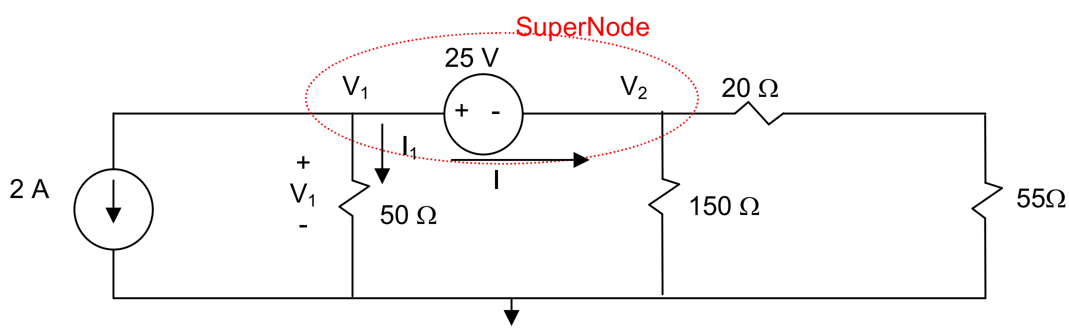


Solution:

4S. Use the node-voltage method to find V1 and the power delivered by the 25 V voltage source in the following circuit,



Solution: P_{25V} **= ?**



Use SuperNode technique (V_1 & V_2):
KCL for Super Node (all current out of suppernode) → $2 + V_1/50 + V_2/150 + V_2/75 = 0$
We also have the relationship between nodes in supper node → $V_1 - V_2 = 25$

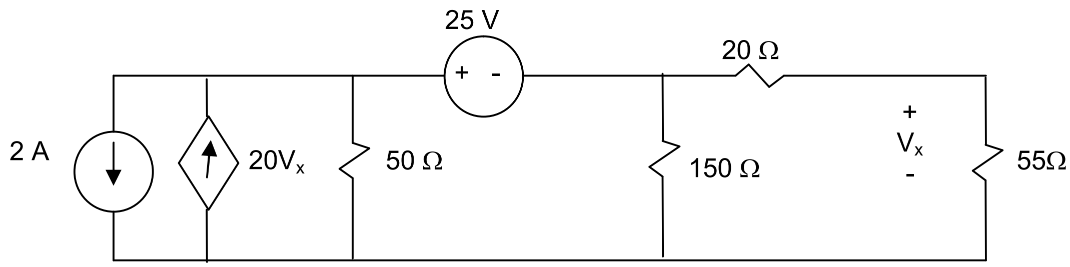
$V_1 = -37.5$ V; $V_2 = -62.5$ V;

$I_1 = V_1/50 = -37.5/50 = -0.75$ A

KCL at node V_1 → $2 - 0.75 + I = 0$ → $I = -1.25$ A

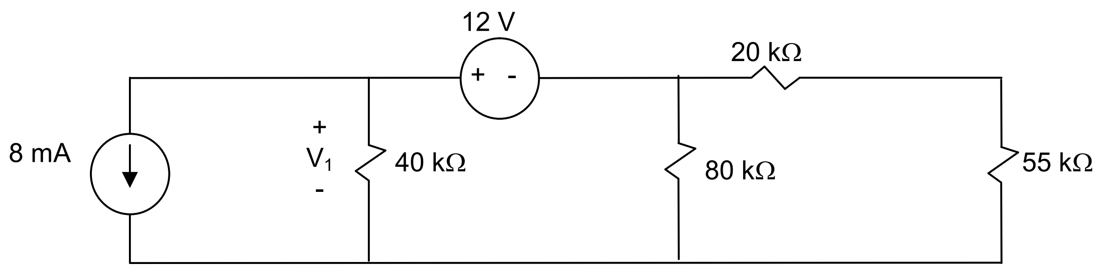
$P_{25V} = V_1 * I = (25)*(-1.25) = -31.25$ W delivered.

4U. Use the node-voltage method to find Vx and the power consumed by the 55 Ω resistor in the following circuit:

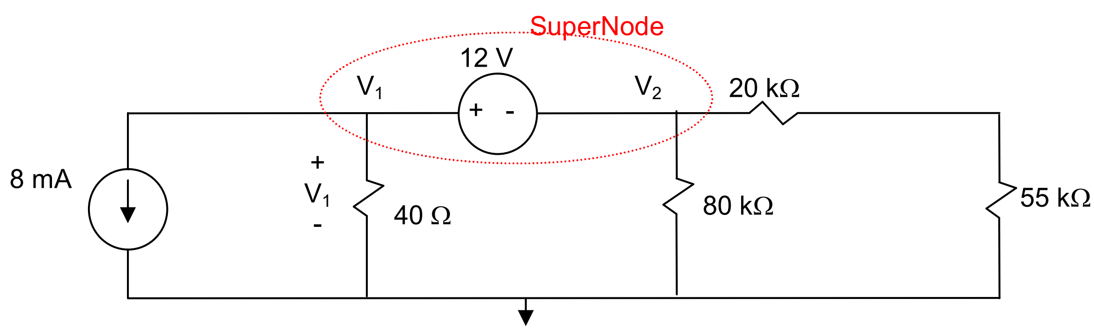


Solution:

4Sb. Use the node-voltage method to find V_1 in the following circuit,



Solution:



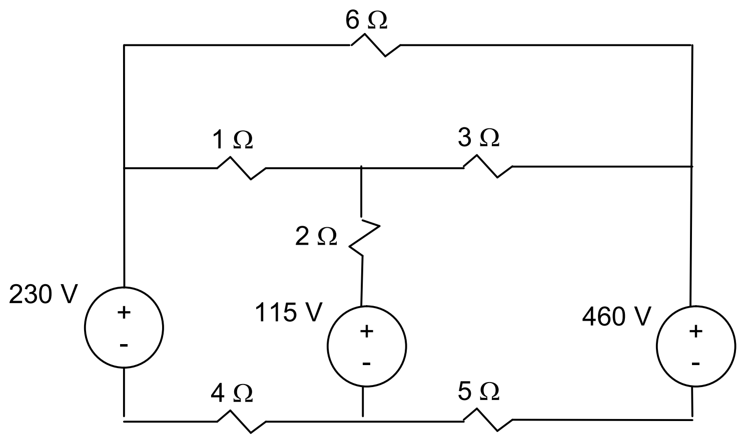
Use SuperNode technique (V_1 & V_2):

KCL for Super Node (all current out of SuperNode) → 8 + $V_1/40 + V_2/80 + V_2/75 = 0$ → $(1/40)V_1 + (1/80+1/75)V_2=-8$

We also have the relationship between nodes in supper node → $V_1 - V_2 = 12$

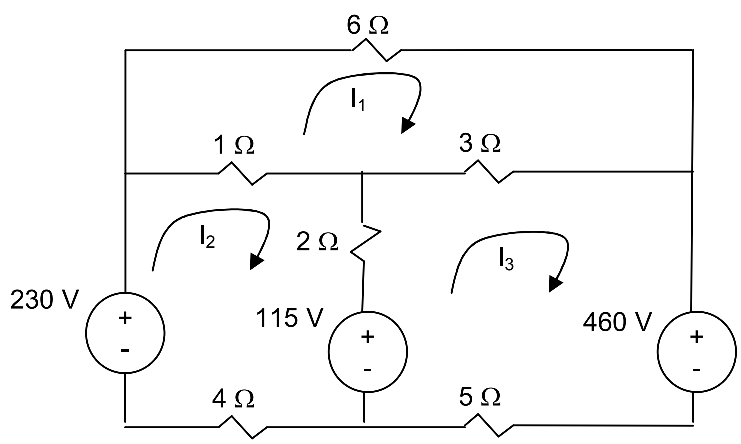
<u>V_1= -151.3 V;</u>

5S. a) Use the mesh-current method to find the total power developed in the following circuit.
b) Check your answer by showing that the total power developed equals the total power dissipated.



Solution:

a) Applu Mesh-Current to find total power developed



Loop #1 KVL → $6I_1 + 3\,(I_1 - I_3) + (I_1 - I_2) = 0$
Loop #2 KVL → $-230 + (I_2 - I_1) + 2(I_2 - I_3) + 115 + 4I_2 = 0$
Loop #3 KVL → $460 + 5\,I_3 - 115 + 2(I_3 - I_2) + 3(I_3 - I_1) = 0$

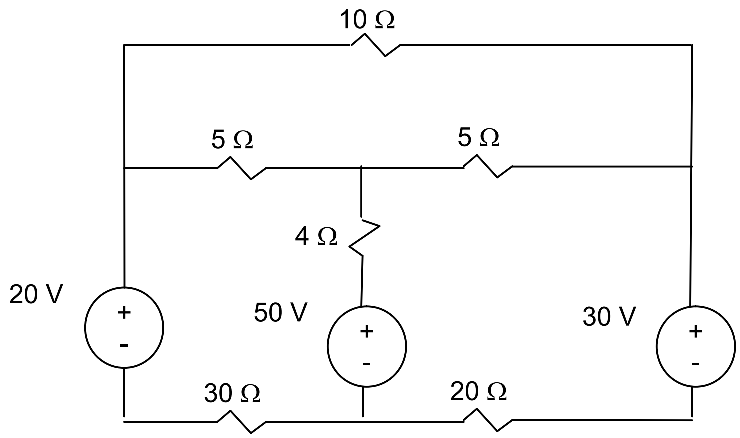
$I_1 = -10.6A$; $I_2 = 4.4A$; $I_3 = -36.8A$;

$P_{230V} = 230 * I_2 = 230*(4.4) = -1{,}012$ W Developed
$P_{115V} = 115*(I_2 - I_3) = 115*(4.4 - (-36.8)) = 4{,}738$ W Consumed
$P_{460V} = 460 * I_2 = 460*(-36.8) = -16{,}928$ W Developed

$P_{\text{Total developed}} = P_{230V} + P_{460V} = -1{,}012 - 16{,}928 = 17{,}940$ W

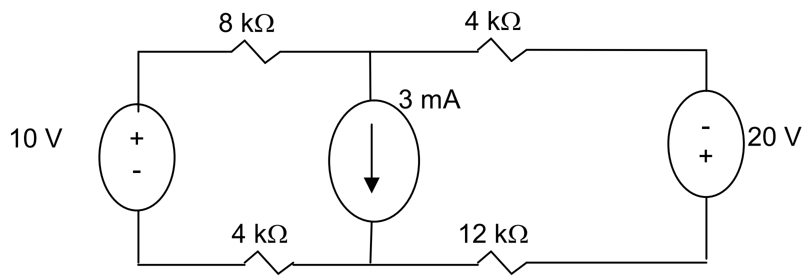
b) $P_{\text{Total developed}} = P_{\text{Total consumed}}$?
$P_{\text{Total consumed}} = 6(I_1)^2 + 3(I_1 - I_3)^2 + (I_1 - I_2)^2 + 2(I_2 - I_3)^2 + 4(I_2)^2 + 5(I_3)^2 + P_{115V}$
$= 6(-10.6)^2 + 3(-10.6 - (-36.8))^2 + (-10.6 - 4.4)^2 + 2(4.4 - (-36.8))^2 + 4(4.4)^2 + 5(-36.8)^2 + P_{115V}$
$P_{\text{Total consumed}} = P_{\text{Total developed}} = 17940$ → Answer checked.

5U. a) Use the mesh-current method to find the total power developed in the following circuit.
b) Check your answer by showing that the magnitude of total power developed equals the total power dissipated.

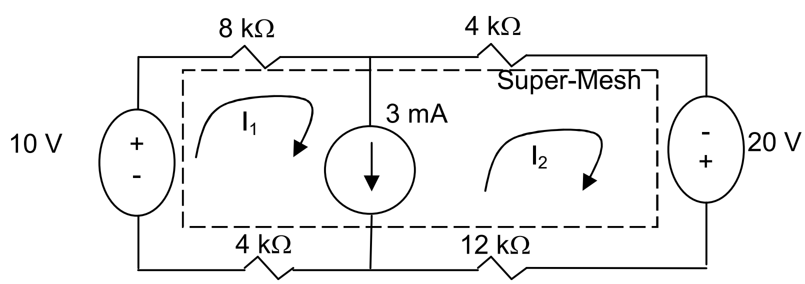


Solution:

5Sb. Use the mesh-current method to find the total power consumed in the circuit shown below.



