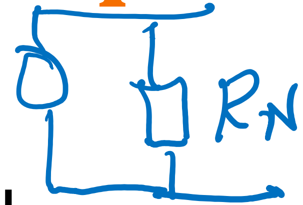
Lecture 13: Norton and IV tools

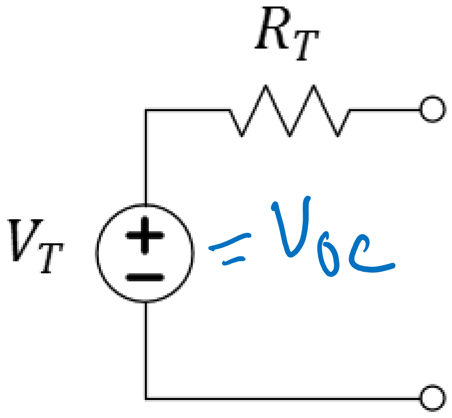
- Norton
- Source Transformations
- Superposition

Thevenin and Norton Equivalents

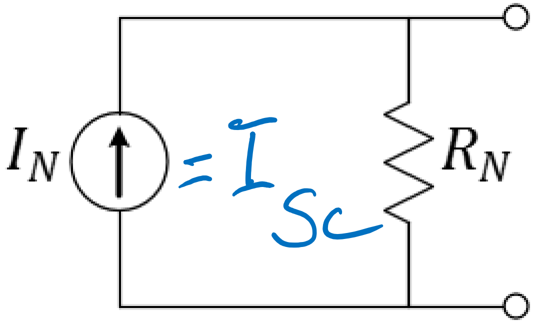
$I_{sc} = \frac{V_{oc}}{R_T}$ $\quad R_T = R_N$ $\quad I_{sc}$



$R_N = R_T$



The circuit on the left and the circuit on the right can be made to behave identically by the choice of values as seen through the terminals.

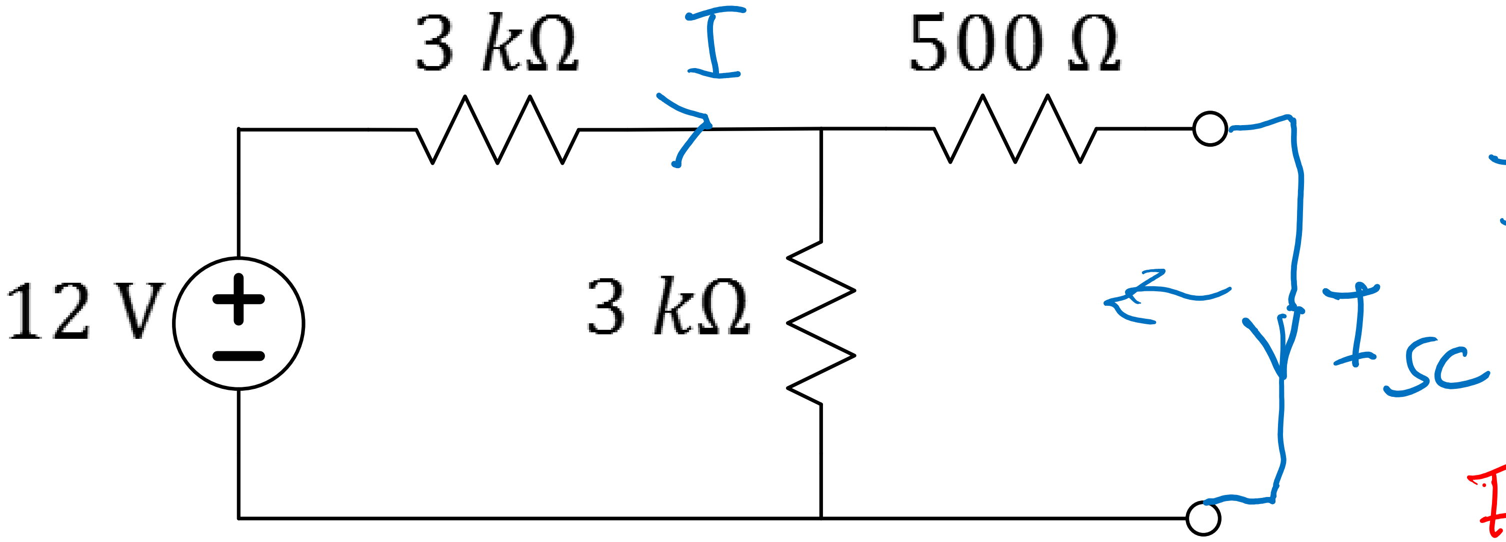


$R_T = R_N$

- Either can be used to represent universal: $I = I_{sc} - \frac{I_{sc}}{V_{oc}} V$
- Contain all information on how circuits interact with other circuits
- Loses information on power dissipation WITHIN the circuit

