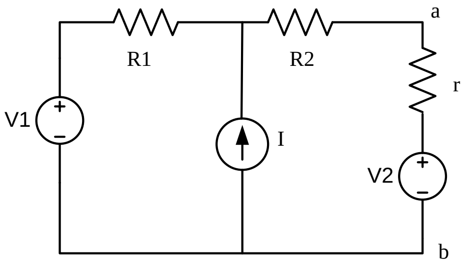
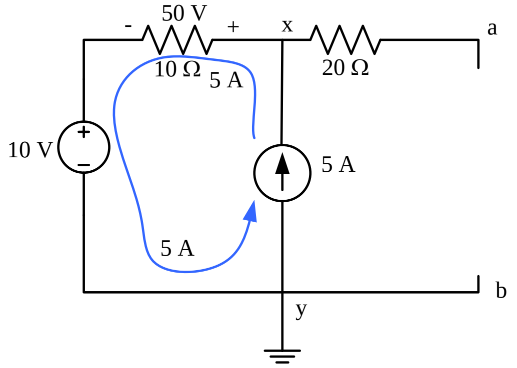
Solutions to Numerical Problems on DC Networks

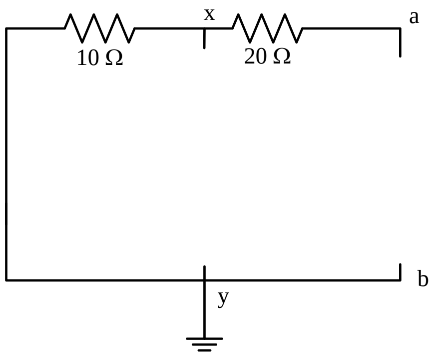
1. Find Thevenin's voltage across a-b terminal in the circuit given below. Also find the internal resistance across the open circuited a-b terminal, where R1 = 10ohm, R2 = 20ohm, V1 = 10volt, V2 = 20volt, I = 5A.



Solution:

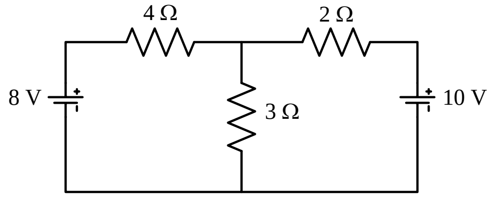


$V_{Th} = V_{ab} = V_{xy} = 10 + 5\times10 = 60$ V

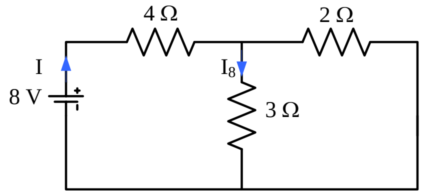


$R_{Th} = R_{ab} = 20 + 10 = 30\ \Omega$

2. Determine the current through the 3 ohm resistance by Superposition Theorem & verify using nodal analysis.

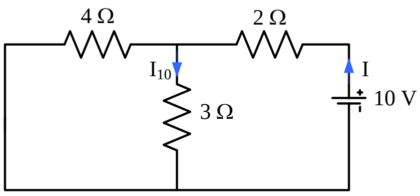


Solution:



$$I = \frac{8}{4+3//2} = \frac{8}{4+\frac{6}{5}} = \frac{40}{26}\text{A}$$

$$I_8 = I \times \frac{2}{2+3} = \frac{40}{26} \times \frac{2}{5} = \frac{16}{26} = 0.615\text{A}$$



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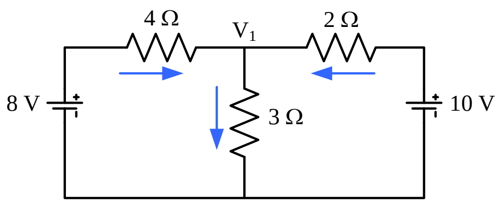
$$I = \frac{10}{2+3//4} = \frac{10}{2+\frac{12}{7}} = \frac{70}{26}\text{A}$$

$$I_{10} = I \times \frac{4}{4+3} = \frac{70}{26} \times \frac{4}{7} = \frac{40}{26} = 1.538\text{A}$$