Solution:



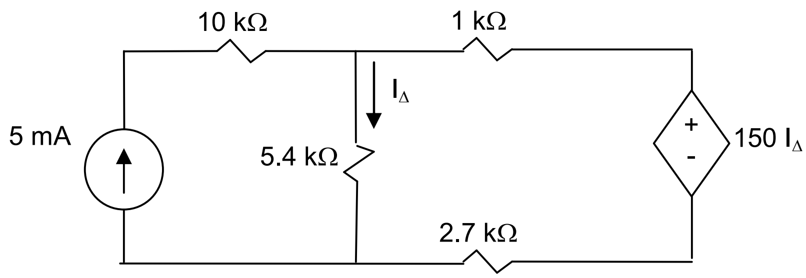
Super-Mesh KVL → $-10 + 8\ I_1 + 4\ I_2 - 20 + 12\ I_2 + 4I_1 = 0$ → $12\ I_1 + 16\ I_2 = 30$
Relationship of two mesh within super-mesh → $I_1 - I_2 = 3$

$I_1 = 2.8$ mA ; $I_2 = -0.2$ mA;

Resistors and the 20v Source are consuming power
$P_{\text{Total Dissipated}} = \Sigma(I^2R) + P_{\text{20v Source}}$
$= 8000*I_1^2 + 4000*I_2^2 + 12000*I_2^2 + 4000*I_1^2 = 12000*(0.0028)^2 + 16000*(0.0002)^2 + 20*(0.0002)$
$= 0.095 + 0.004$ W

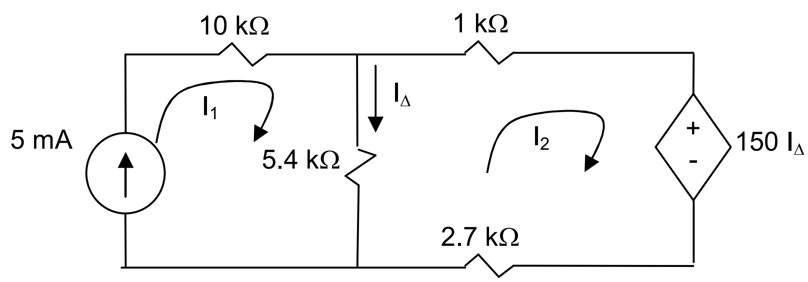
6S. a) Use the mesh-current method to solve for I_Δ in the following circuit.
b) Find the power delivered by the independent current source.

c) Find the power delivered by the dependent voltage source.



Solution:

a) find I_Δ



We have $I_1 = 0.005$ A & $I_\Delta = I_1 - I_2$

Write KVL for Mesh #2 → $5.4\ (I_2 - I_1) + I_2 + 150\ (I_1 - I_2) + 2.7\ I_2 = 0$

Insert I_1 value to above equation → $5.4\ (I_2 - .005) + I_2 + 150\ (I_2 - .005) + 2.7 = 0$

→ $I_2 = 0.003$ A → $I_\Delta = I_1 - I_2 = 0.002$ A

b) $P_{0.005A\ \text{source}} = I_1 * V_{0.005A\ \text{source}} = -\ (0.005) * (\ 10 * 5 + 5.4 * 2) = -0.304$ W

c) $P_{0.150I\Delta\ \text{dependent source}} = I_2 * V_{0.005A\ \text{source}} = (.003)*(150*0.002) = 0.9$ mW consumed

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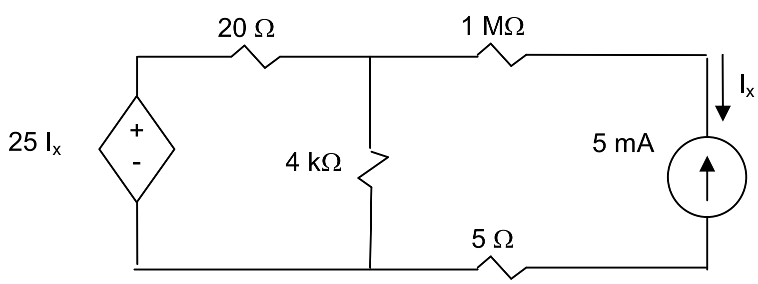
6U. a) Use the mesh-current method tofind I_x in the following circuit.

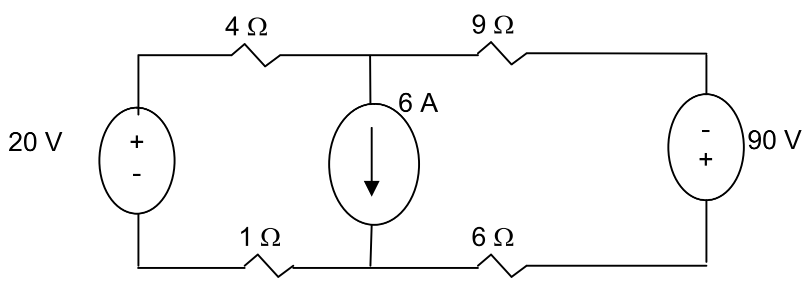


b) Find the power delivered by the independent current source.

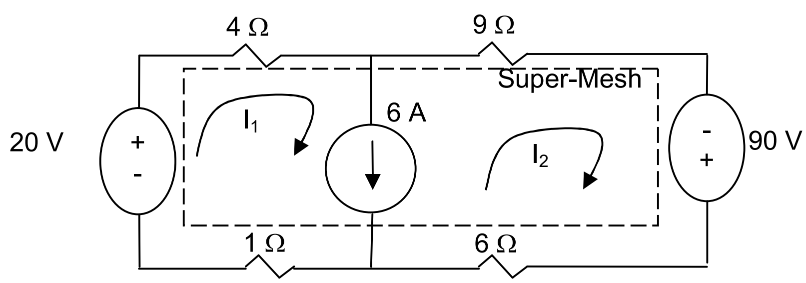
c) Find the power delivered by the dependent voltage source.

Solution:

7S. Use the mesh-current method to find the total power dissipated in the circuit shown below.



Solution:
a)

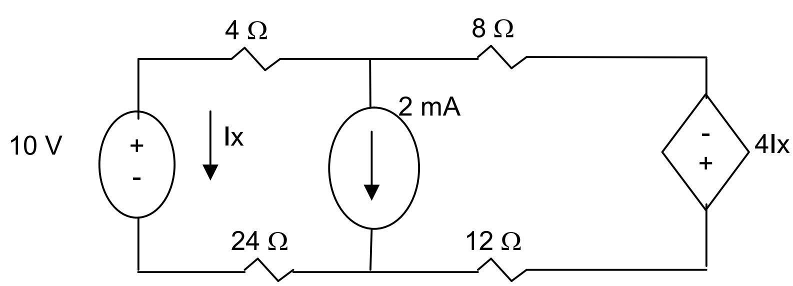


Super-Mesh KVL → $-20 + 4\,I_1 + 9\,I_2 - 90 + 6\,I_2 + I_1 = 0$ → $5\,I_1 + 15\,I_2 = 110$
Relationship of two mesh within super-mesh → $I_1 - I_2 = 6$

$I_1 = 10A$; $I_2 = 4A$;

$P_{\text{Total Dissipated}} = \Sigma(I^2R) = 4*I_1^2 + 9*I_2^2 + 6*I_2^2 + I_1^2 = 4*10^2 + 9*4^2 + 6*4^2 + 1*10^2 = 740$ W

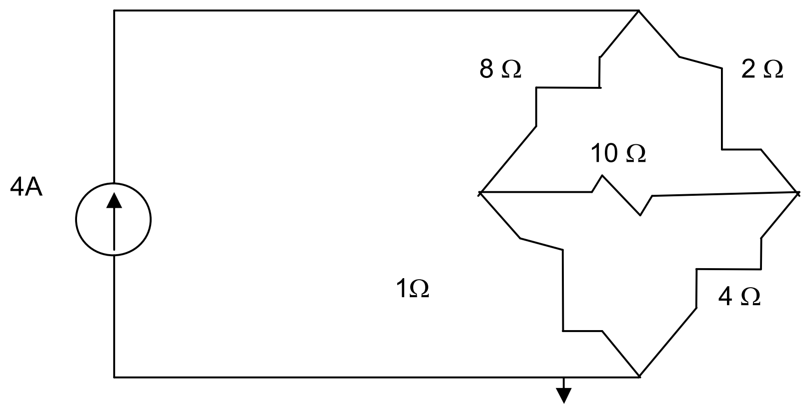
7U. Use the mesh-current method to find the total power dissipated in the circuit shown below.



Solution:

8S. Assume you have been asked to find the power dissipated in the 10 Ω resistor in the following circuit.
a) Which method of circuit analysis would you recommend? Explain why.
b) Use your recommendation method of analysis to find the power dissipated in the 10 Ω resistor.
c) Would you change your recommendation if the problem had been to find the power developed by the 4 A current source? Explain.

d) Find the power delivered by the 4 A current source.



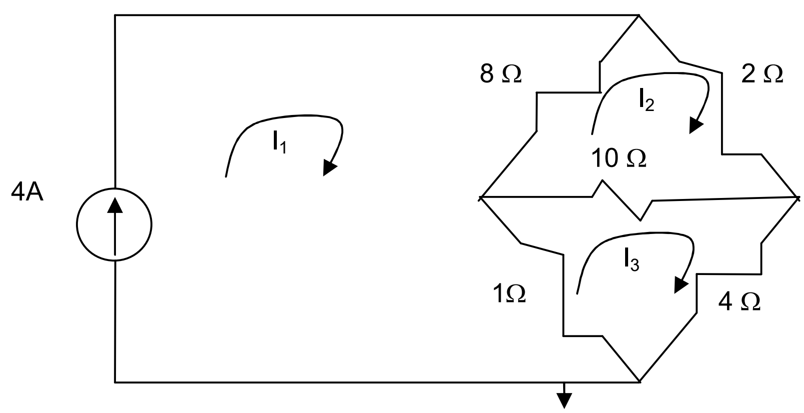
Solution:

a) Which method?

* 4 Essential nodes 3 node-voltage equations
* 6 Essential branches (6 – (4-1)) = 3 current-mesh equations

Mesh-Current since one of the Mesh currents is known so there are only two mesh-current equations.

b) $P_{10\Omega}$ = ?



KVL for Mesh#1 → $I_1 = 4$ A
KVL for Mesh#2 → $8(I_2 – I_1) + 2I_2 + 10(I_2 – I_3) = 0$
KVL for Mesh#3 → $(I_3 – I_1) + 10(I_3 – I_2) + 4I_3 = 0$

Inset I_1 value into equations #2 & #3
$20\ I_2 - 10\ I_3 = 32$
$-10\ I_2 + 15\ I_3 = 4$

$I_2 = 2.6$; $I_3 = 2$ A

$P_{10\Omega} = R*I^2 =(10)*(2.6 – 2)^2 = 3.6$ W

c) No, since it is straight forward to calculate the voltage drop across the current source from mesh currents.

d) $P_{4A\ souces}$ =?
$P_{4A\ souces}$ = I * V = - 4 * (8*($I_1 – I_2$) + 1*($I_1 – I_3$)) = - 4*(8*(4 - 2.6) + 1*(4 – 2))
$P_{4A\ souces}$ = 52.8 W delivered

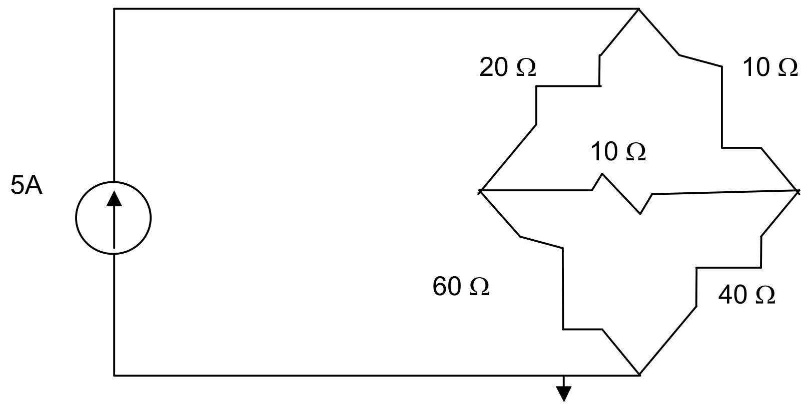
8U. Assume you have been asked to find the power dissipated in the 20 Ω resistor in the following circuit.

a) Which method of circuit analysis would you recommend? Explain why.

b) Use your recommendation method of analysis to find the power dissipated in the 20 Ω resistor.

c) Would you change your recommendation if the problem had been to find the power developed by the 5 A current source? Explain.

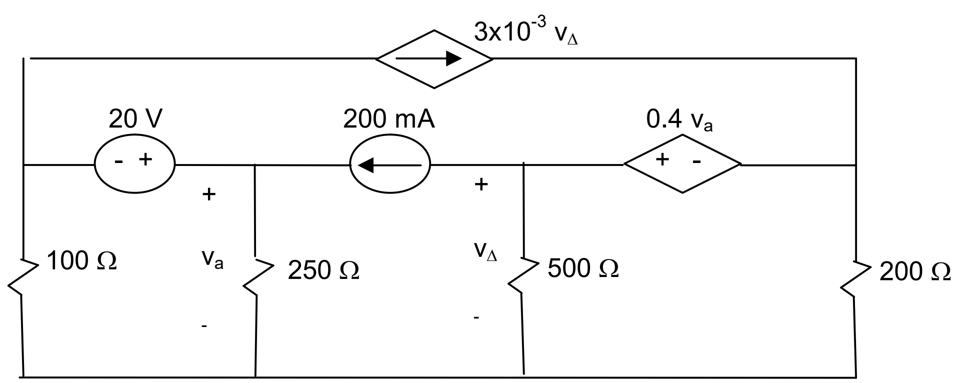
d) Find the power delivered by the 5 A current source.



