

# Department of Computer Science and Engineering (CSE) BRAC University

Spring 2023

CSE250 - Circuits and Electronics

## CIRCUIT CONFIGURATIONS

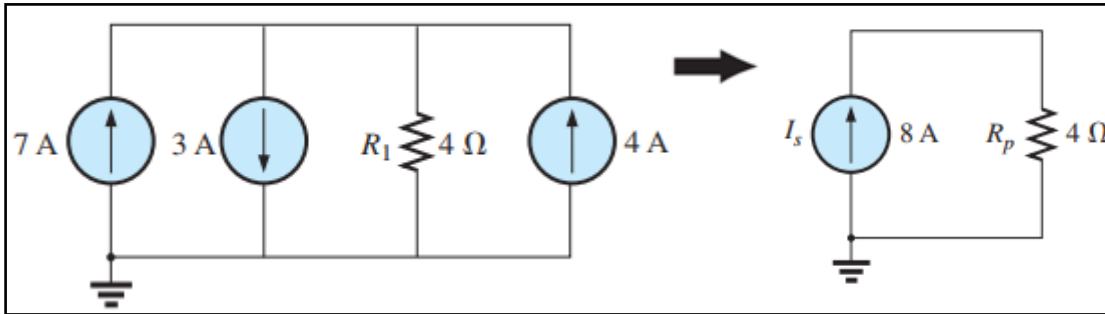
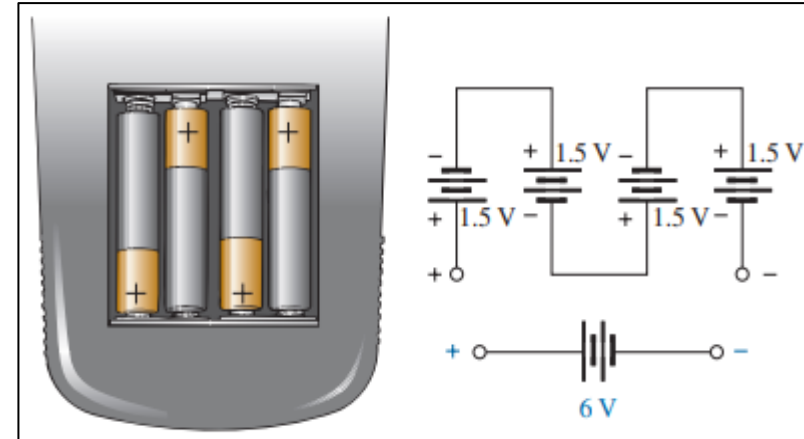
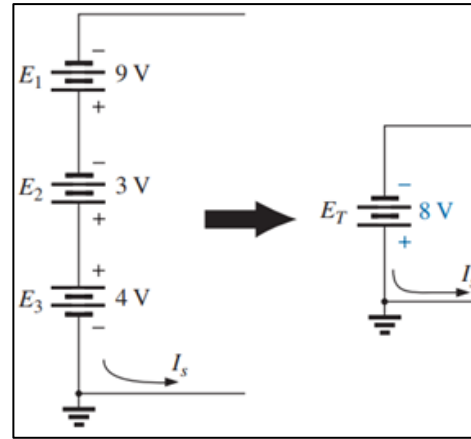
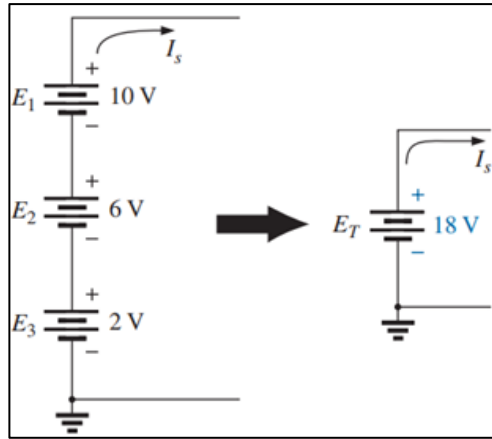


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# Circuit Configurations

- Circuit elements can be connected to each other in two main ways: series connection and parallel connection.
- In *series configuration*, components are connected end-to-end in a line. The same current flows through all the components. If one component breaks down, the whole circuit will burn out.
- In *parallel configuration*, all components are connected across each other leads forming exactly two sets of electrically common points. There are many paths for current flow, but only one voltage across all components.
- Another configuration occurs when the circuit components are not connected in series or parallel but rather in a 'Y' or ' $\Delta$ ' configuration. *Wye-Delta transformation* is required to simplify such configuration.
- The majority of electric circuits use all configurations simultaneously.

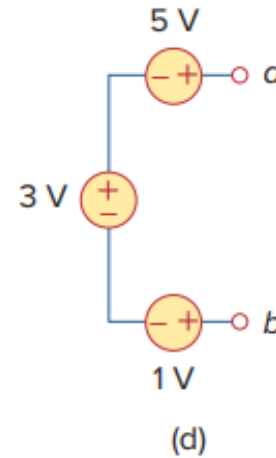
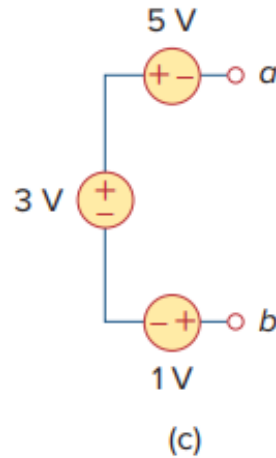
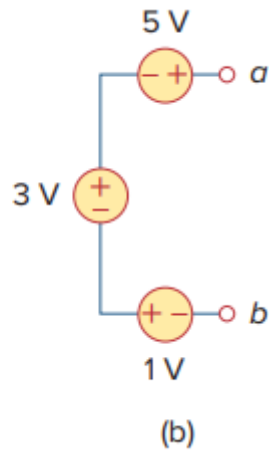
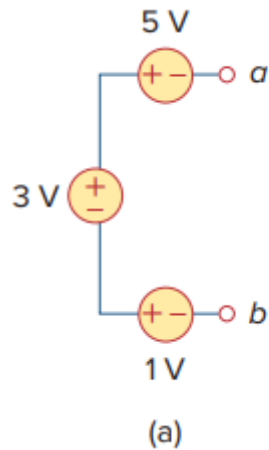
# Different arrangements of sources



It is not practical to connect voltage sources of unequal ratings in parallel and current sources of unequal currents in series due to the direct violation of KVL and KCL respectively.