$$\therefore I_3 = I_8 + I_{10} = 0.615 + 1.538 = 2.153\text{A}$$

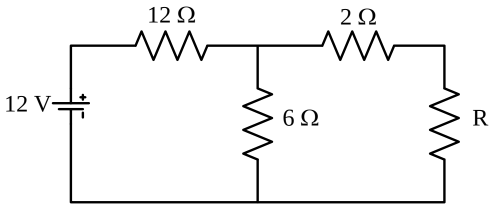


$$\frac{8-V_1}{4} + \frac{10-V_1}{2} = \frac{V_1}{3}$$

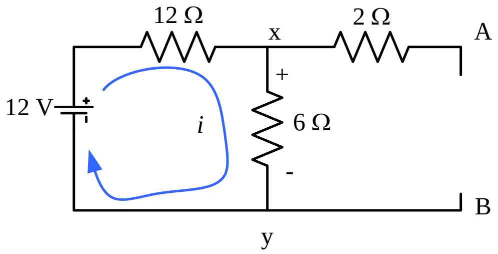
or, $V_1 = 6.46$ V

$$\therefore I_3 = \frac{V_1}{3} = \frac{6.46}{3} = 2.153\text{A}$$

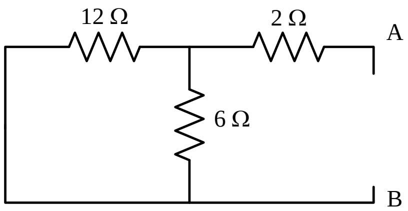
3. In the network, calculate the resistance R which will allow maximum power dissipated in it. Also calculate the maximum power.



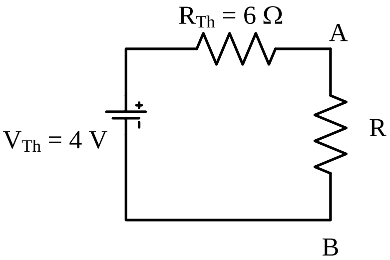
Solution:



$$V_{Th} = V_{AB} = V_{xy} = 6 \times i = 6 \times \frac{12}{(12+6)} = 4 \text{ V}$$



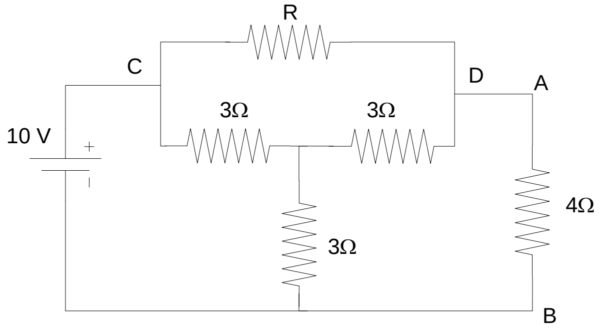
$$R_{Th} = R_{AB} = 2 + 12 // 6 = 2 + \frac{12 \times 6}{12+6} = 2 + 4 = 6\ \Omega$$



For maximum power transfer, $R = R_{Th} = 6\ \Omega$

Maximum power, $P_{\max} = \frac{V_{Th}^{\ 2}}{4R_{Th}} = \frac{4^2}{4 \times 6} = 0.667 \text{ W}$

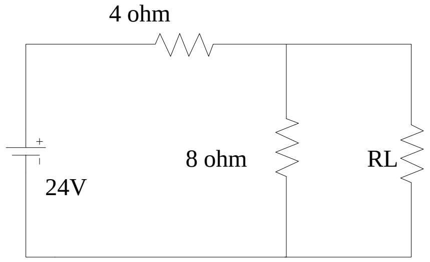
4. Determine the value of R in the following Figure such that the 4 Ω resistance consumes maximum power.



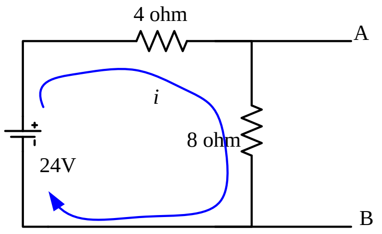
Solution:

For the resistance 4 Ω, maximum power will be delivered to it when the current through it is maximum. Current through the 4 Ω is maximum in the circuit when the internal impedance of the circuit is zero. Thus value of R = 0.