Solution:

8Sb. a) Would you use the node-voltage or mesh-current method to find the power absorbed by the 20 V source in the following circuit? Explain your choice.

b) Use the method your selected in (a) to find the power.



Solution:

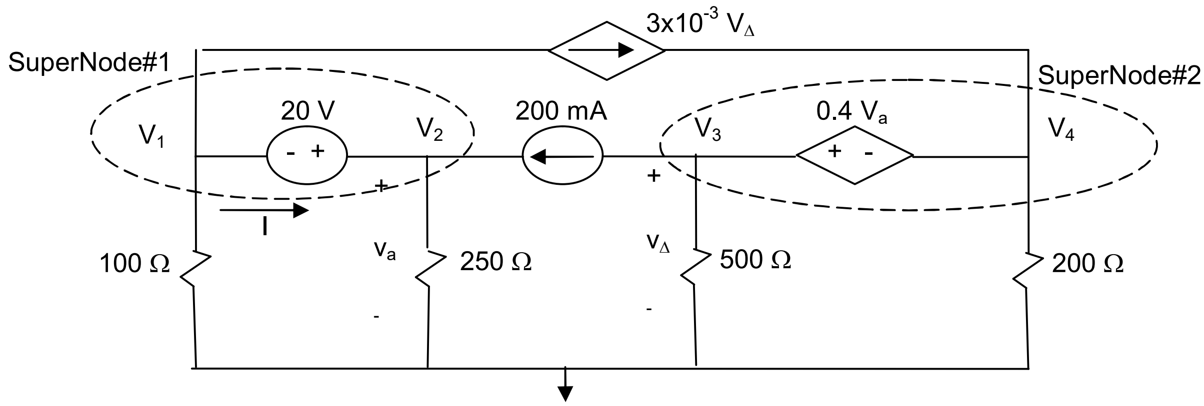
a)) Which method?

* 5 Essential nodes 4 node-voltage equations

* 8 Essential branches (8 – (5-1)) = 4 mesh-current equations

although number of equations are the same, Node-voltage is a better choice. This is driven by the fact that with the two super nodes and easier constraint equation formulation.

b) $P_{20V\ sources}$ =?



Super Node #1 KCL → $-0.2 + .003V_{\Delta} + V_1/100 + V_2/250 = 0$

Relationship → $V_2 - V_1 = 20$

Super Node #2 KCL → $+0.2 - .003V_{\Delta} + V_4/200 + V_3/500 = 0$

Relationship → $V_3 - V_4 = 0.4\ V_a$

Constraint equations in term of node voltages

$V_a = V_2$

$V_{\Delta} = V_3$

Simplified equation:

$0.01\ V_1 + 0.004\ V_2 + 0.003V_3 = 0.2$

$-V_1 + V_2 = 20$

$-0.001\ V_3 + 0.005\ V_4 = -0.2$

$+0.4\ V_2 - V_3 + V_4 = 0$

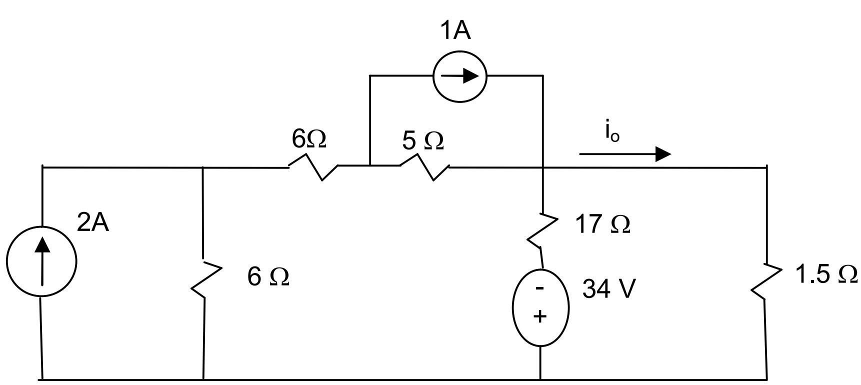
V_1=15.48 V; V_2=35.482 V; V_3=-32.23 V; V_4=-46.45V;

Note: I can be found by apply KCL at node V_1

$P_{20V\ Source} = -(20)*I = -20(V_1/100 + 0.003V_3) = -20(15.48/100 + 0.003*(-32.28)) = -1.16\ W$

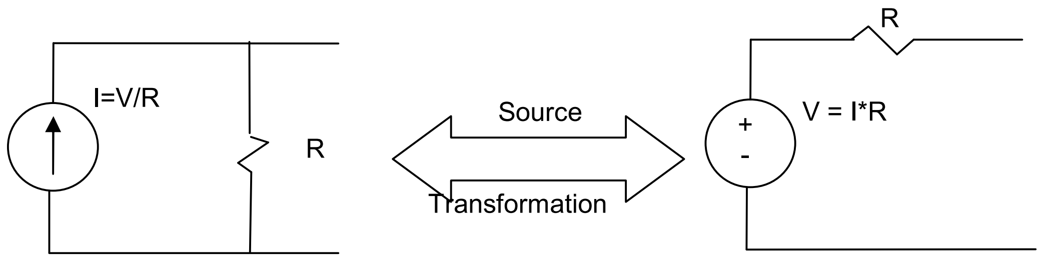
9S. a) Use a series of source transformations to find i_o in the following circuit

b) Verify your solution by using the mesh-current method to find i_o.

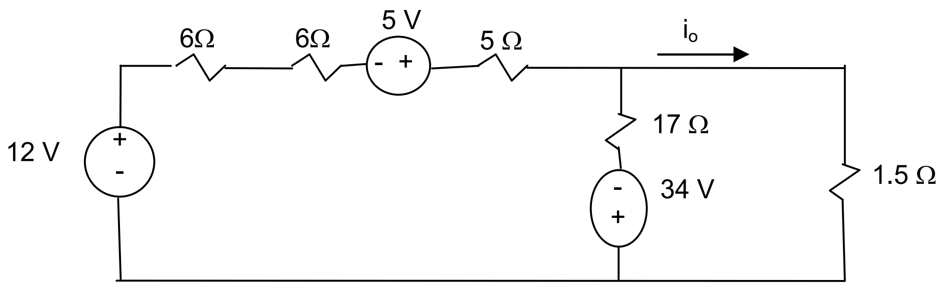


Solution:

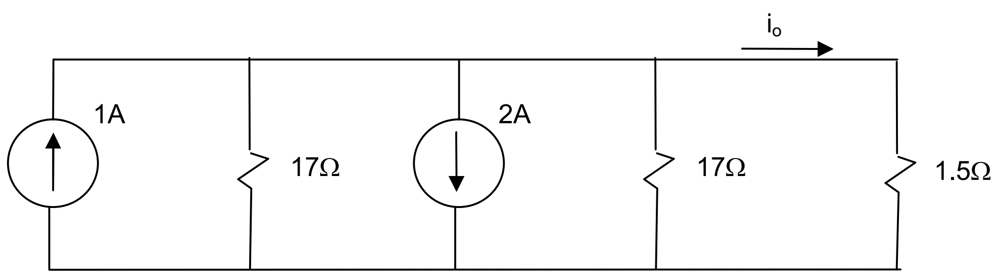
a) Use the following transformation rule:



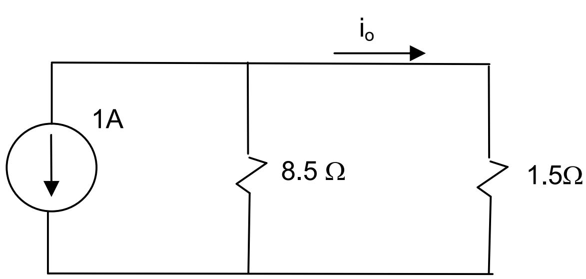
First Set of transformations (2A, 6Ω → 12V; 1A, 5Ω → 5V)



Second Set of transformations
(12+5V, 12+5 Ω → 1A; 34V , 17 Ω → 2A;)

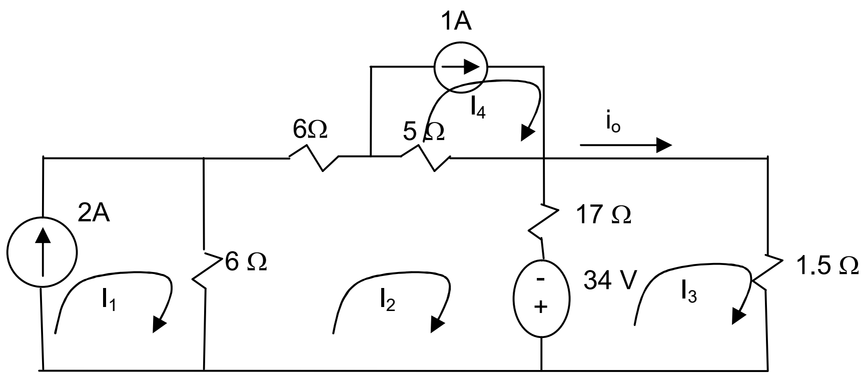


Simplify by adding current source and Req for 17 || 17 = 8.5 Ω



i_o = -1 * (8.5/(1.5 + 8.5)) = -0.85 A

b) Find i_o using mesh-current technique.

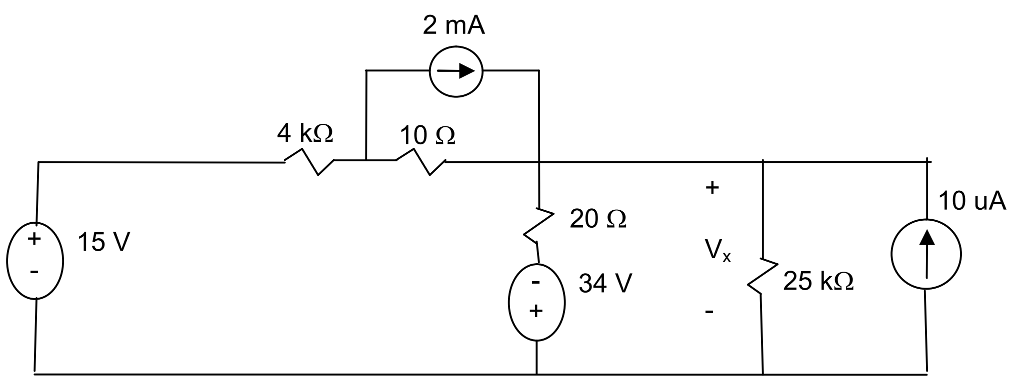


KVL for Mesh #1 → $I_1 = 2$ A
KVL for Mesh #2 → $6(I_2 - I_1) + 6\ I_2 + 5(I_2 – I_4) + 17\ (I_2 – I_3) - 34 = 0$
KVL for Mesh #3 → $+34 + 17\ (I_3 – I_2) + 1.5\ I_3 = 0$
KVL for Mesh #4 → $I_4 = 1$ A

$34I_2 - 17I_3 - 5I_4 = 46$
$-17\ I_2 + 18.5I_3 = -34$

$I_3 = Io = -0.85$ A

9U. a) Use a series of source transformations to find V_x in the following circuit
b) Verify your solution by using the Node-Voltage method to find V_x.



Solution:

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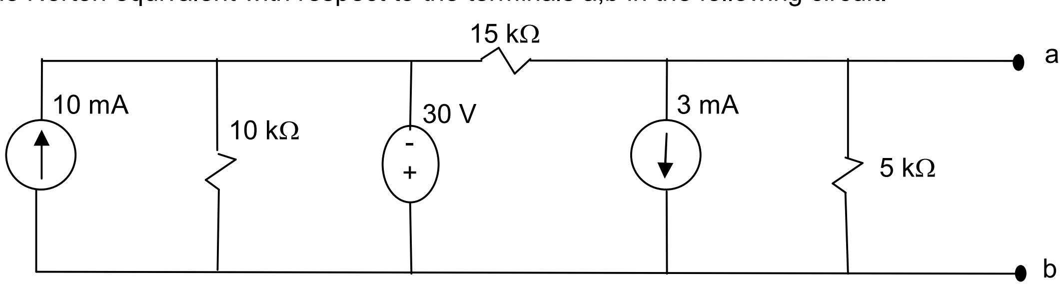
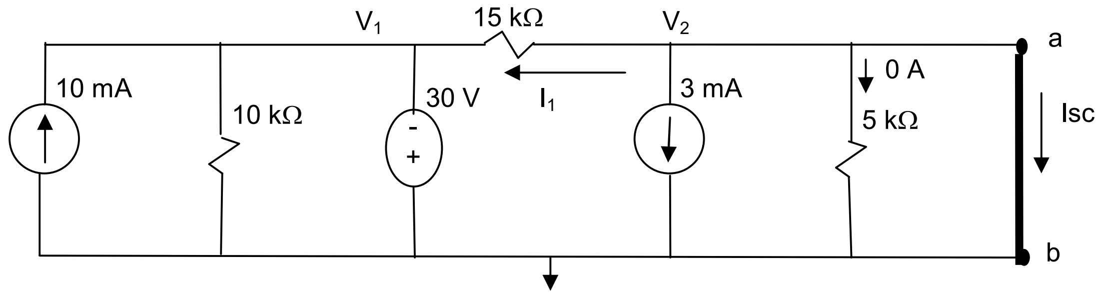
10 S. Find the Norton equivalent with respect to the terminals a,b in the following circuit.