# Problem 1

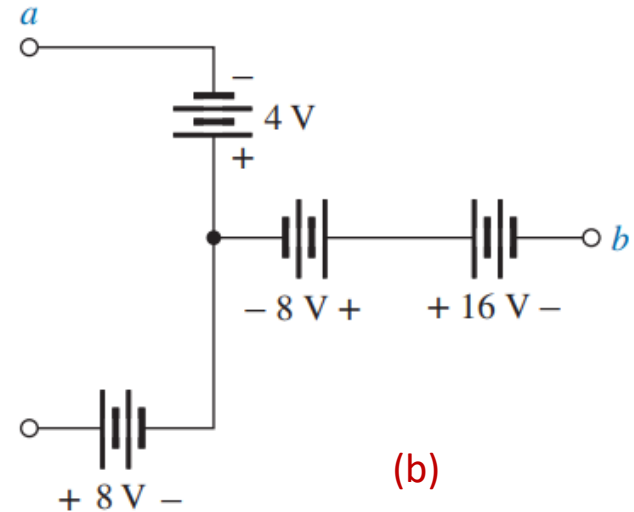
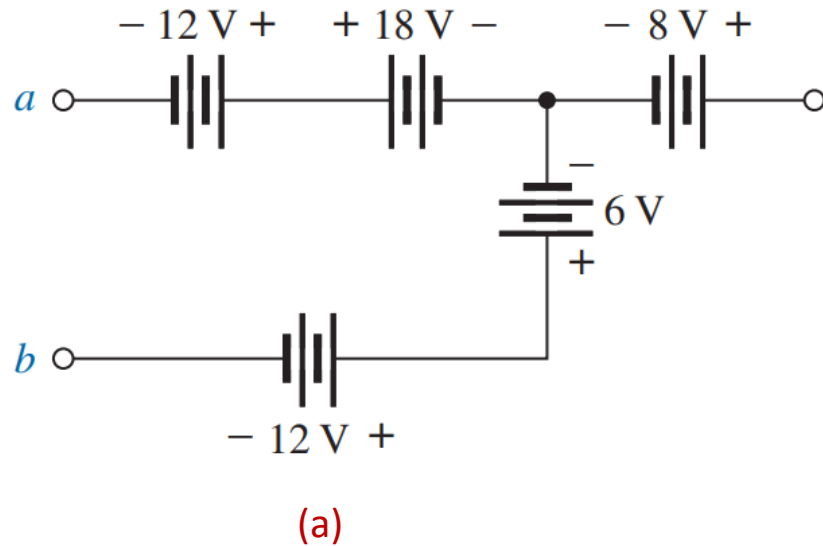
- For each of the circuits shown below, calculate  $V_{ab}$



Ans: (a)  $V_{ab} = 1\text{ V}$ ; (b)  $V_{ab} = 10\text{ V}$ ; (c)  $V_{ab} = -3\text{ V}$ ; (d)  $V_{ab} = 7\text{ V}$

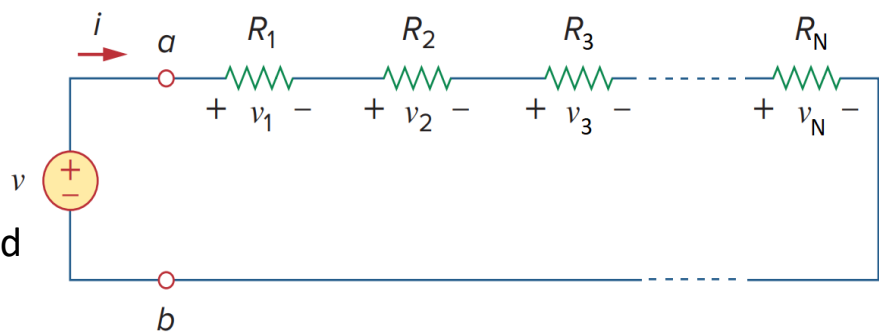
# Problem 2

- For each of the circuits shown below, calculate  $V_{ab}$



Ans: (a)  $V_{ab} = 12\text{ V}$ ; (b)  $V_{ab} = 4\text{ V}$

# Series resistors



- Consider  $N$  number of resistors connected in series with a power supply of  $v$  volts.
- If the current flowing through the series circuit is  $i$ , then the voltage drops across the resistors can be written as,

$$v_1 = iR_1, v_2 = iR_2, v_3 = iR_3, \dots, v_N = iR_N$$

$$\text{According to the KVL, } v = v_1 + v_2 + v_3 + \dots + v_N$$

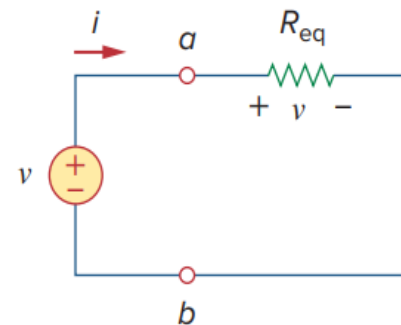
$$\Rightarrow v = i(R_1 + R_2 + R_3 + \dots + R_N)$$

$$\Rightarrow i = \frac{v}{R_1 + R_2 + R_3 + \dots + R_N}$$

- It can be written as,  $v = iR_{eq}$ , implying that the series resistors can be replaced by an equivalent resistor  $R_{eq}$ ; that is,