Norton

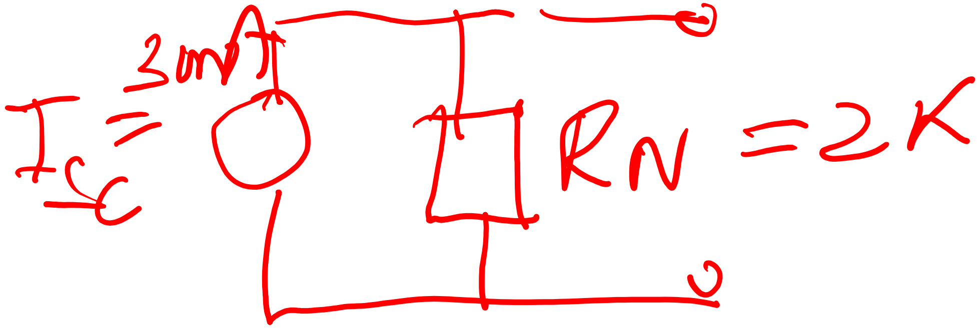
$$R_N = \frac{3K \cdot 3K}{6K} + 0.5K = 2K$$



$$I_{sc} = \frac{I \cdot 3K}{3K + 0.5K} = \frac{I\,3}{3.5}$$

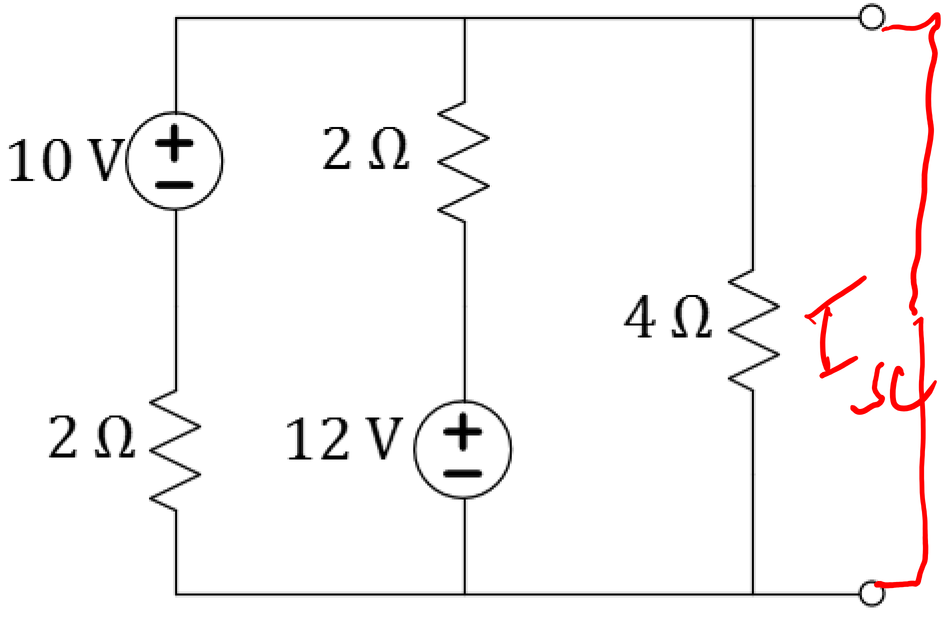
$$I = \frac{12}{\left(3K + \frac{1.5K}{3.5}\right)} = 3.5mA$$

Q: What is the Norton equivalent for the circuit above?

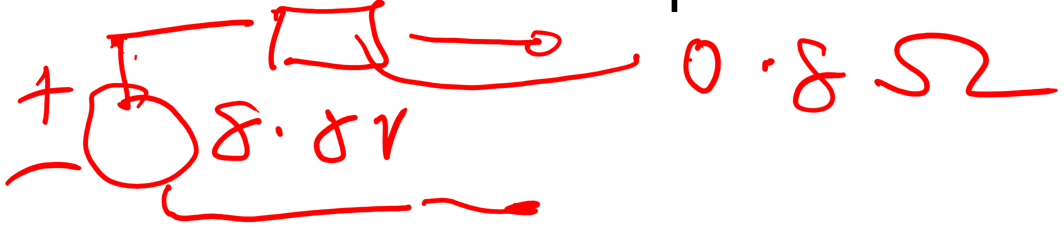


$$I_{sc} = 3mA$$

Source Transformations



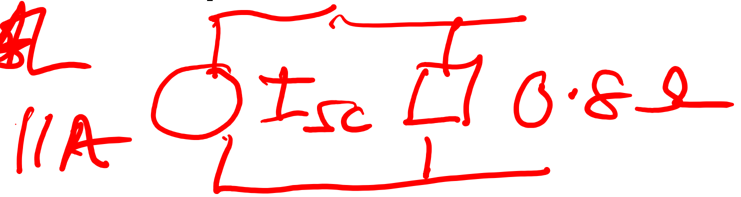
"Source transformations" involve changing Thevenin subcircuits into Norton and Norton subcircuits into Thevenin to gain an advantage in absorbing another part of the circuit. Continue until the entire circuit has been reduced to either a Thevenin or Norton equivalent.