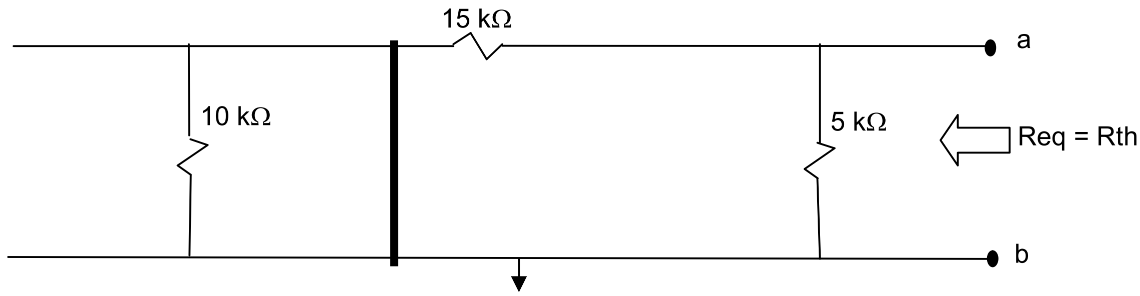
Solution:

Step 1 -- Find Isc (a-b shorted)



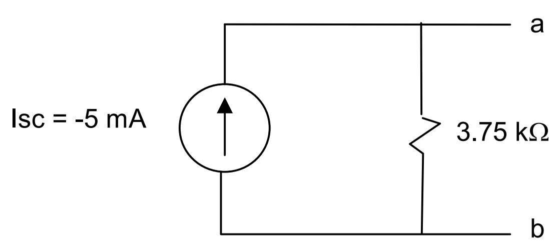
V_1 = -30 V
V_2 = 0 V
I1 = $(V_2 - V_1)$ / 15K = 2 mA
KCL at V_2 → Isc + 0 +3 + I_1 = 0 → Isc = -5 mA

Step 2 – Find Req = Rth by deactiving sources
(Current Source → Open I=0; Voltage Source → short V=0)

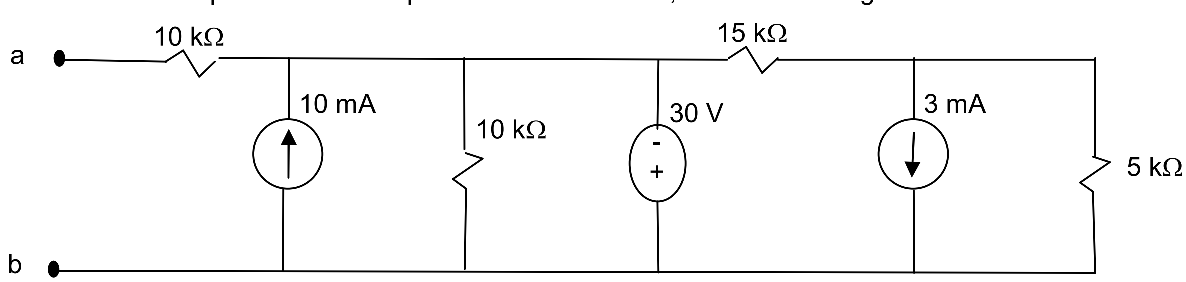


Rth = ((10 || 0) + 15) || 5 = 3.75 kΩ

Step3 – Draw Norton Equivalent

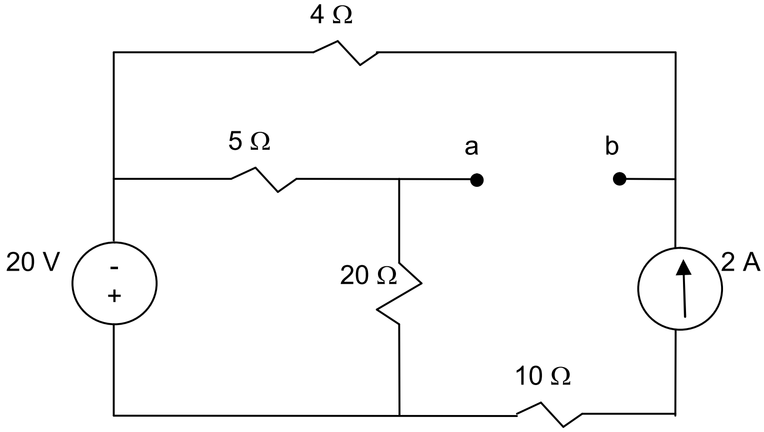


10U. Find the Norton equivalent with respect to the terminals a,b in the following circuit.



Solution:

10S. Find and draw the Norton equivalent of the following circuit at terminals a and b.

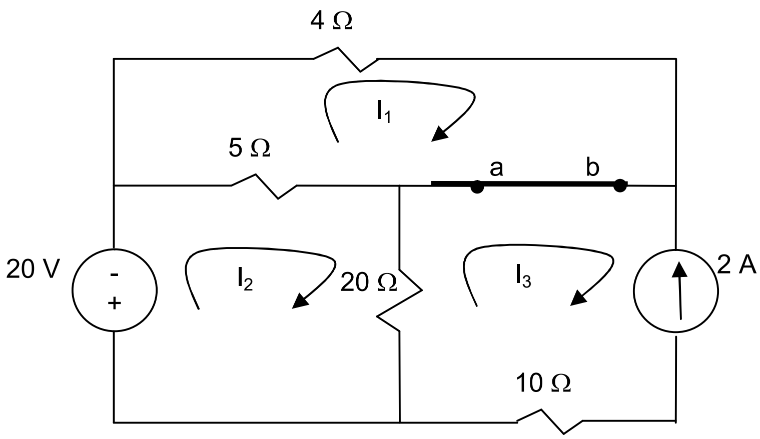


Solution:

Deactivate sources to find Rth = Rab

Rth = Rab = (4 + (5 || 20) = 8 Ω

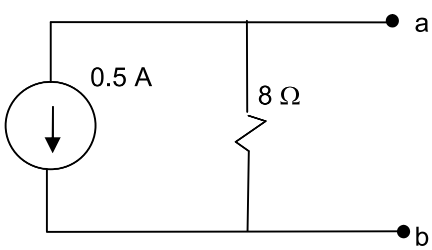
Find Isc = Iab



Mesh #1 → $4I_1 + 5(I_1 - I_2) = 0$ → $9I_1 - 5I_2 = 0$ → $I_2 = 9I_1/5$
Mesh #2 → $+20 + 5(I_2 - I_1) + 20(I_2 - I_3) = 0$ → $-5I_1 + 25I_2 = -60$ → $-5I_1 + 45I_1 = 60-$ → $I_1 = -1.5$
Mesh #3 → $I_3 = -2$

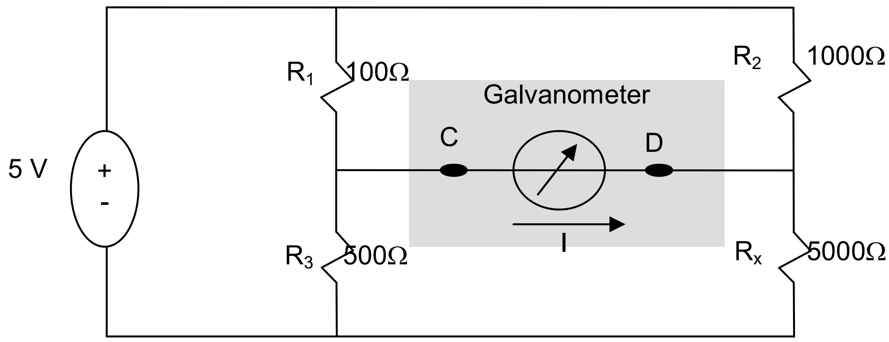
Find Isc = Iab = $I_3 - I_1 = -0.5$

Norton Equivalent:



11S. The Wheatstone bridge in the circuit shown below, is balanced when R3 equals 500Ω. If the galvanometer had a resistance of 50Ω, how much current will the galvanometer detects when the bridge is unbalanced by setting R3 to 501 Ω.

Hint: Find the Thevenin equivalent with respect to the galvanometer terminals when R3=501Ω. Note that once we have found this Thevenin equivalent, it is easy to find the amount of unbalanced current in the galvanometer branch for different galvanometer movements.



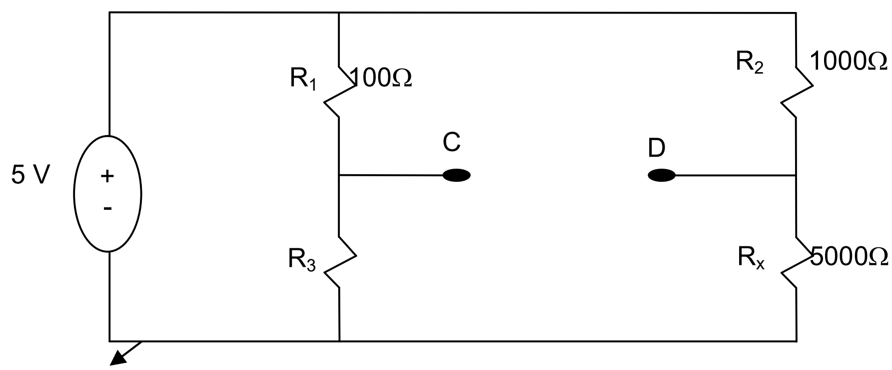
Solution:

Given: Balanced I=0 when R_3 = 500 Ω → V_{CD} = 0; Rg = 50 Ω

Find: I if R = 501Ω

Step 1 – Find Thevenin Equivalent with respect to C and D

A. Open CD and find $V_{open\ CD}$ = Vth



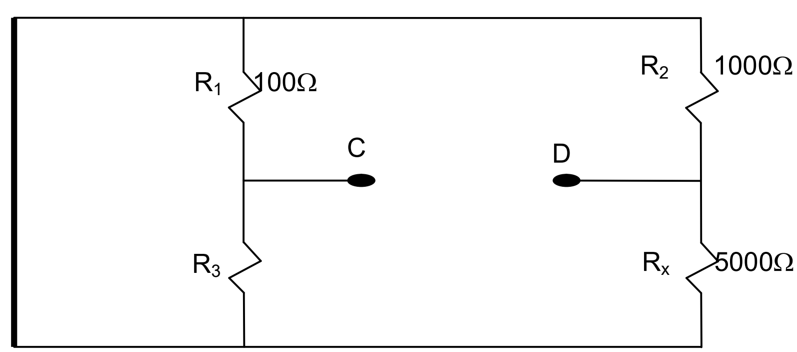
Use the voltage divider to find V_C and V_D

$V_C = 5*R_3 / (R_3 + 100)$

$V_D = 5*5000 / (5000 + 1000)=25/6$

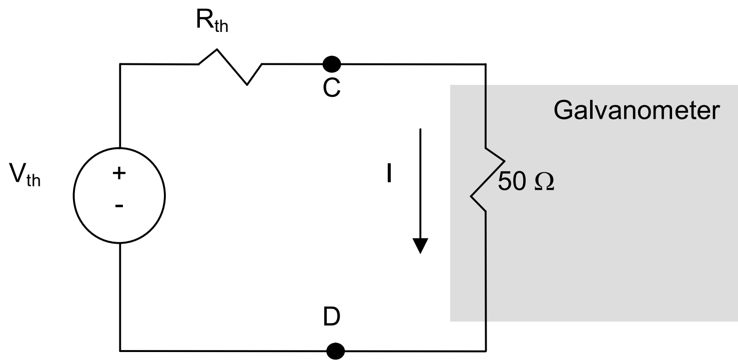
$V_{th} = V_{CD} = V_C – V_D = 5*R_3 / (R_3 + 100) - 25/6$

B. Deactivate source (V=0 short) and find $R_{eq} = R_{th}$



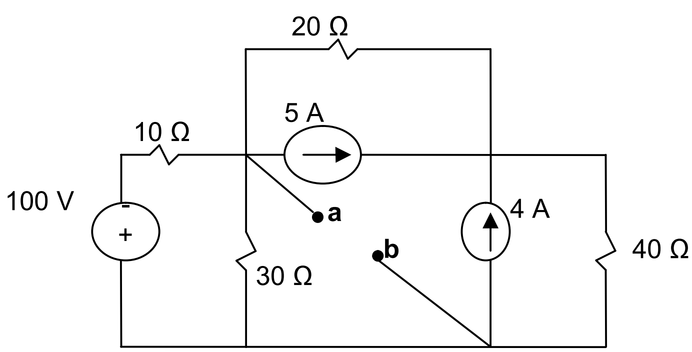
$R_{CD\,eq} = R_{th} = (100 \parallel R_3) + (1000 \parallel 5000) = 100R_3/(100+ R_3) + 5000/6$

Step 2 – Use Thevenin Equivalent to find current through Galvanometer when $R_3 = 501$



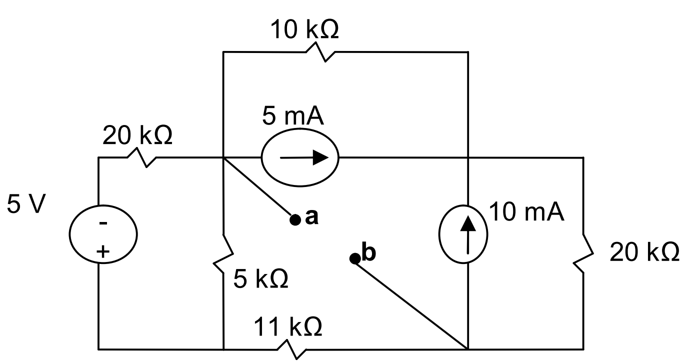
$I = V_{th} \ / \ (R_{th} + 50) = \mathbf{(}\ 5{*}R_3 \ / \ (R_3 + 100) - 25/6\ \mathbf{)} \ / \ \mathbf{(}\ (5000/6 + 100R_3/(100+ R_3) + 50\mathbf{)}$ when R3 = 501
$I = 1.43$ uA

11U. Draw and determine the value of components in the Thevenin Equivalent for the following circuit at terminals a and b.