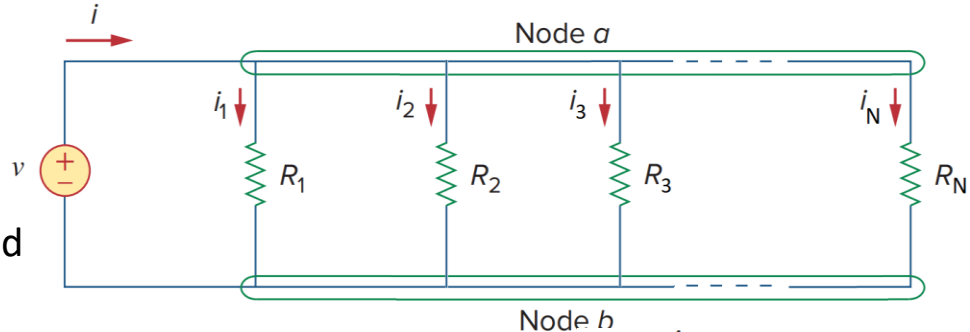
$$R_{eq} = R_1 + R_2 + R_3 + \dots + R_N$$

- The two circuits have the same voltage-current relationships at terminal a-b, hence, they are equivalent to each other.



# Parallel resistors

- Consider N number of resistors connected in parallel with a power supply of  $v$  volts.



- Therefore, they have the same voltage  $v$  across them. So,

$$v = i_1 R_1 = i_2 R_2 = i_3 R_3 = \dots = i_N R_N$$

- According to the KCL,  $i = i_1 + i_2 + i_3 + \dots + i_N$

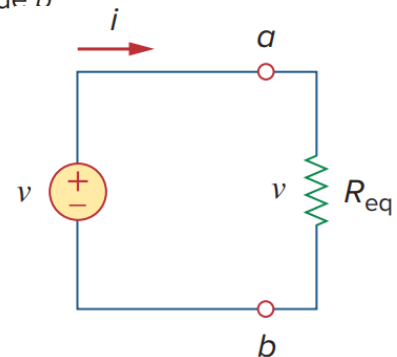
$$\Rightarrow i = \frac{v}{R_1} + \frac{v}{R_2} + \frac{v}{R_3} + \dots + \frac{v}{R_N}$$

$$\Rightarrow i = v \left( \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots + \frac{1}{R_N} \right)$$

- It can be written as,  $i = \frac{v}{R_{eq}}$ , implying that the parallel resistors can be replaced by an equivalent resistor  $R_{eq}$ ; that is,

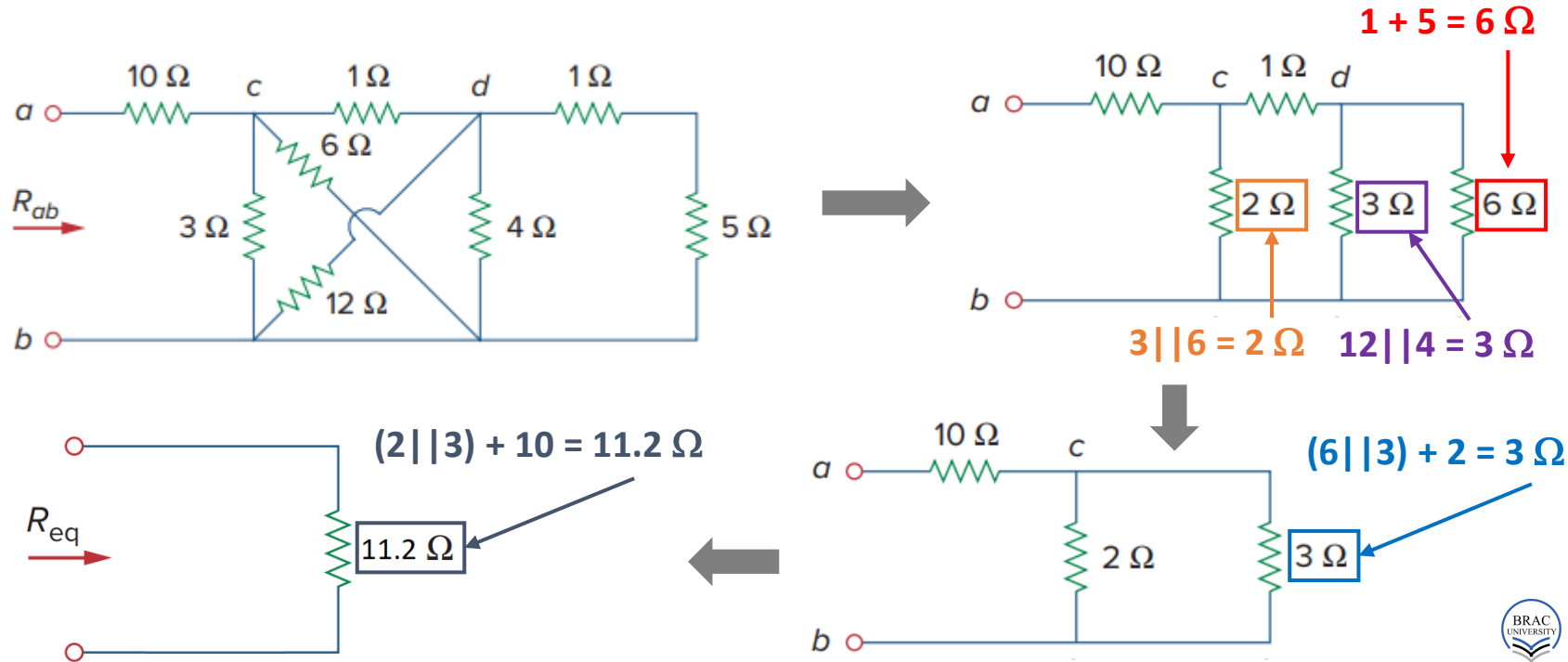
$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots + \frac{1}{R_N}$$

- The two circuits have the same voltage-current relationships at terminal a-b, hence, are equivalent to each other.