Q: Use "source transformations" to find the Thevenin equivalent of the circuit above.

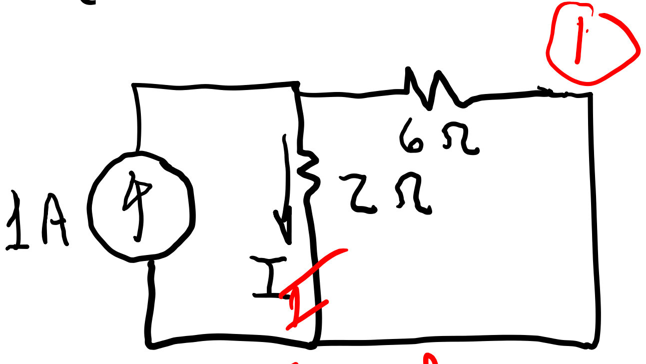
$I_{sc} = \frac{10}{2} + \frac{12}{2} = 11A$

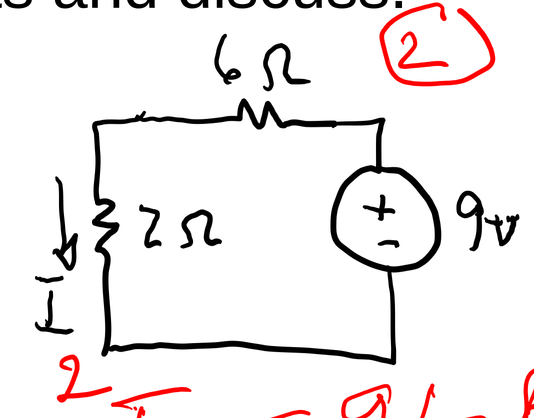
$R_N = 0.8\Omega$

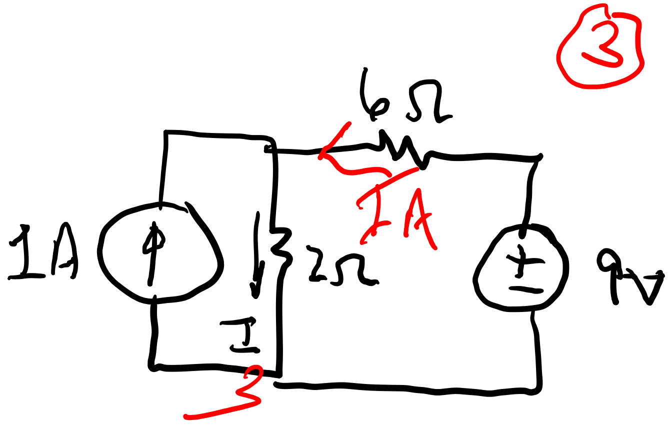


Explore More! Superposition

Q: Find I for all three circuits and discuss.







$I_1 = 6/8\,A$

$I_2 = 9/8\,A$

***Superposition** Theorem*. *The total current in any part of a linear **circuit** equals the algebraic sum of the currents produced by each source separately. To evaluate the separate currents to be combined, replace all other voltage sources by short **circuits** and all other current sources by open **circuits**.*

From: http://hyperphysics.phy-astr.gsu.edu/hbase/electric/suppos.html

$I_3 = 1 + I_A$ — (1)

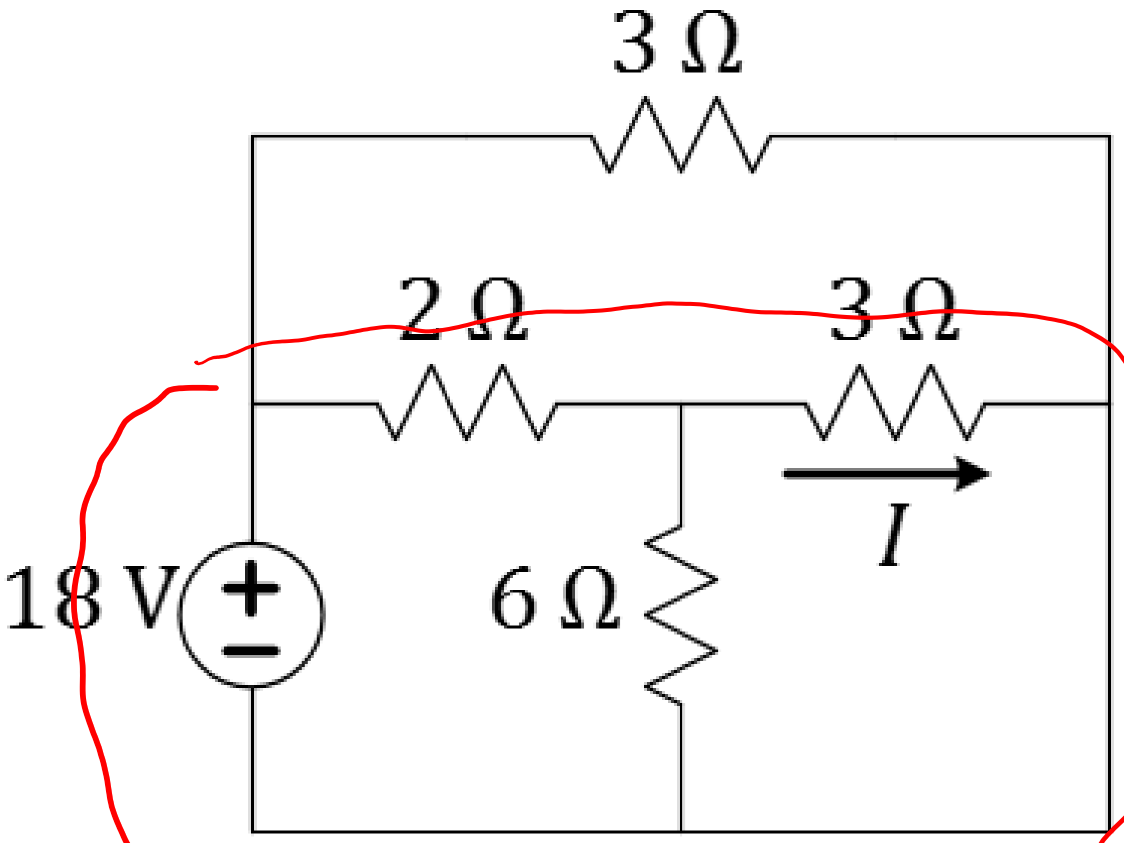
$I_A = (9 - 2I_3)/6$ — (2)