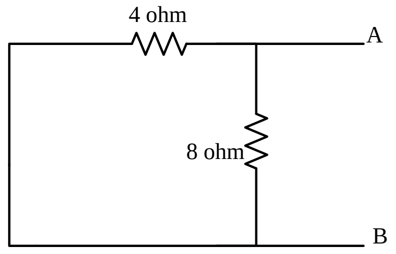
5. Find the value of load resistance (R_L) for which the power source will supply maximum power. Also find the value of maximum power for the network shown below:



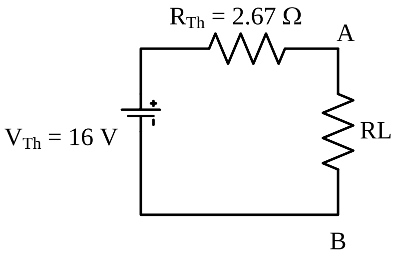
Solution:



$$V_{Th} = V_{AB} = 8 \times i = 8 \times \frac{24}{(4+8)} = 16$$



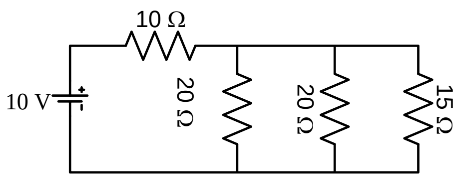
$$R_{Th} = R_{AB} = 4 // 8 = \frac{4 \times 8}{4+8} = 2.67\ \Omega$$



For maximum power transfer, $RL = R_{Th} = 2.67\ \Omega$

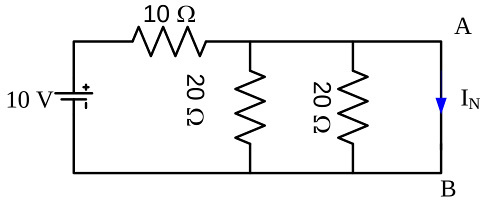
Maximum power, $P_{\max} = \dfrac{{V_{Th}}^2}{4R_{Th}} = \dfrac{16^2}{4 \times 2.67} = 24\ \text{W}$

6. Determine the current I_l through the 15 ohm resistor in the network given by Norton's Theorem.

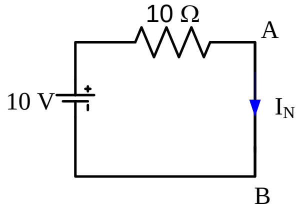


Solution:

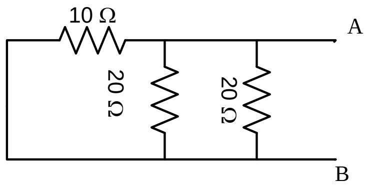
Short circuit the 15 ohm resistance:



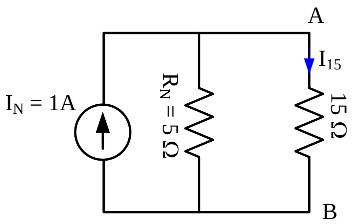
The two 20 ohm resistances in parallel with the short circuited path together becomes zero ohms:



$$I_N = \frac{10}{10} = 1 \text{ A}$$

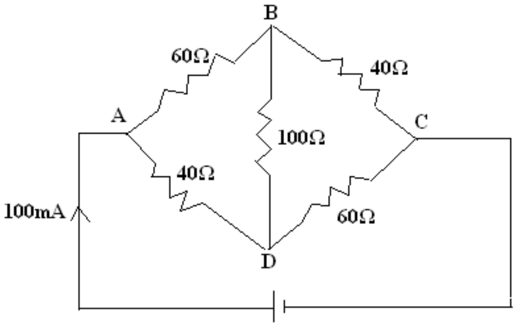


$$R_N = R_{AB} = (20 // 20) // 10 = 10 // 10 = 5\,\Omega$$

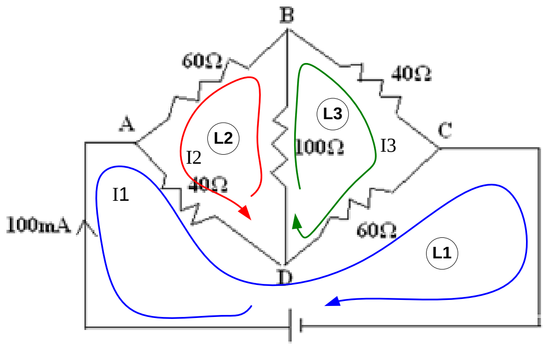


$$I_{15} = 1 \times \frac{5}{5+15} = 0.25 \text{ A}$$

7. Find the currents through R_{BC}, R_{CD}, R_{BD} in the following circuit:



Solution:



In Loop L1:
I1 = 100

In Loop L2:
60I2 + 40(I2 + I1) + 100(I2 + I3) =0
or, 200I2 + 100I3 + 40I1 = 0
or, 200I2 + 100I3 + 40×100 = 0
or, 2I2 + I3 = - 40 (i)

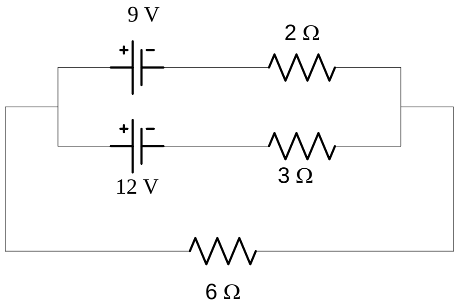
In Loop L3:
40I3 + 60(I3 - I1) + 100(I2 + I3) =0
or, 200I3 + 100I2 - 60I1 = 0
or, 200I3 + 100I2 - 60×100 = 0
or, 2I3 + I2 = 60 (ii)

Solving (i) and (ii):

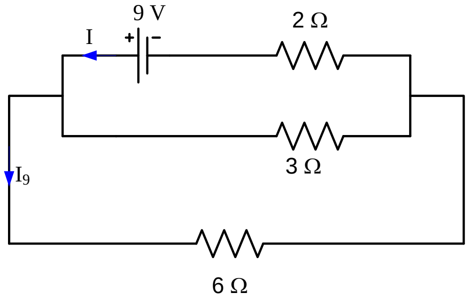
I2 = - 140/3 mA
I3 = 160/3 mA

∴ I_{BD} = - (I2 + I3) = - (-140/3 + 160/3) = - 20/3 mA,
I_{AD} = (I1 + I2) = 100 – 140/3 = 160/3,
I_{AB} = - I2 = 140/3,
I_{DC} = (I1 – I3) = 100 – 160/3 = 140/3 mA,
I_{BC} = I3 = 160/3 mA

8. Calculate the current flowing through the 6Ω resistor with the help of superposition theorem.

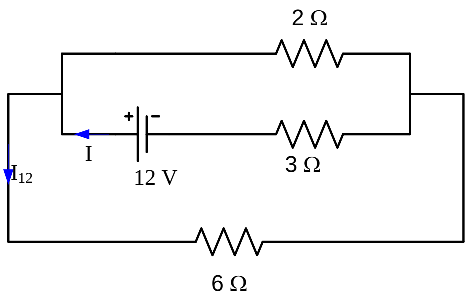


Solution:



$$I = \frac{9}{6//3+2} = \frac{9}{\frac{18}{9}+2} = \frac{9}{4}\text{ A}$$

$$I_9 = \frac{9}{4} \times \frac{3}{3+6} = \frac{3}{4}\text{ A}$$

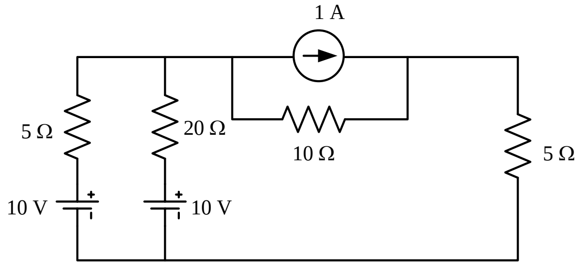


$$I = \frac{12}{6//2+3} = \frac{12}{\frac{12}{8}+3} = \frac{8}{3}\text{ A}$$

$$I_{12} = \frac{8}{3} \times \frac{2}{2+6} = \frac{2}{3}\text{ A}$$

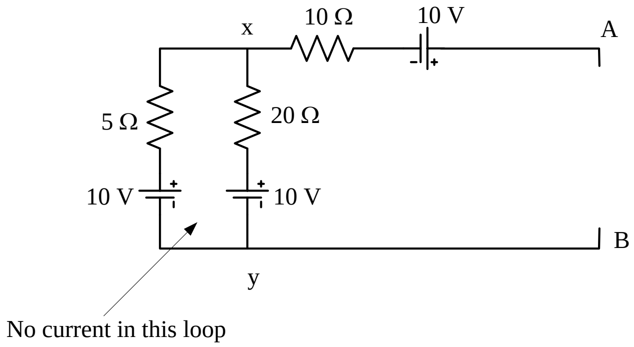
$$\therefore I_6 = I_9 + I_{12} = \frac{3}{4} + \frac{2}{3} = \frac{17}{12} = 1.42\text{ A}$$

9. Find the current through 5 Ω Resistor using Thevenin's Theorem in the fig. Below

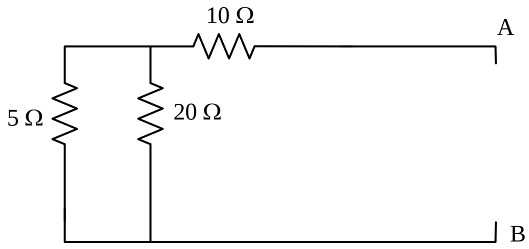


Solution:

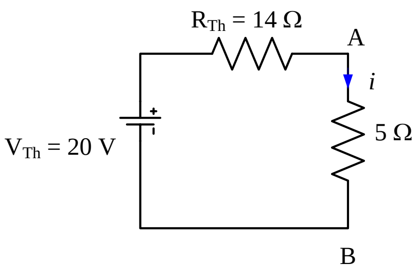
Convert the 1 A current source to equivalent voltage source



$$V_{Th} = V_{AB} = V_{Ax} + V_{xy} = 10 + 10 = 20 \text{ V}$$

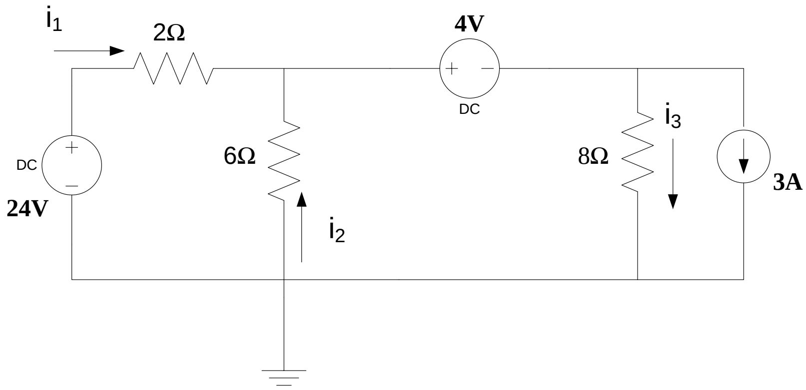


$$R_{Th} = R_{AB} = (5 // 20) + 10 = \frac{5 \times 20}{5 + 20} + 10 = 14 \ \Omega$$