# Example 1

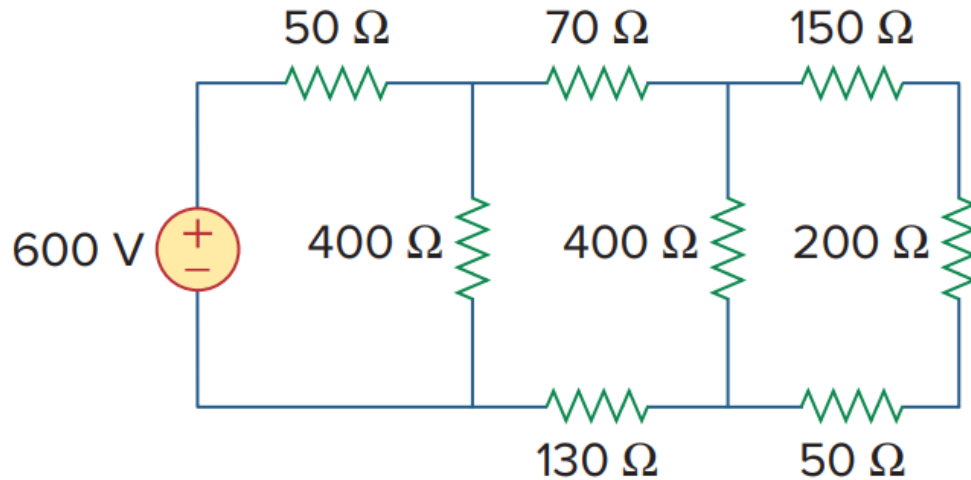
- Using series/parallel resistance combination, find  $R_{ab}$  for the circuit shown below.





# Problem 3

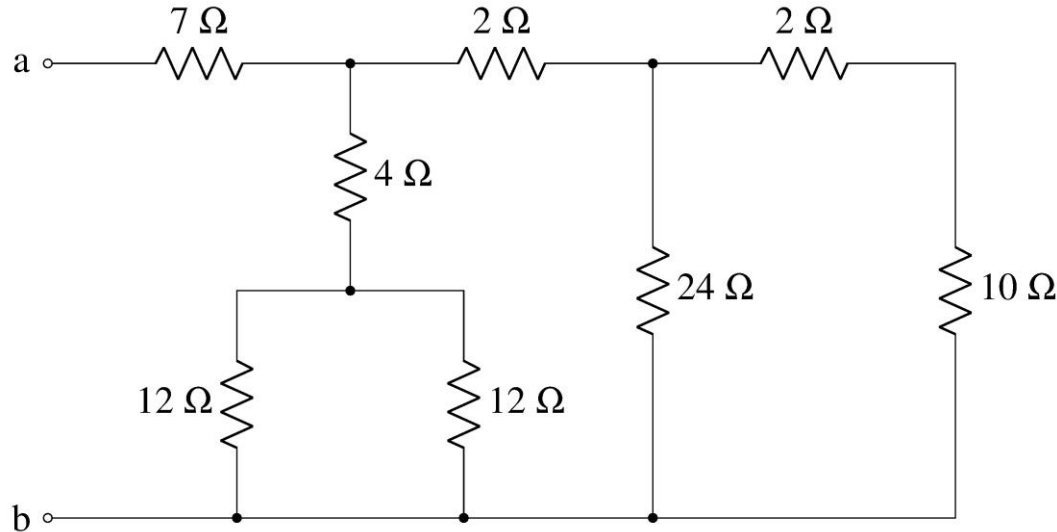
- Using series/parallel resistance combination, find the equivalent resistance seen by the source in the circuit below.



$$\underline{\text{Ans: } R_{eq} = 250 \, \Omega}$$

# Problem 4

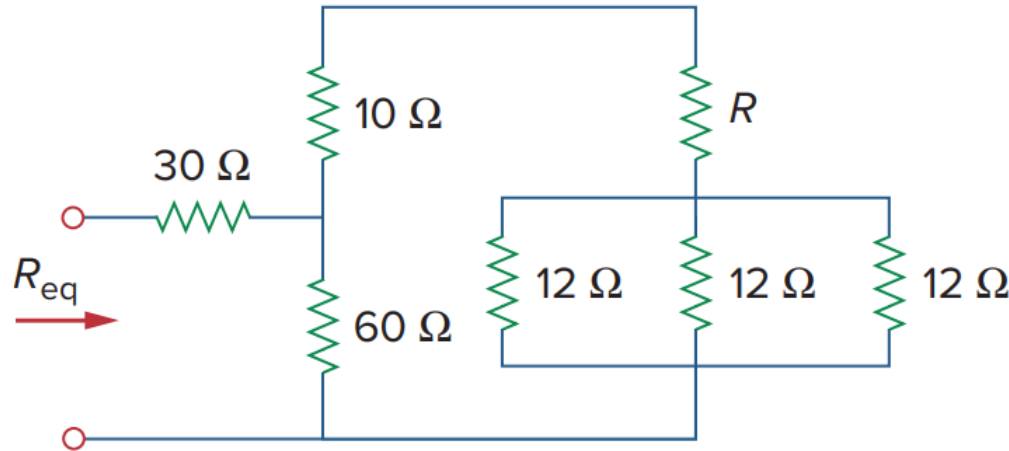
- Find the equivalent resistance between terminals  $a$  and  $b$ .