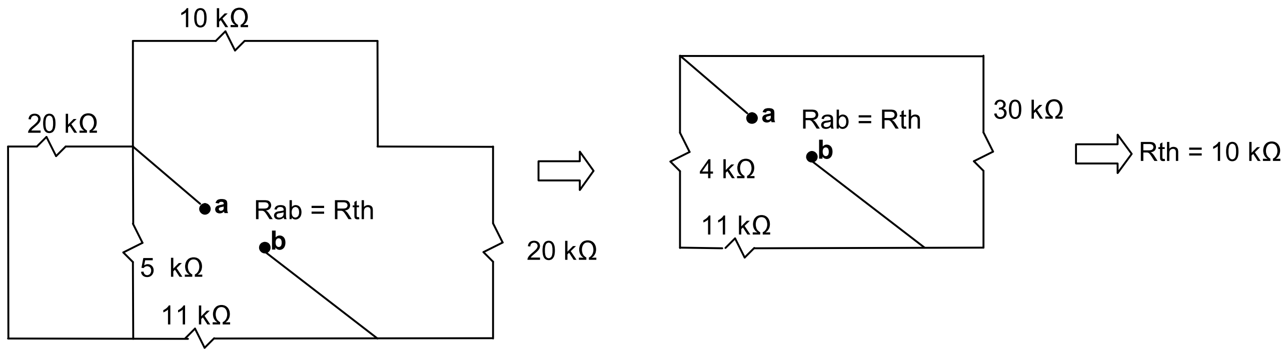


Solution:

11Sb. Draw and determine the value of components in the Thevenin Equivalent for the following circuit with respect to ab terminals. Use Superposition to find Vth.



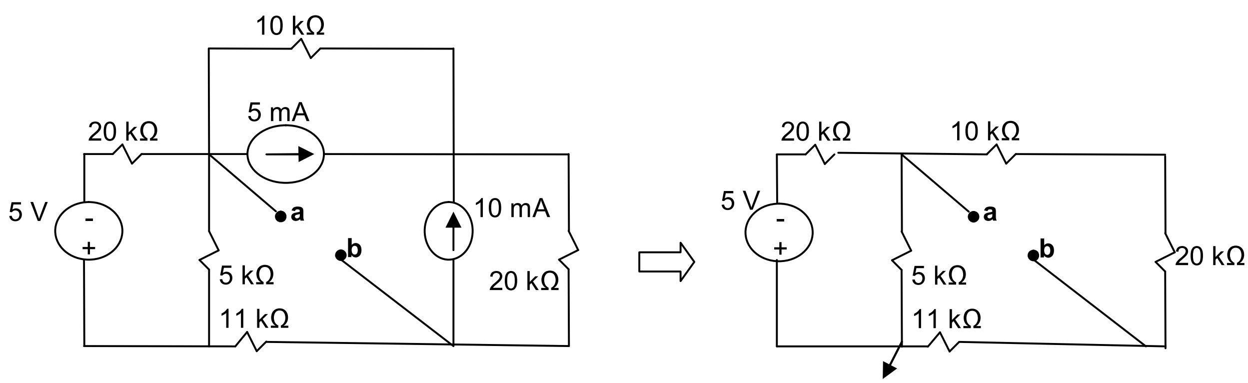
Solution:
Since sources are all independent sources then deactivate all sources and find R_{th}



Now find Open circuit voltage (Vth):

Apply SuperPosition →

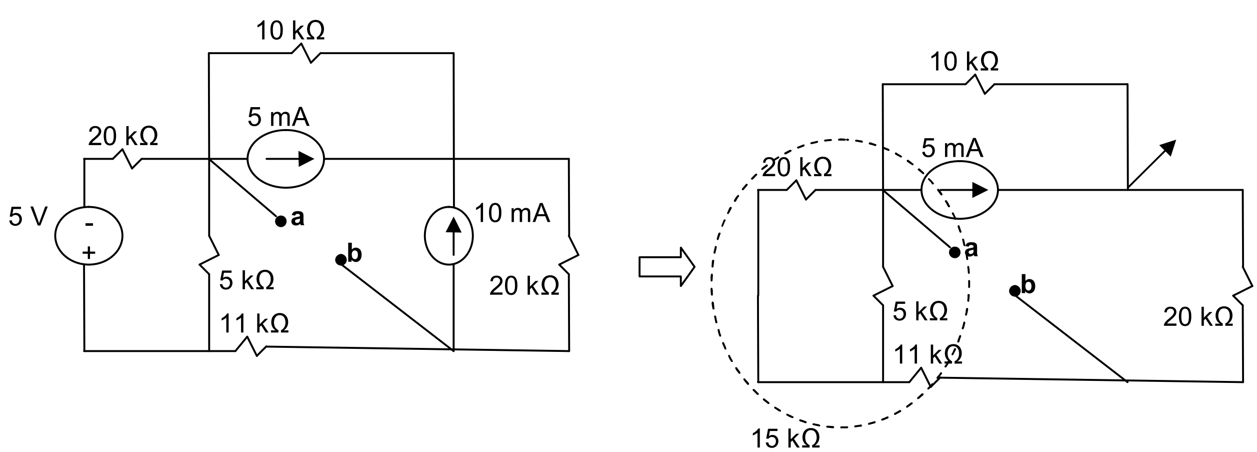
<u>Only 5V source is active:</u>



$(Va - (-5))/20 + (Va - Vb)/30 + Va/5 = 0$ $17\,Va - 2\,Vb = -15$
$(Vb - Va)/30 + Vb/11 = 0$ $-11\,Va + 41\,Vb = 0$

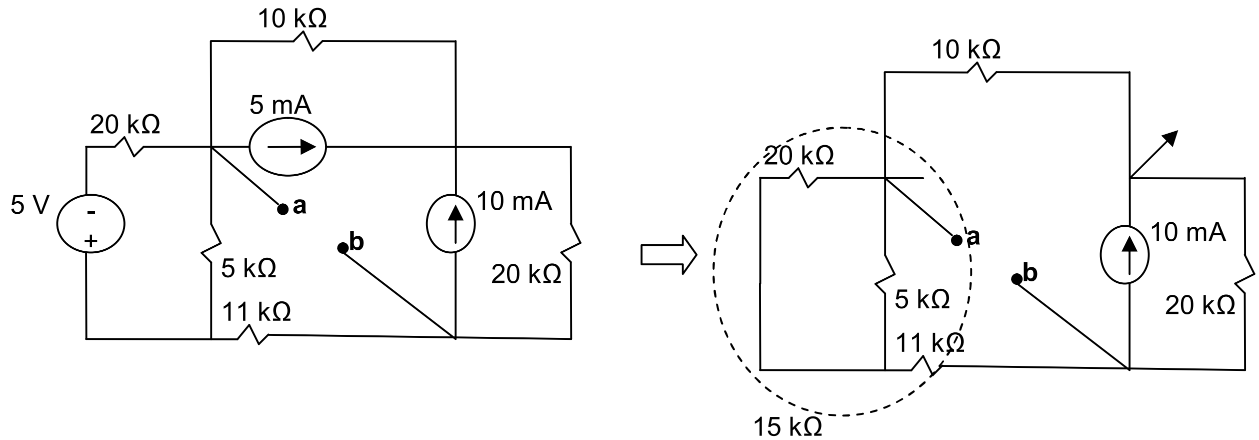
$Va = -0.9$, $Vb = -0.2$ → $Vab_1 = -0.7$ V for 5v Supply

<u>Only 5 mA source is active</u>



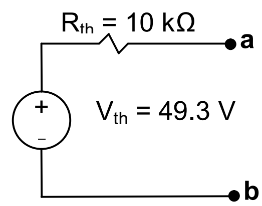
$(Va - Vb)/15 + 5 + Va/10 = 0$ → $5Va - 2Vb = -150$
$(Vb - Va)/15 + Vb/20 = 0$ → $-4Va + 7Vb = 0$
Solve → $Va = -38.9$ & $Vb = -22.2$ → $Vab_2 = (-38.9) - (-22.2) = -16.7$ v

Only 10 mA source is active

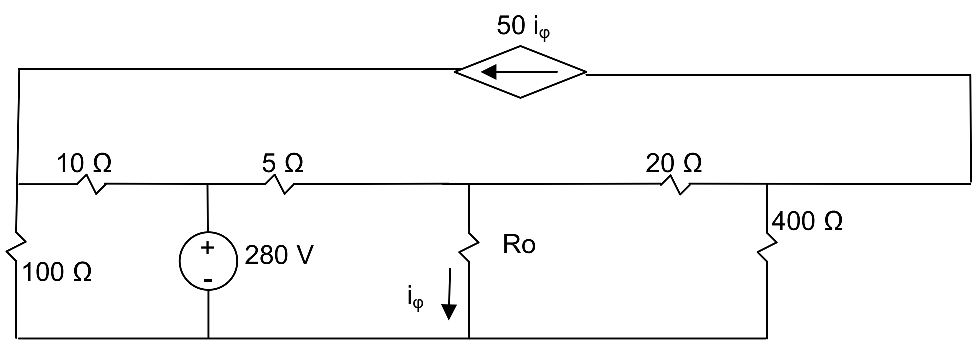


(Va –Vb)/15 + Va/10 = 0 → 5Va -2Vb = 0
(Vb – Va)/15 + 10 + Vb/20 =0 → -4Va + 7Vb = -600
Solve → Va = -44.4 & Vb =-111.1 → V_{ab3}= (-44.4) – (-111.1) = + 66.7v

Therefore Vth = Vab1 + Vab2 + Vab3 = -0.7 - 16.7 + 66.7 = 49.3 v and R_{th} = 10 k Ω



11Sc.

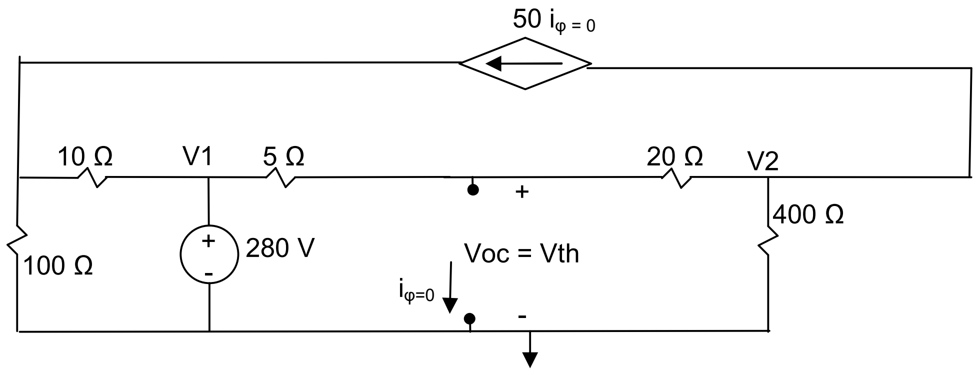


For the above circuit, find the Thevenin equivalent with respect to terminals of Ro.