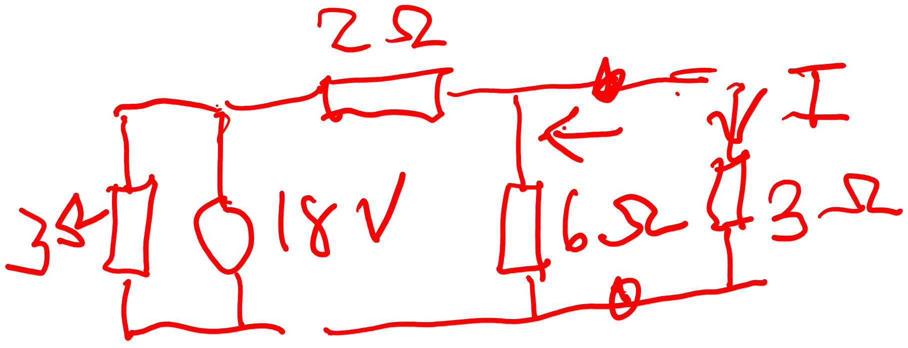
$I_3 = 1 + \dfrac{(9 - I_3 \cdot 2)}{6}$

$8 I_3 = 15$

$I_3 = 15/8$

What are the possible strategies to find *I*?





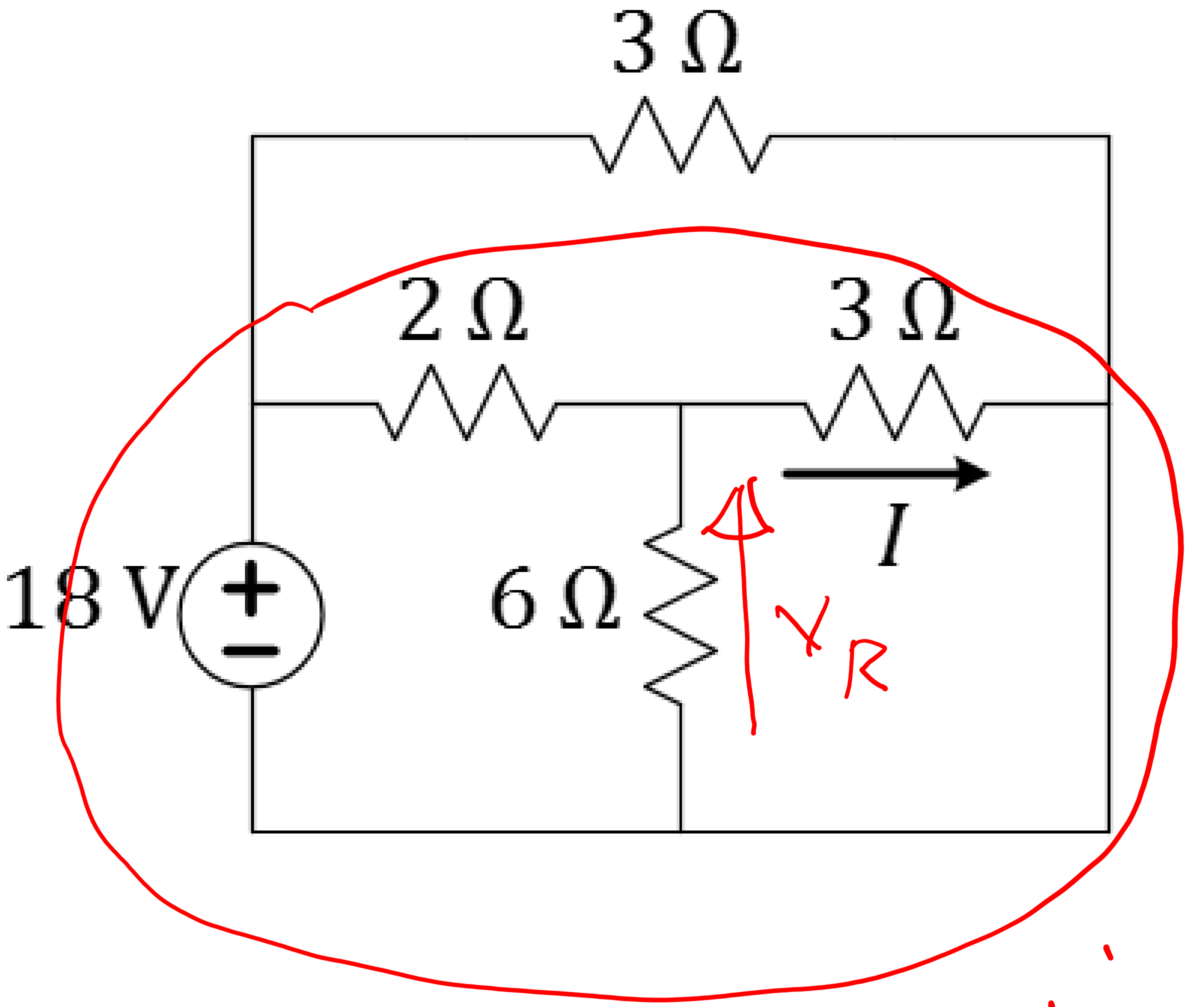
$R_T = 12/8\ \Omega \qquad V_{oc} = \frac{6 \cdot 18}{8}$