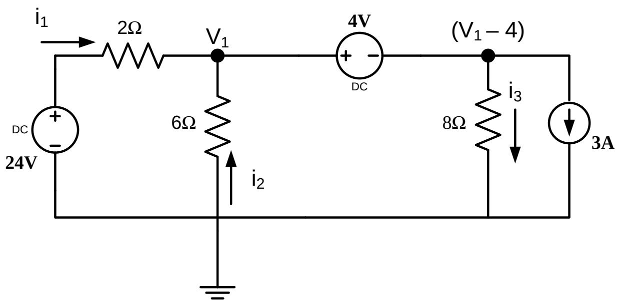


$$i = \frac{20}{14 + 5} = 1.05 \text{ A}$$

10. For the circuit shown below, determine the currents i_1, i_2, i_3 using nodal analysis:



Solution:



$$i_1 + i_2 = i_3 + 3$$

$$\frac{24 - V_1}{2} + \frac{0 - V_1}{6} = \frac{V_1 - 4}{8} + 3$$

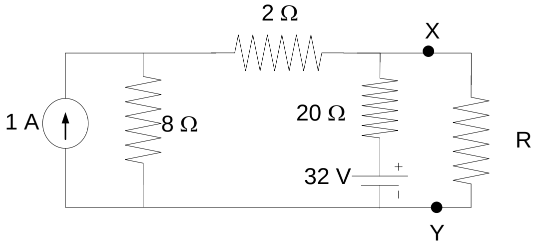
or, V_1 = 12 V

$$\therefore i_1 = \frac{24 - V_1}{2} = 6 \text{ A}$$

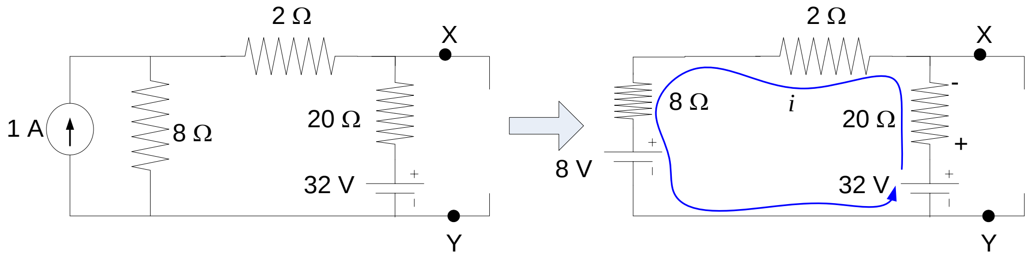
$$i_2 = \frac{0 - V_1}{6} = -2 \text{ A}$$

$$i_3 = \frac{V_1 - 4}{8} = 1 \text{ A}$$

11. Find the Thevenin's equivalent circuit of the following figure between the terminals X-Y.

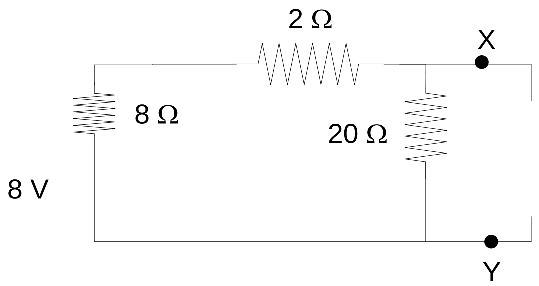


Solution:

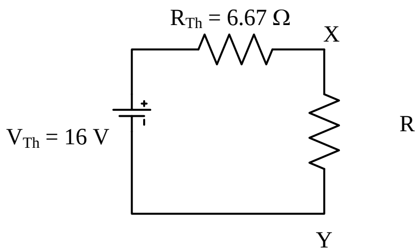


$$i = \frac{32-8}{20+2+8} = \frac{24}{30}\text{ A}$$

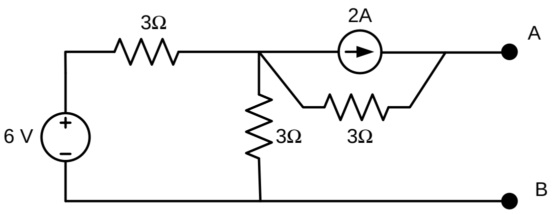
$$V_{Th} = V_{XY} = 32 - 20 \times i = 32 - 20 \times \frac{24}{30} = 32 - 16 = 16\text{ V}$$