Ans:  $R_{ab} = 12\ \Omega$

# Problem 5

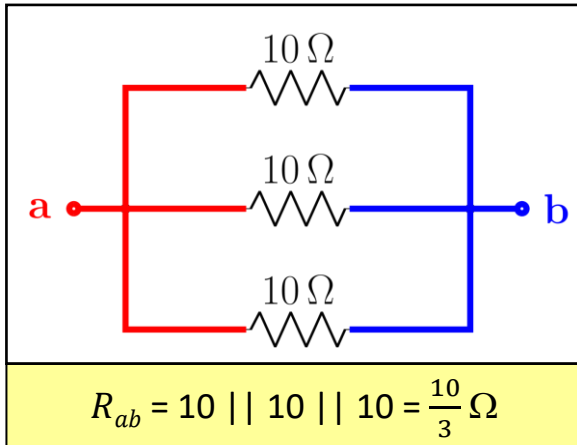
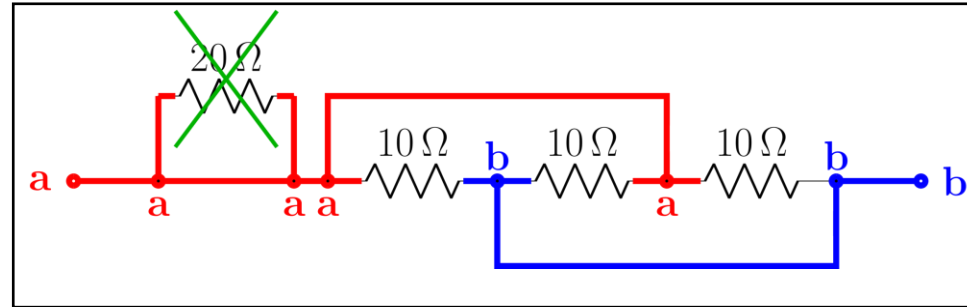
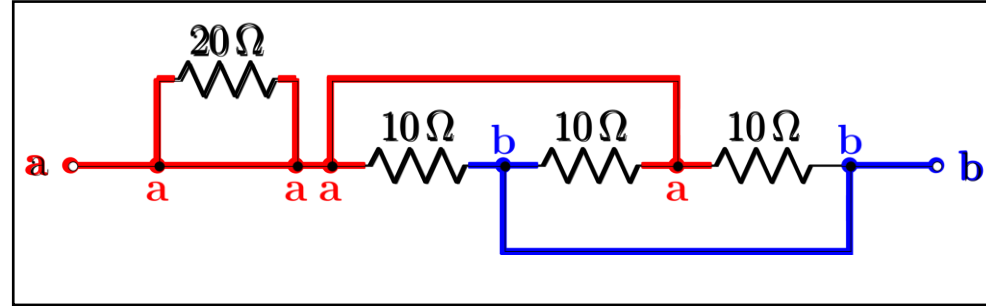
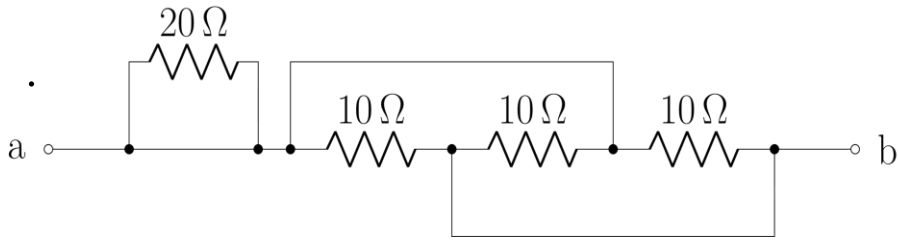
- If  $R_{eq} = 50 \Omega$  in the circuit, find  $R$ .