Solution:

a) Thevenin equivalent

Find Voc (Open Circuit $i_{\varphi=0}$)

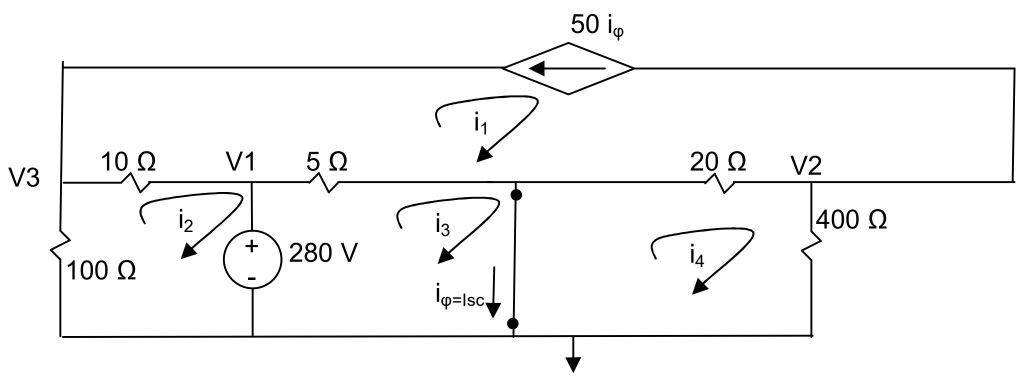


From the circuit:
V1=280 V
$i_{\varphi=0}$

KCL at V2 → (V2 – 280)/25 + V2/400 = 0 → V2 = 264 V

Voc = Vth = V1 - 5*(V1 – V2)/25 = 280 - 5 *(280 - 264)/25 = 277V

Find Isc



Mesh Current Analysis equations:

$i_1 = - 50\ i_\Phi = -50\ (i_3 – i_4) = 50\ i_4 – 50\ i_3$

$+280 + 100\ i_2 + 10\ (i_2 – i_1) =0$

$-280 + 5\ (i_3 – i_1) =0$

$20\ (i_4 – i_1) + 400\ i_4 =0$

Simplify to 4 equations and 4 unknowns:

$i_1 + 50\ i_3 - 50\ i_4 = 0$

$-10i_1 + 110i_2 = -280$

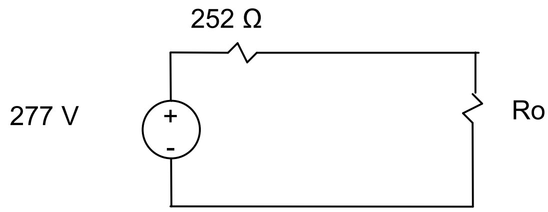
$-5i_1 + 5\ i_3 = 280$

$-20i_1 + 420\ i_4 = 0$

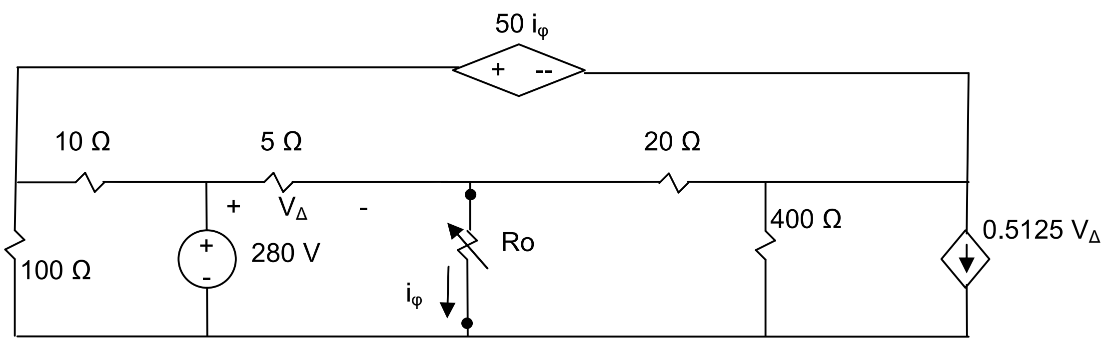
Solve the equations:

i_1= - 57.6 A ; i_2= - 7.8A ; i_3= - 1.6 ; i_4= - 2.7 ; → $i_{sc} = i_3 – i_4$= -1.6 – (-2.7) = 1.1 A

Rth = Voc / Isc =277/1.1 = 252 Ω

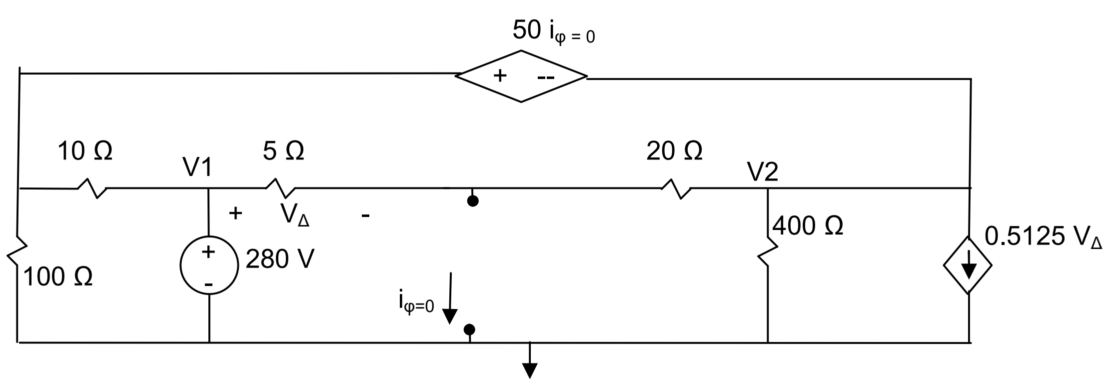


11Sd. Using Node-Voltage Method for the following circuit:
a) Find the Thevenin equivalent with respect to terminals of Ro.
b) Find the Ro value that results in maximum power delivery to Ro.



<u>**Solution**</u>
a) Thevenin equivalent

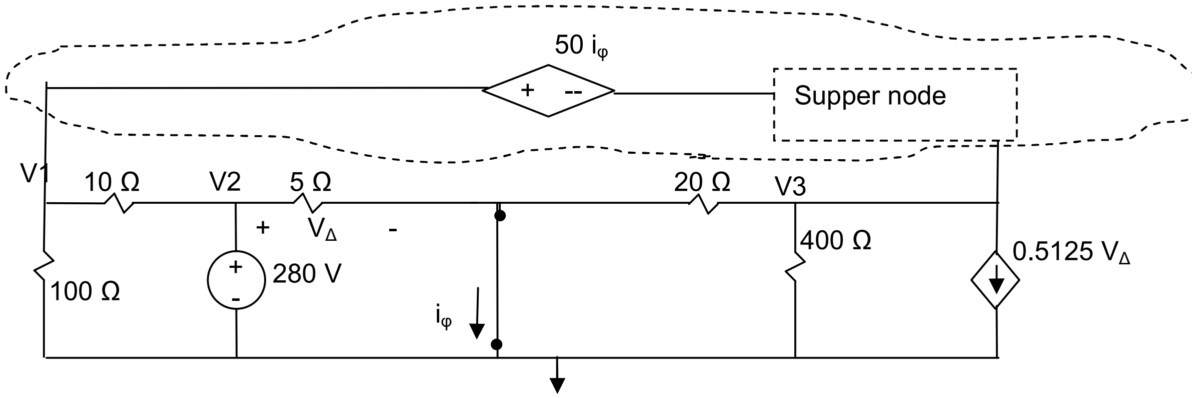
First find Voc



KCL at V1=280 V
KCL at V2 → (V2 – 280)/25 + V2/400 + (V2 -280)/10 + V2/100 + 0.5125 V_Δ= 0 → V2 = 257 V
V_Δ = (V1 – V2)/25)*5 = (280– V2)/5 = (280– 257)/5 = 23/5 = 4.6 V

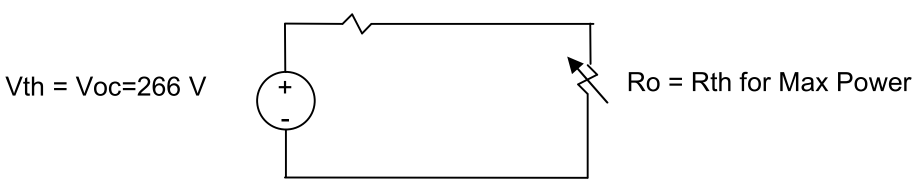
V_Δ = (280– V2)/5 = (280– 257)/5 = 23/5 = 4.6 V
Voc = Vth = V1 - V_Δ = 275.4

First find Isc

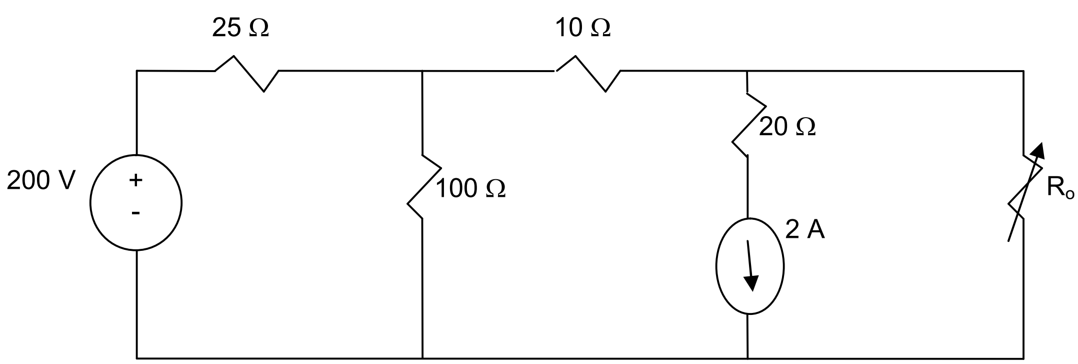


KCL at V2=280 V → V2=V_Δ = 280 V
i_φ = (V2) / 5 + (V3) / 20
Supper Node Equation V1 – V3 = 50 i_φ = (V2) / 5 + (V3) / 20 = 10 V2 + 2.5 V3 → V1 = 2800 + 3.5 V3
KCL at Supper Node → V3/400 + V3/20 + 0.5125 V_Δ + V1/100 + (V1 – V2)/10 =0
Substitute known values →
V3/400 + V3/20 + 0.5125 *280 + (2800 + 3.5 V3)/100 + (2800 + 3.5 V3 – 280)/10 =0
Find V3 = -945.14 → V1 = -508 → Isc = I_φ = (V1 – V3)/30 = 8.7 A

Rth = Voc / Isc=275.4/8.7=31.65 Ω

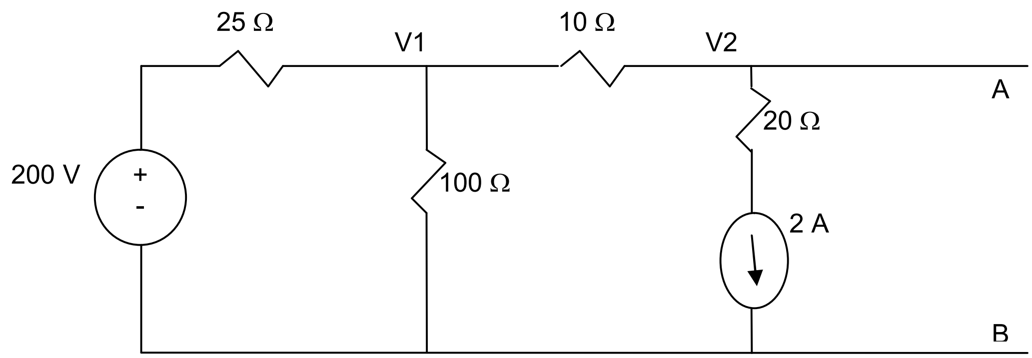


12S. The variable resistor (R_o) in the following circuit is adjusted until the power dissipated in the resistor is 50 W. Find the values of R_o that satisfy this condition.