$I = \frac{6}{8} \cdot 18 \Big/ 12/8 + 3 = \frac{18}{6} = 3\ A$

Q: Is one of the resistors in parallel with the voltage source? If so, which?

Q: What is the value of the labeled current?

More...



$$I = \frac{V_R}{3}$$

$$V_R = \frac{6 /\!/ 3}{6 /\!/ 3 + 2} \cdot 18$$

$$= \frac{36}{4} = 9V$$

$$\therefore I = \frac{9}{3} = \underline{\underline{3A}}$$

L13 Learning Objectives

a. Explain equivalency of Thevenin and Norton by matching points on the IV.
b. Solve circuits for the Norton Equivalent
c. Use Source Transformations to reduce a circuit to Thevenin and/or Norton
d. Use Superposition to reduce a tougher circuit analysis to analysis of two or more single-supply circuits.

Lecture 14: Node Method For Circuit Analysis

- Review of circuit-solving strategies
- Node Method steps
- Node Method with a “floating” source
- Practice with the Node Method

The Node Method

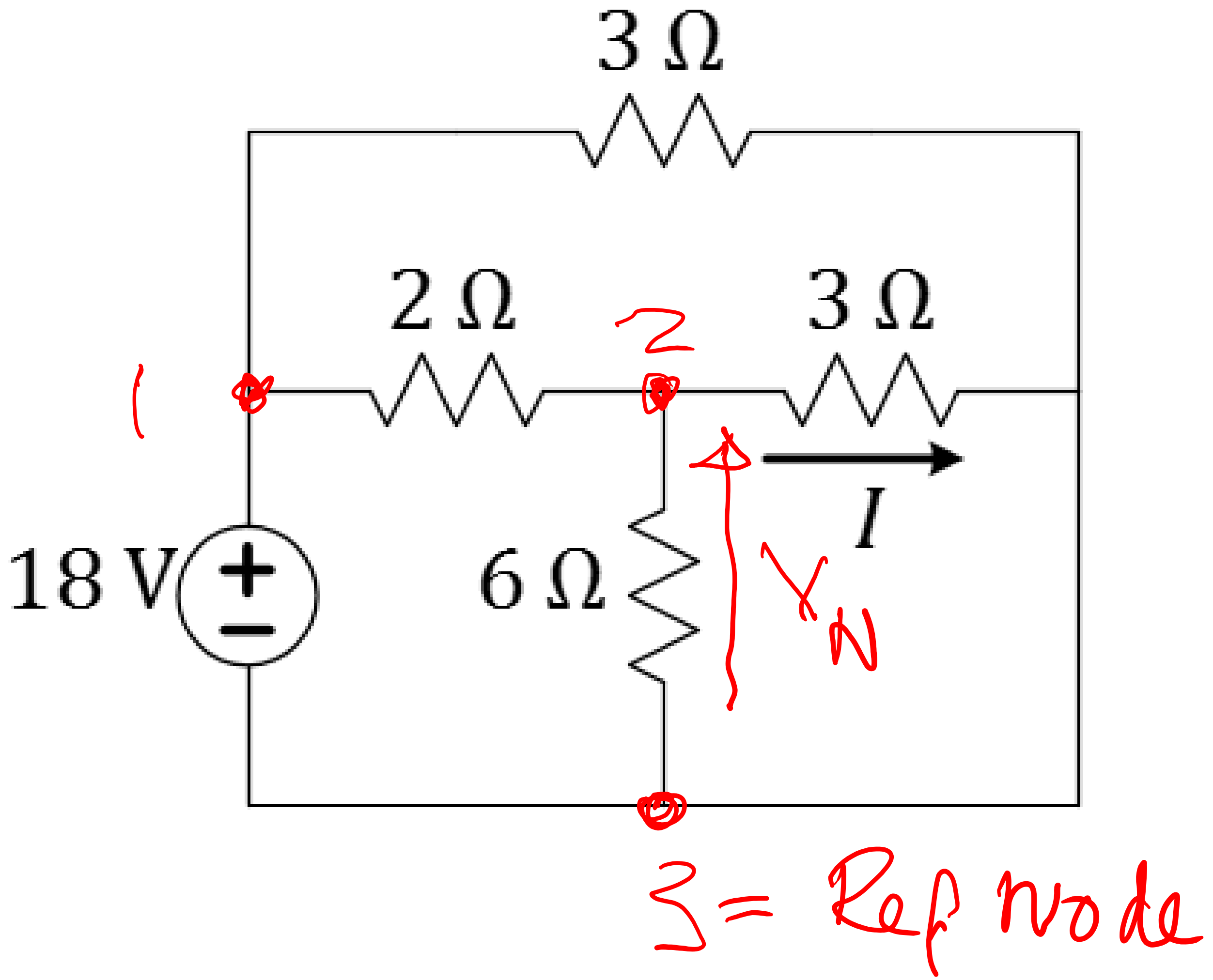
1. Identify or pick “ground” (0 V reference)