Ans:  $R = 16 \Omega$

# Example 2

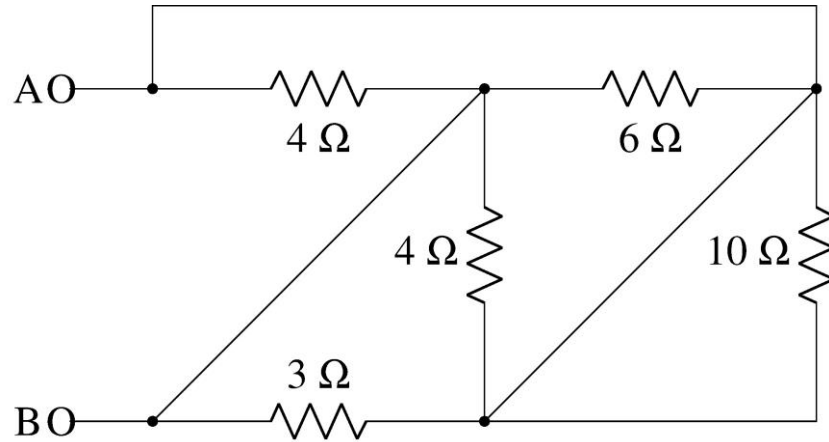
- Find  $R_{ab}$



$$R_{ab} = 10 \parallel 10 \parallel 10 = \frac{10}{3} \Omega$$

# Problem 6

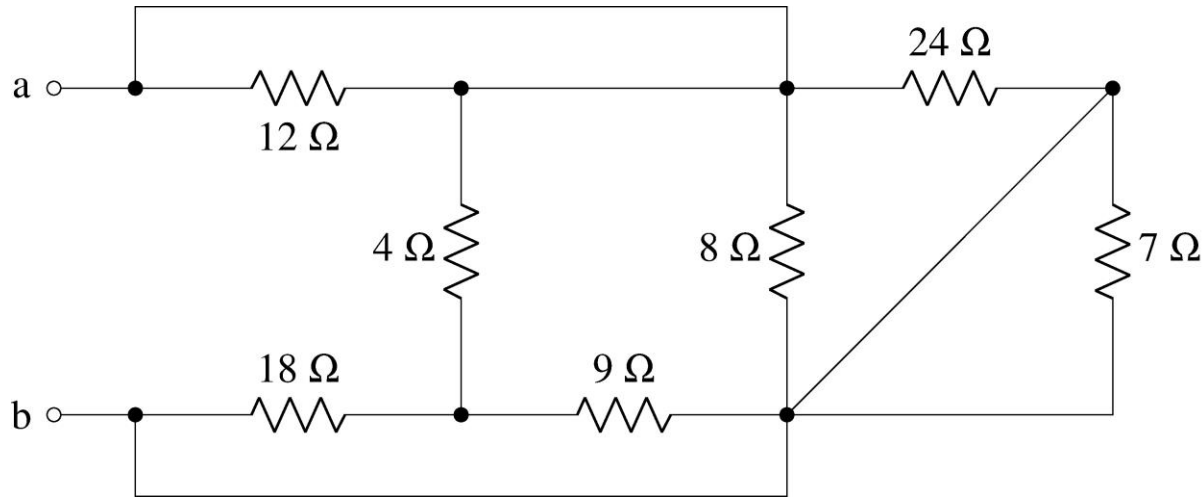
- Find the equivalent resistance between terminals  $A$  and  $B$ .



Ans:  $R_{AB} = 1\ \Omega$

# Problem 7

- Find the equivalent resistance between terminals  $a$  and  $b$ .



Ans:  $R_{ab} = 3.75\ \Omega$

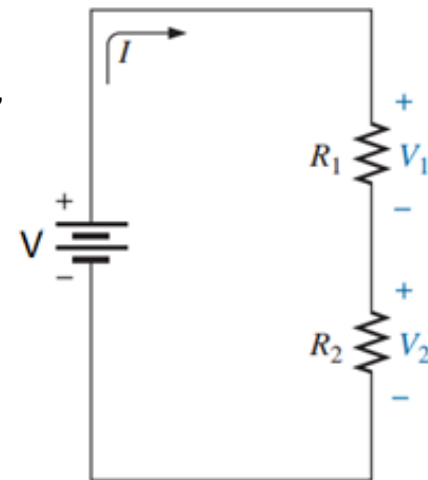
# Voltage Division Rule

- The voltage division rule permits the determination of the voltage across a series resistor without first having to determine the current of the circuit.
- The current through the series circuit can be found using Ohm's law as,

$$I = \frac{V}{R_1 + R_2}$$

- Applying Ohm's law to each of the resistors,

$$\begin{aligned} V_1 &= IR_1 \quad \text{and} \quad V_2 = IR_2 \\ \Rightarrow V_1 &= \frac{V}{R_1 + R_2} R_1 \quad \text{and} \quad V_2 = \frac{V}{R_1 + R_2} R_2 \\ \Rightarrow V_1 &= \frac{R_1}{R_1 + R_2} \times V \quad \text{and} \quad V_2 = \frac{R_2}{R_1 + R_2} \times V \end{aligned}$$

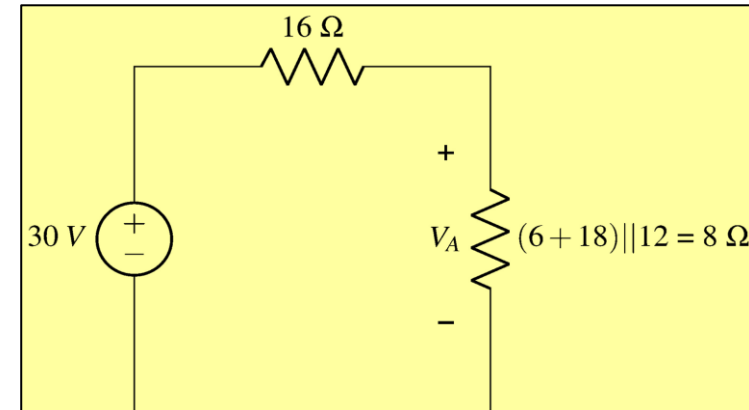
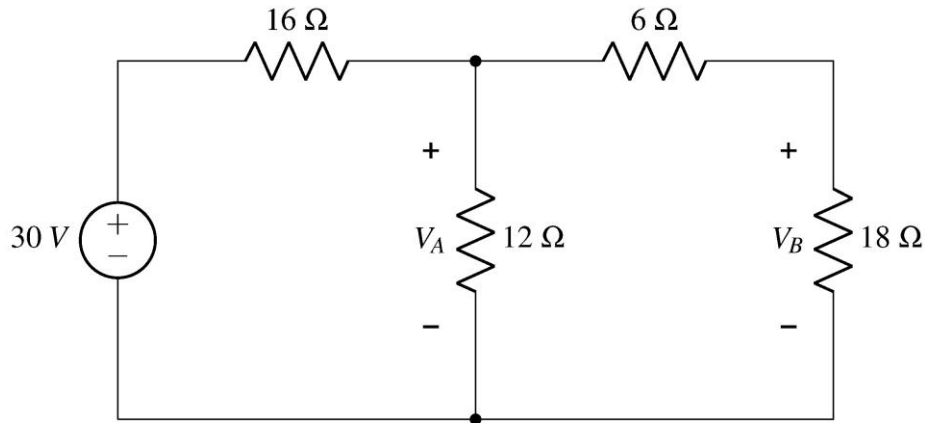


- In general, for any number of resistors connected in series to a supply voltage, the voltage across any particular resistor  $R_x$  is,

$$V_x = \frac{R_x}{R_1 + R_2 + R_3 + \dots + R_N} \times V$$

# Example 3

- Using the voltage divider rule, find the voltages  $V_A$  and  $V_B$ . Don't calculate currents.