Solution:

1) Find Thevenin equivlanet – Voc=Vth



KCL at V1 → (V1 – 200)/25 + V1/100 + (V1 – V2)/10 = 0

KCL at V2 → 2 + (V2 – V1)/10 = 0

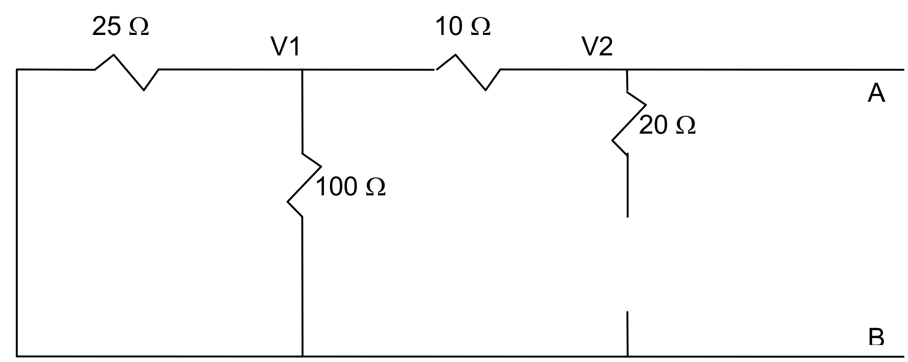
→

15V1 – 10V2 = 800

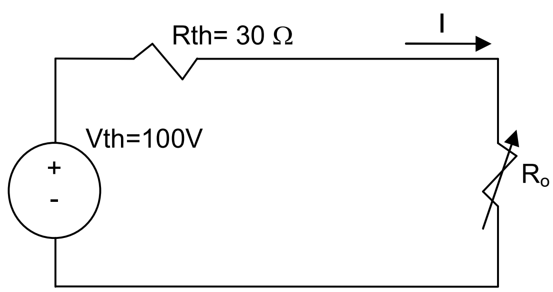
V1 - V2 =20

→ Vth = Voc = V2 = 100 V

2) Deactivate Sources to find Rth



Rth = (25 || 100) + 10 = 30 Ω



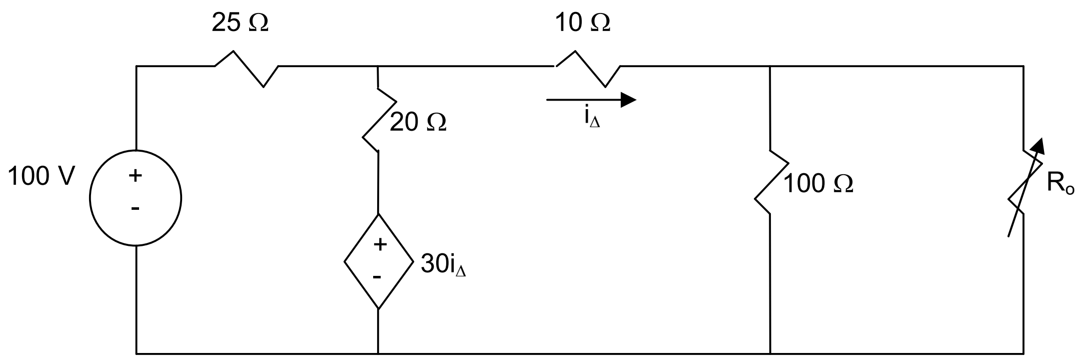
P_{Ro} = 50 W → 50 = I^2 Ro → Ro = 50/ I^2

KVL → -100 + 30 I + I Ro =0 → -100 + 30I + 50/I =0 → 30 I^2 - 100I + 50 = 0

$$I = \frac{100 \pm \sqrt{10{,}000 - 6{,}000}}{60} = \frac{100 \pm 200}{60} = 5A \quad or \quad -1.67A$$

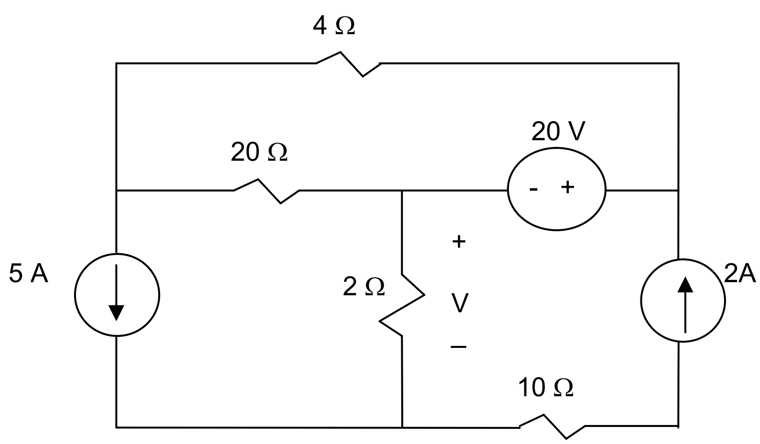
Ro = 50/ I^2 = 2Ω or 18Ω

12U. The variable resistor (R_o) in the following circuit is adjusted until the power dissipated in the resistor is 25 W. Find the values of R_o that satisfy this condition.



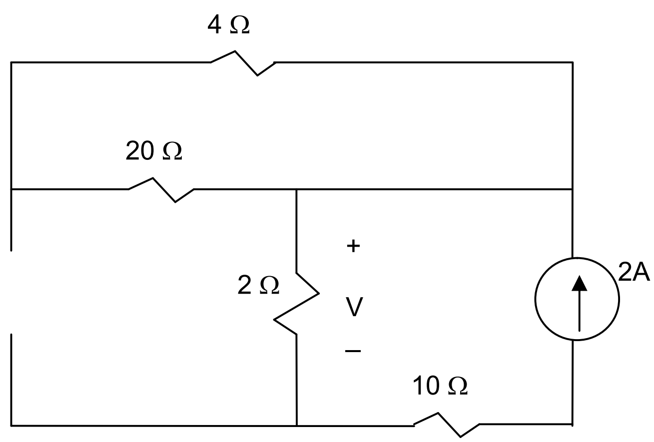
Solution:

13S. Use the principle of superposition to find the voltage v in the following circuit.



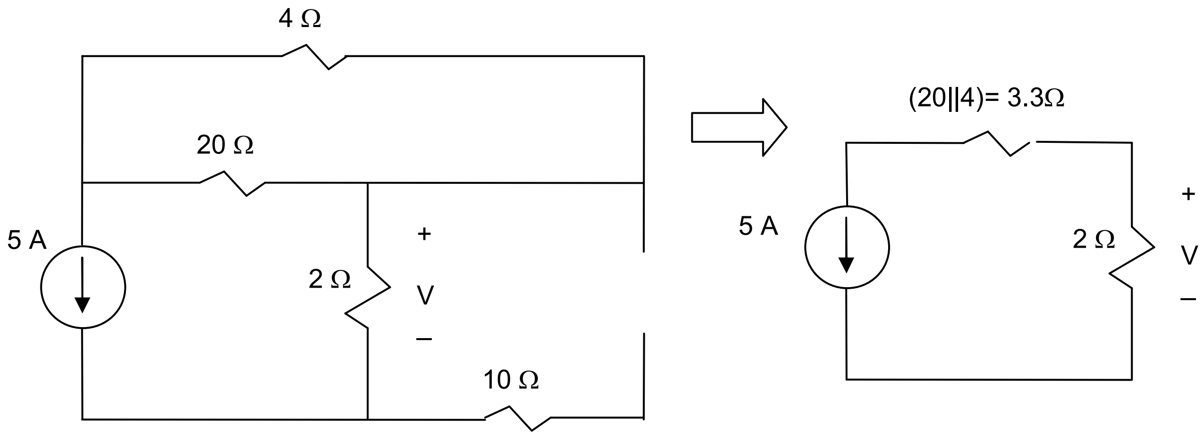
Solution:

1) Activate only 2A source



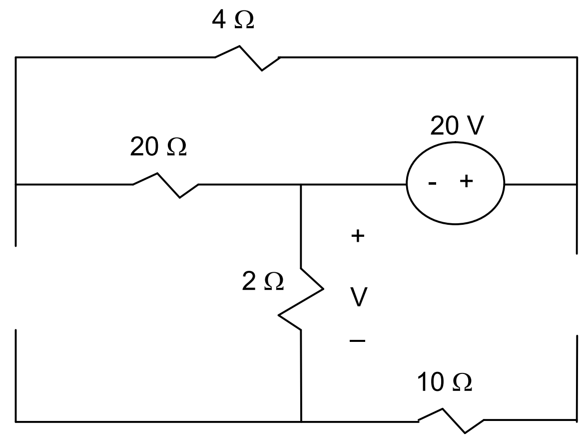
$V_{2A} = 2x2 = 4V$

2) Activate only 5A source



$V_{5A} = -5x2 = -10V$

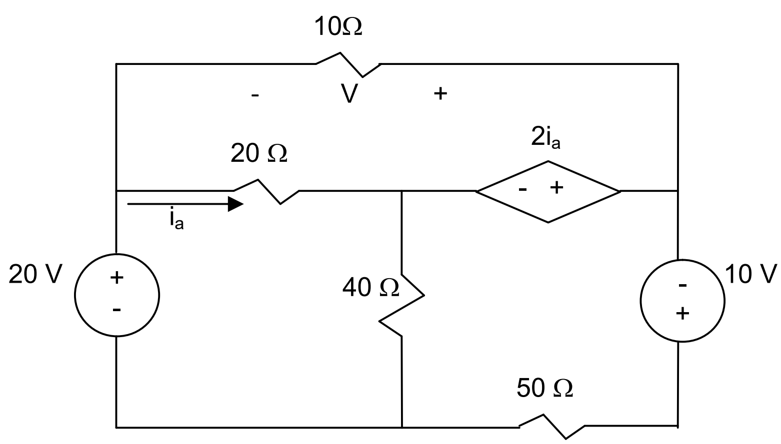
3) Activate only 20V source



$V_{20v} = -0$

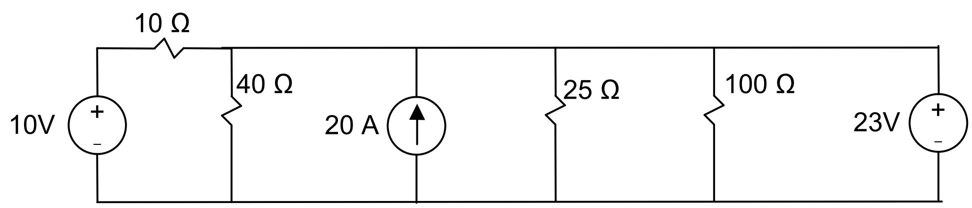
Total response, $V = V_{2A} + V_{5A} + V_{20v} = 4 - 10 + 0 = -6$ V

13U. Use the principle of superposition to find the voltage V in the following circuit.



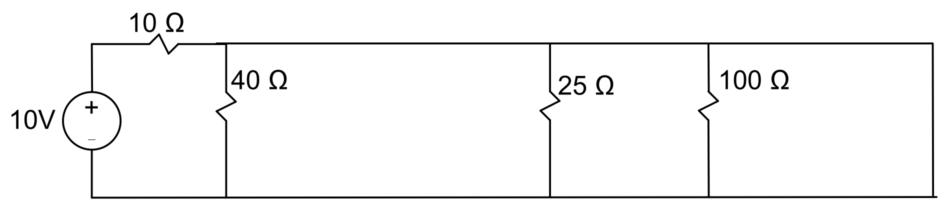
Solution:

13Sb. What is the value of current through 40 Ω resistor that is directly attributable to the 10 V voltage source.

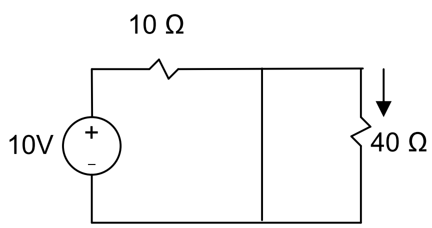


Solution:

- De-activate all the sources except the 10v

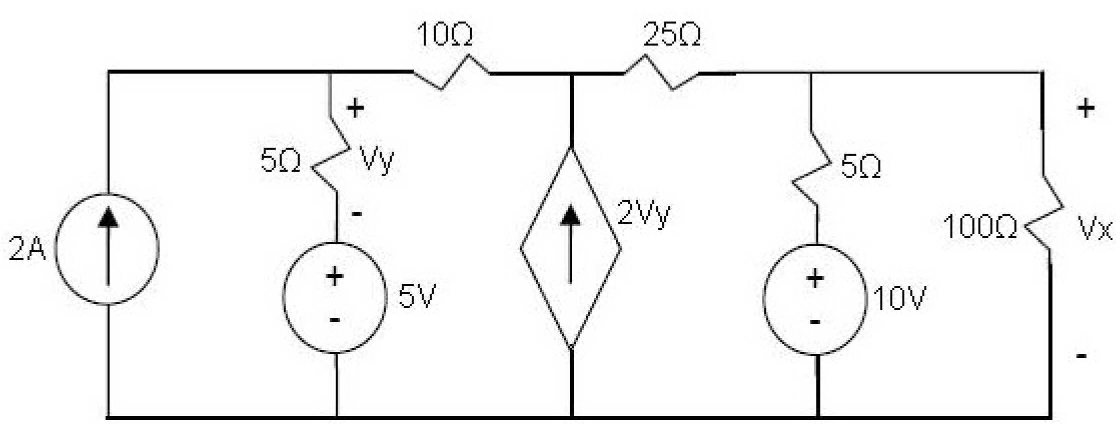


- Simplify and find the current resulting from the 10v supply.



Current through the 40 Ω is zero since all the current goes through the short.

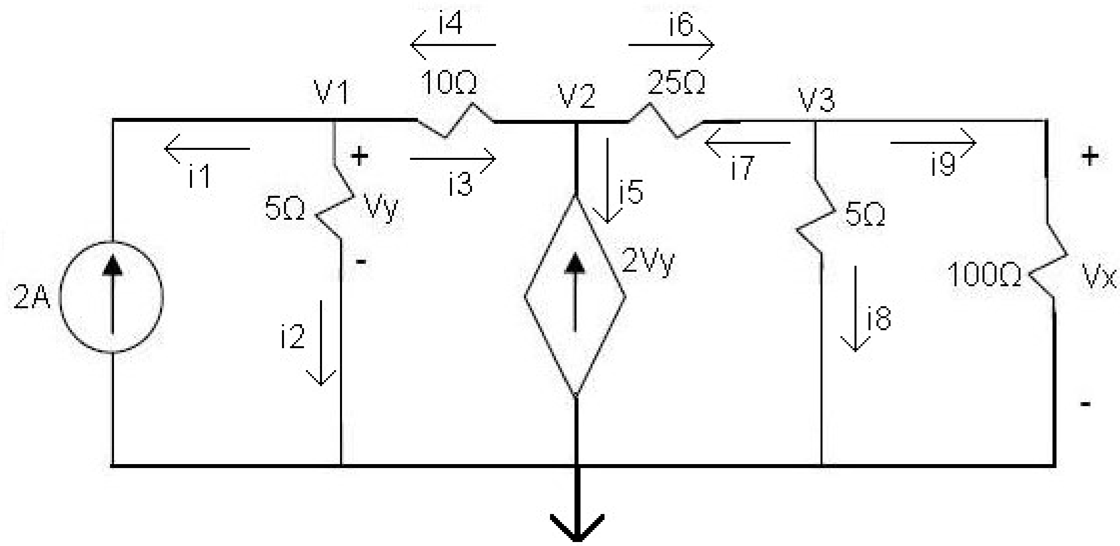
13Sc Use the Super-Position principle to find Vx in the following circuit.