2. Label all the node voltages
   (use values when you can; variables when you must)

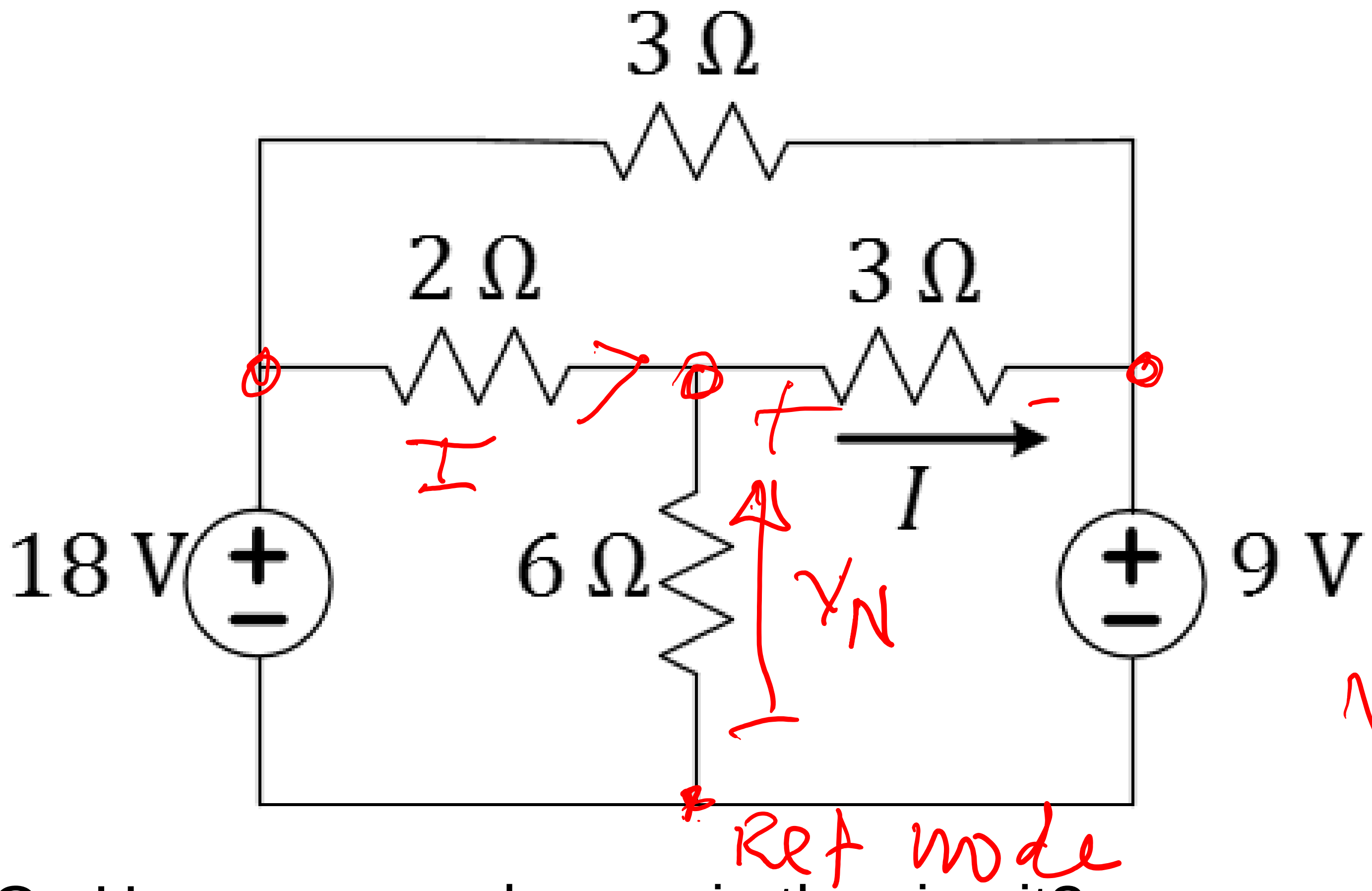
3. Use KCL at convenient node(s)/supernode(s)