$$V_A = \frac{8}{8 + 16} \times 30 = 10 \text{ V}$$

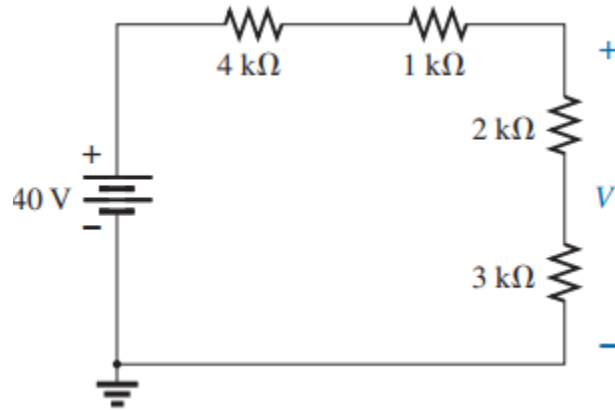


$$V_B = \frac{18}{18 + 6} \times V_A = 7.5 \text{ V}$$



# Problem 8

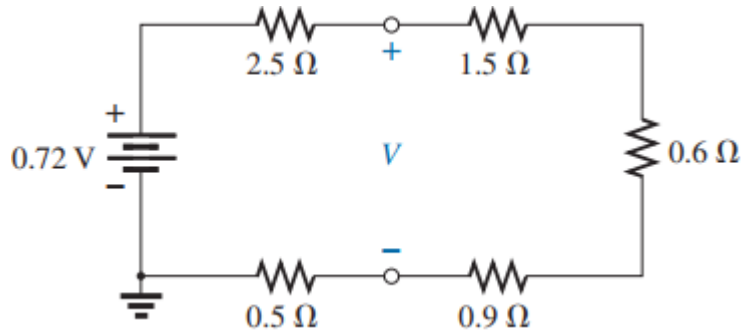
- Using the voltage divider rule, find the indicated voltage. Don't calculate current.



Ans:  $V = 20\text{ V}$

# Problem 9

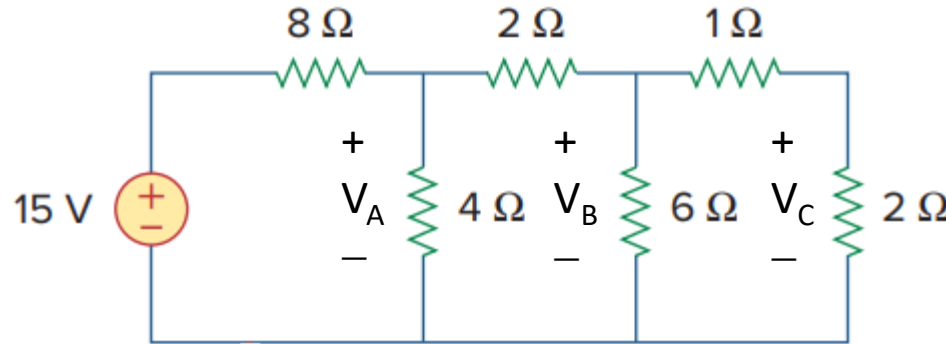
- Using the voltage divider rule, find the indicated voltage. Don't calculate current.



$$\text{Ans: } V = 0.36 \text{ V}$$

# Problem 10

- Using the voltage divider rule, find the voltages  $V_A$ ,  $V_B$ , and  $V_C$ . Don't calculate currents.



**Ans:  $V_A = 3\text{ V}$ ;  $V_B = 1.5\text{ V}$ ;  $V_C = 1\text{ V}$**

# Current Division Rule

- The current division rule permits the determination of the currents through resistors connected in parallel without first having to determine the voltage across them.

- Since the voltage  $V$  is the same across parallel elements, the following is true:

$$V = I_1 R_1 = I_2 R_2 = I_3 R_3 = \dots = I_N R_N$$

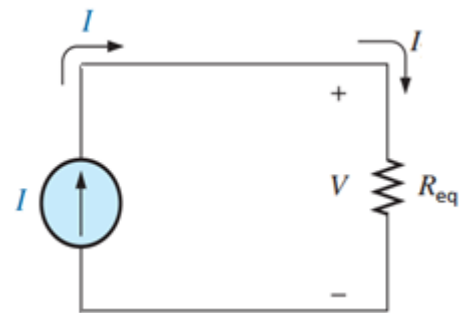
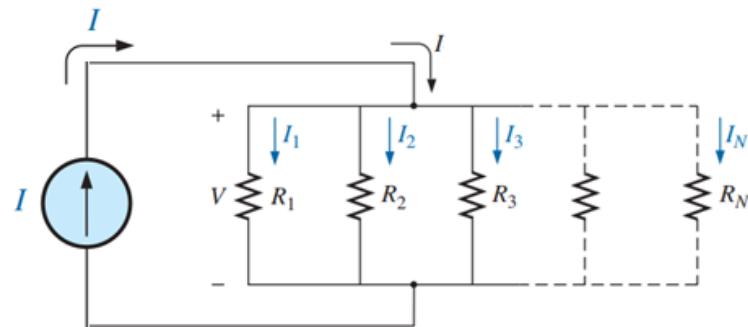
- Substituting  $V$  with  $V = IR_{eq}$ ,

$$IR_{eq} = I_1 R_1 = I_2 R_2 = I_3 R_3 = \dots = I_N R_N$$

$$\Rightarrow I_1 = \frac{R_{eq}}{R_1} \times I, \quad I_2 = \frac{R_{eq}}{R_2} \times I, \quad I_3 = \frac{R_{eq}}{R_3} \times I$$