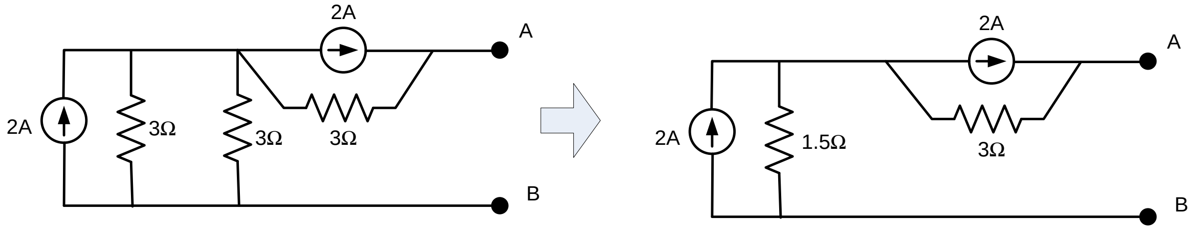
$$R_{Th} = R_{XY} = 20 // (8+2) = \frac{20 \times 10}{20+10} = 6.67\ \Omega$$

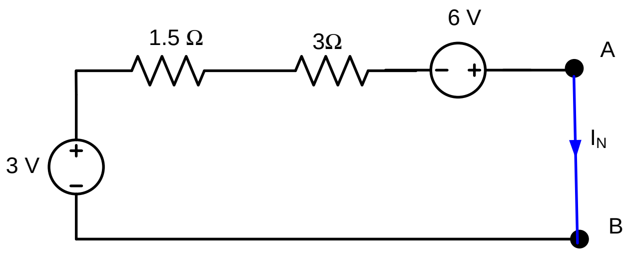


12. For the circuit shown in Figure determine equivalent source current and source resistance across A-B.

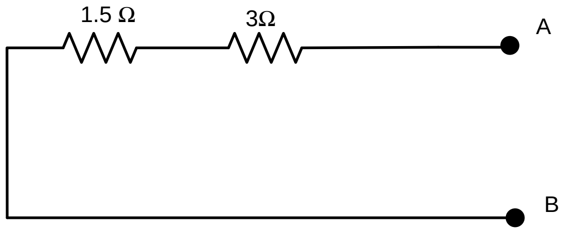


Solution:



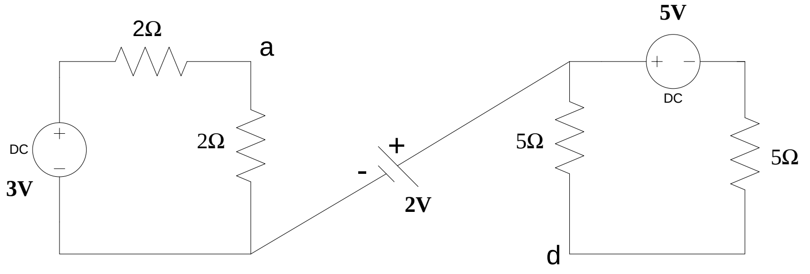


$$I_N = \frac{3+6}{1.5+3} = \frac{9}{4.5} = 2\,\text{A}$$

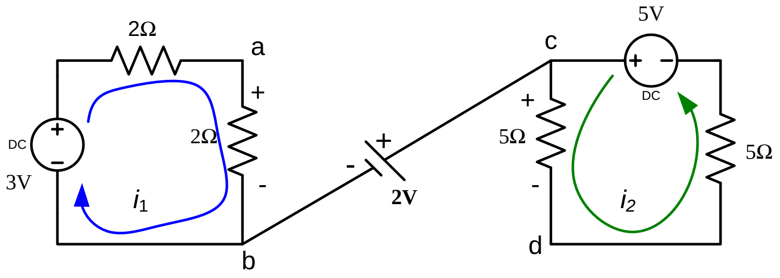


$$R_N = R_{AB} = 3 + 1.5 = 4.5\,\Omega$$

13. For the circuit shown below, find the potential difference between a and d:



Solution:



$$i_1 = \frac{3}{2+2} = 0.75\,\text{A}$$

$$i_2 = \frac{5}{5+5} = 0.5\,\text{A}$$

$$V_{ad} = V_{ab} + V_{bc} + V_{cd} = i_1 \times 2 - 2 + i_2 \times 5 = 0.75 \times 2 - 2 + 0.5 \times 5 = 1.5 - 2 + 2.5 = 2\,\text{A}$$