4. Use voltages to find the currents

Try Node Method



Node method is a good strategy for this problem because it contains two sources



A. 1
B. 2
C. 3
D. 4
E. 5

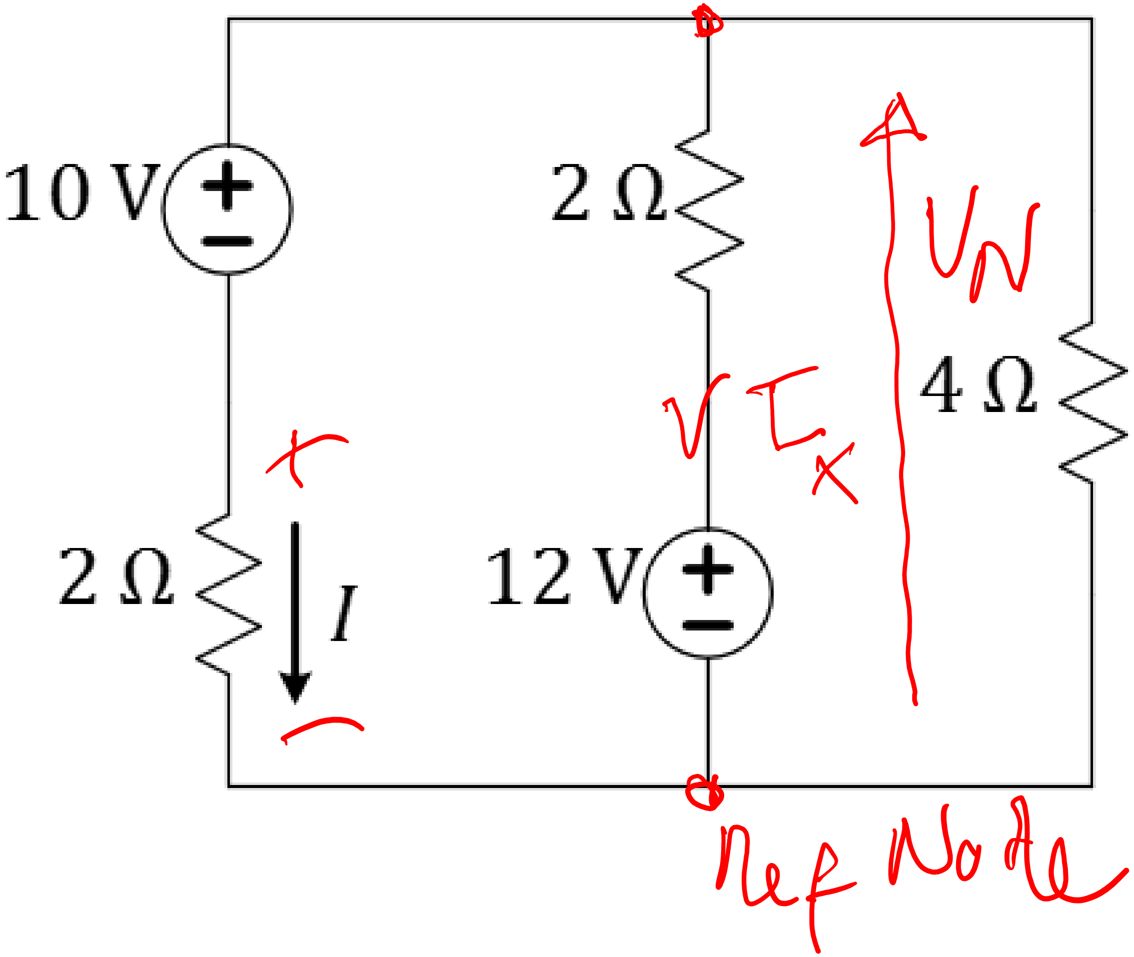
$$\frac{V_N}{6} + I = \frac{18 - V_N}{2} \quad \text{—} ①$$

$$V_N = 3I + 9 \quad \text{—} ②$$

$$\underline{I = 1A}$$

Q: How many nodes are in the circuit?
Q: What is the value of the labeled current?

A *floating* voltage source: relates two nodes but has <u>no known relationship to ground</u>



Q: How many nodes are in the circuit?