Solution:

Deactivate all independent sources.

Activate 2A source and redraw:



Use KCL to find Vx.

KCL @ V1 → $I_1 + I_2 + I_3 = 0$
→ -2 + V1 / 5 + (V1 – V2) / 10 = 0

KCL @ V2 → $I_4 + I_5 + I_6 = 0$
→ (V2 – V1) / 10 + (-2Vy) + (V2 – V3) / 25 = 0

KCL @ V3 → $I_7 + I_8 + I_9 = 0$
→ (V3 – V2) / 25 + V3 / 5 + V3 / 100 = 0

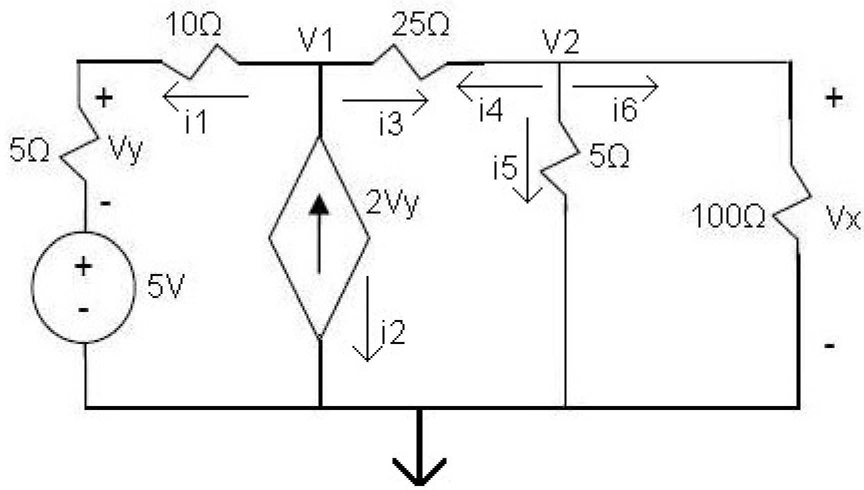
Dependent equation: Vy = V1 / 5

Simplify and solve.

(3/10)*V1 – (1/10)*V2 = 2
(3.5/25)*V2 – (1/2)V1 – (1/25)*V3 = 0
(1/4)*V3 – (1/25)*V2 = 0

V3 = $\mathbf{Vx_1 = -20.1V}$

Activate 5V source and redraw:



Use KCL to find Vx.

KCL @ V1 → $I_1 + I_2 + I_3 = 0$
→ (V1 – 5) / (10 + 5) + (-2*Vy) + (V1 – V2) / 25 = 0

KCL @ V2 → $I_4 + I_5 + I_6 = 0$
→ (V2 – V1)/25 + V2 / 5 + V2 / 100 = 0

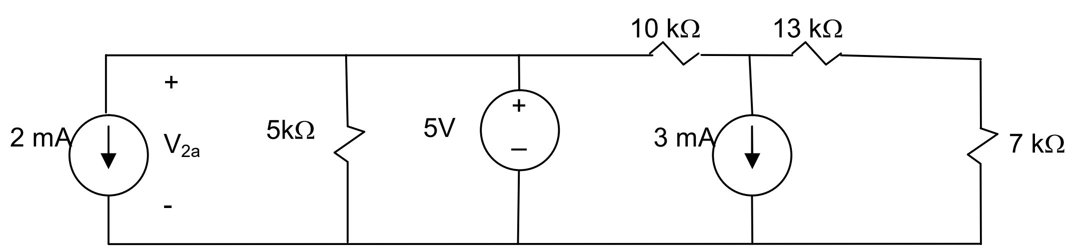
Dependent equation: Vy = (V1 – 5) / 3

Simplify and solve.

(-48 / 75)*V1 – (V2 / 25) + 3 = 0
(V2 / 4) – (V1 / 25) = 0

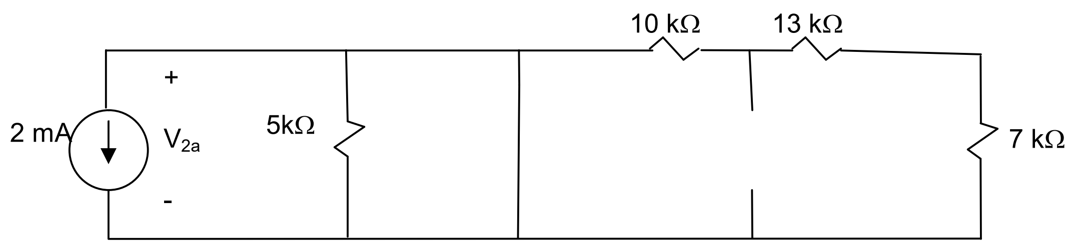
V2 = **Vx_2 = 0.743V**

13Sc. Use the principle of superposition to find voltage V_{2a} in the following circuit:



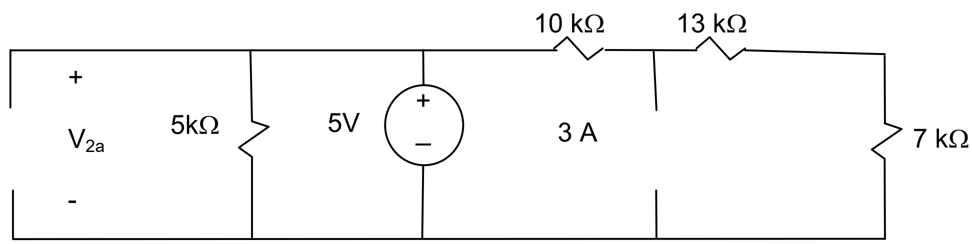
Solution:

Deactivate all except 2 mA
Note: Voltage source deactivates when V=0 → short; Current source deactivates when I=0 → Open



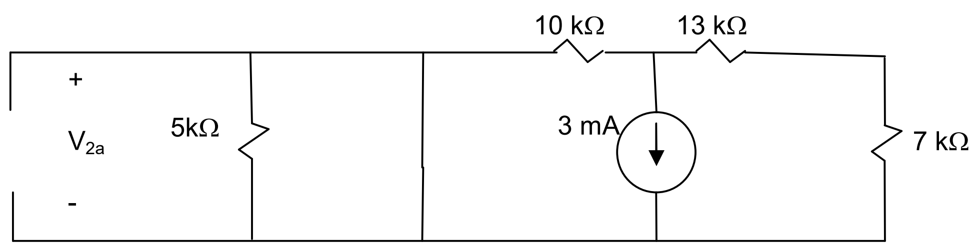
Req = 0 KΩ → V2a = 0 V

Deactivate all except 5V



V2a = + 5 V

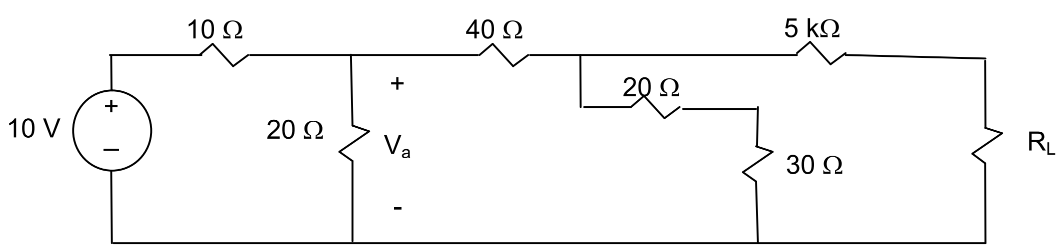
Deactivate all except 3 mA



Req = 0 KΩ → V2a = 0 V

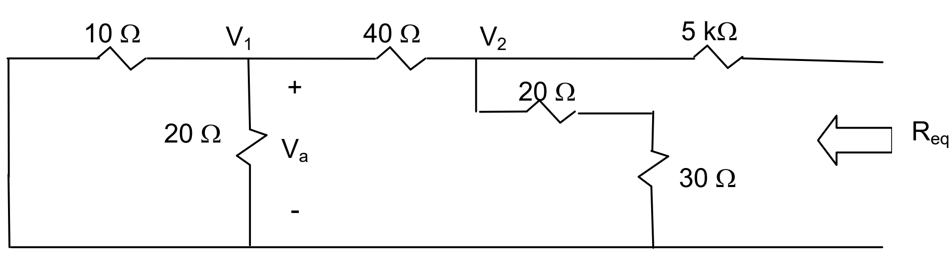
Super positioned input (total Response) = 0 + 5 + 0 = 5V.

14S. In the following circuit, find R_L value such that R_L consumes maximum power.



Solution:

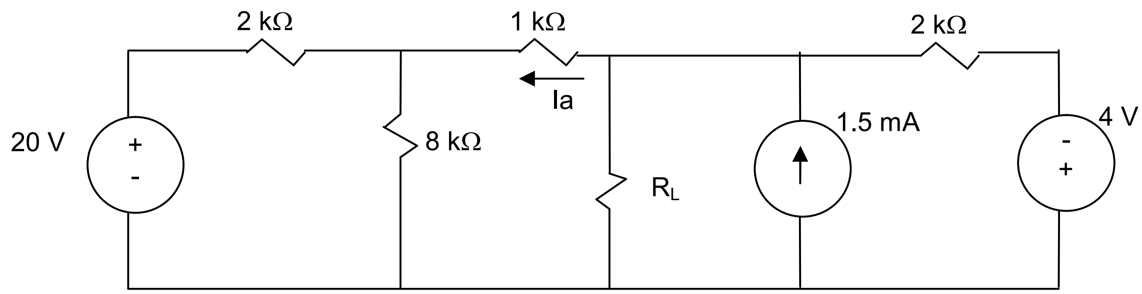
1) Find Rth by Deactivating source (v=0 or open)



R_{eq} = (((10 || 20) + 40) || (20 + 30)) + 5000 = 5024.15 Ω

2) Maximum power Requires $R_L = R_{th}$ = 5024.15 Ω

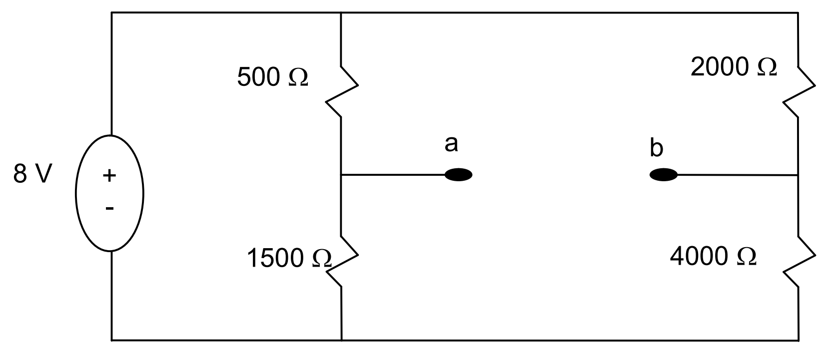
14U. In the following circuit, find R_L value such that R_L consumes maximum power..



Hint: Find R_{th} with respect to R_L terminals First.

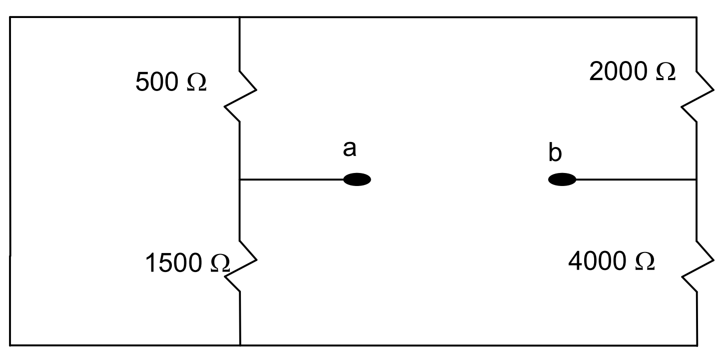
Solution:

14Sb. Find value of a resistor between terminals a and b such that it would consume maximum power:



Solution:

Find R_{th} with respect to terminals a and b by deactivating the independent voltage source



R_{th} = (500 || 1500) + (2000 || 4000) = 1708 Ω

For Maximum power, Rab must be equal to Rth or 1708 Ω