A. 1
B. 2
C. 3
D. 4
E. 5

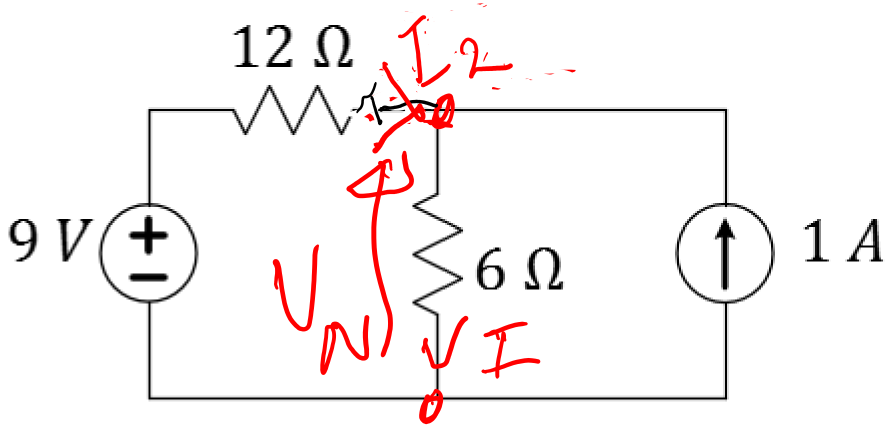
Q: What is the value of the labeled current?

$2I + 10 = V_N$ — (1)

$V_N = 12 + I_x \cdot 2$ — (2)

$\frac{V_N}{4} + I_x = -I$ — (3)

Voltage across a current source is unknown



Q: What is the power supplied or consumed by each element?

$$I = 1 + \frac{(9 - V_N)}{12} \quad — ①$$

$$V_N = I \cdot 6 \quad — ②$$

$$\boxed{I = 7/6\,A}$$

$$P_{6\Omega} = I^2 \cdot 6 = 49/6\,W$$

$$P_{12} = I_2^2 \cdot 12 = 2/6\,W$$

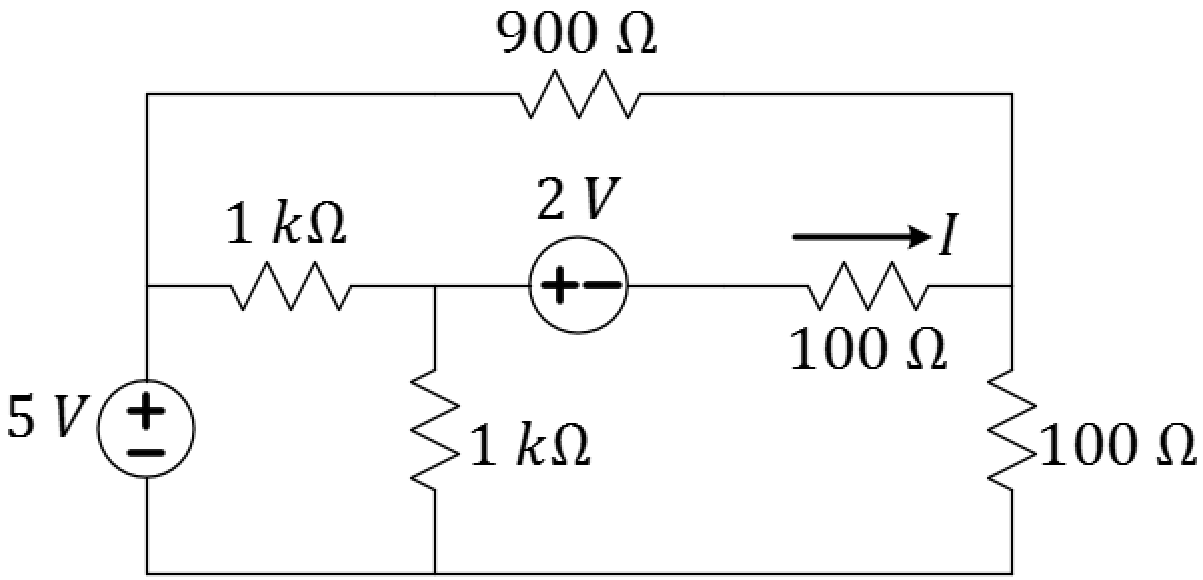
$$\boxed{I_2 = I - 1 = 1/6\,A}$$

$$P_{6\Omega} + P_{12\Omega} = \frac{51}{6} = 8.5\,W$$

$(V_N = 7V)$

From Sources: $-9 \cdot 1/6\,W - 7 \cdot 1\,W = -8.5\,W$

Sometimes two or more node voltages are unknown (more challenging!)



Q: What is the value of *I* in the circuit above?

L14 Learning Objectives

a. Outline (list, describe) steps of the Node Method

b. Use these steps to speed the process of performing circuit analysis via KCL/KVL/Ohm's

c. Identify circuit patterns in which different techniques might simplify the process of finding a solution (Practice!)