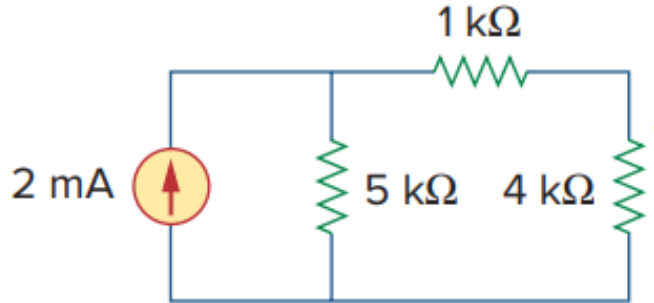
- In general, for any number of resistors connected in parallel to a supply current, the current through any particular resistor  $R_x$  is,

$$I_x = \frac{R_{eq}}{R_x} \times I, \text{ or, } I_x = \frac{(R_x)^{-1}}{(R_1)^{-1} + (R_2)^{-1} + \dots + (R_x)^{-1}} \times I$$



# Example 4

- Calculate the current through the  $5\text{ k}\Omega$  resistor using current division rule. Do not use Ohm's Law.



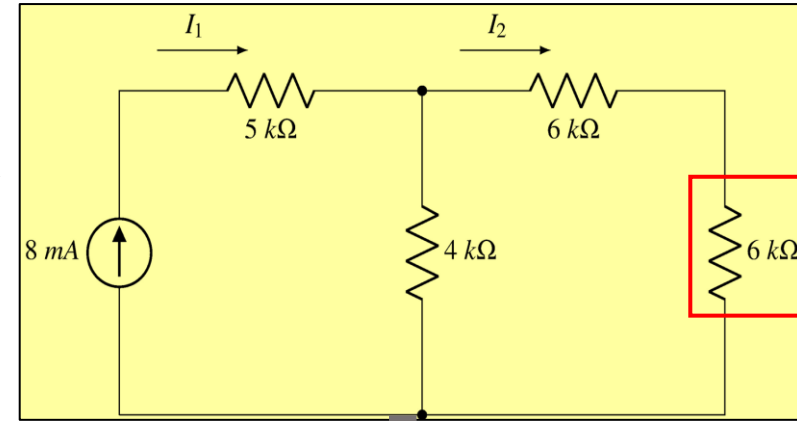
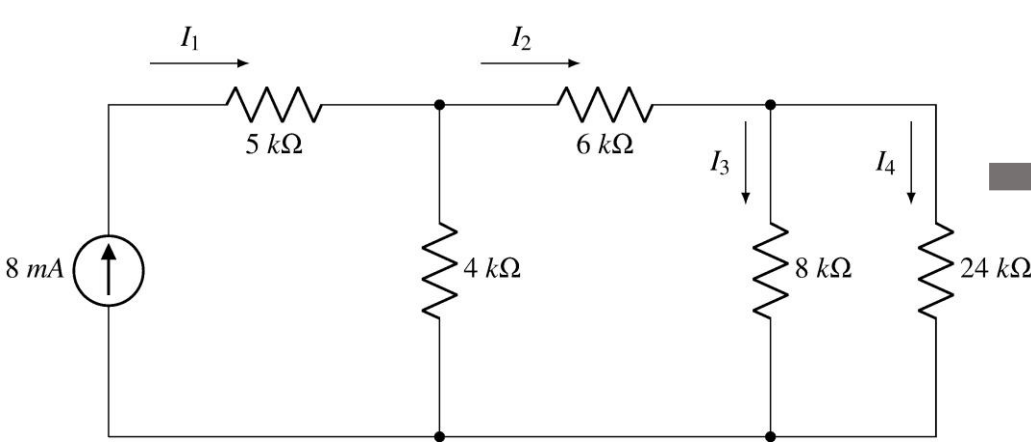
## Solution

Current through the  $5\text{ k}\Omega$  resistor is,

$$\frac{5^{-1}}{(1 + 4)^{-1} + 5^{-1}} \times 2\text{ mA} \\ = 1\text{ mA}$$

# Example 5

- Calculate the currents  $I_1$  to  $I_4$  using current division rule. Don't calculate voltage.

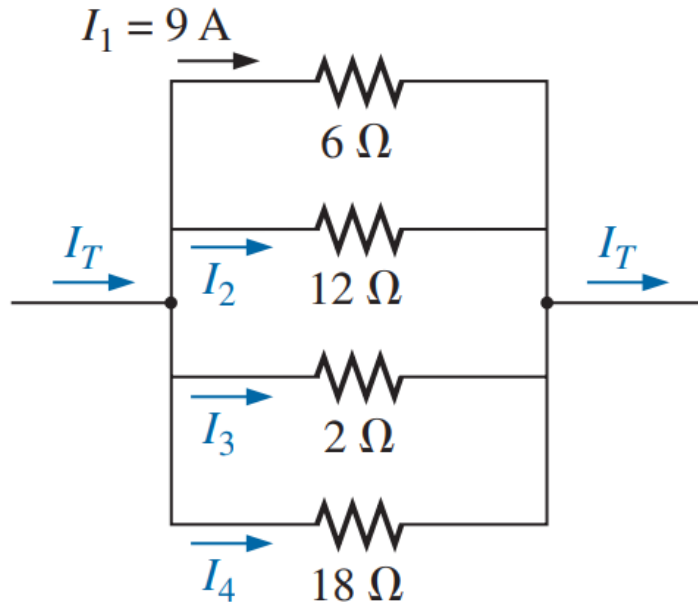


$$I_3 = \frac{8^{-1}}{24^{-1} + 8^{-1}} \times I_2 = 1.5\text{ mA}$$
$$I_4 = I_2 - I_3 = 0.5\text{ mA}$$

$$I_1 = 8\text{ mA}$$
$$I_2 = \frac{12^{-1}}{4^{-1} + 12^{-1}} \times 8\text{ mA} = 2\text{ mA}$$

# Problem 11

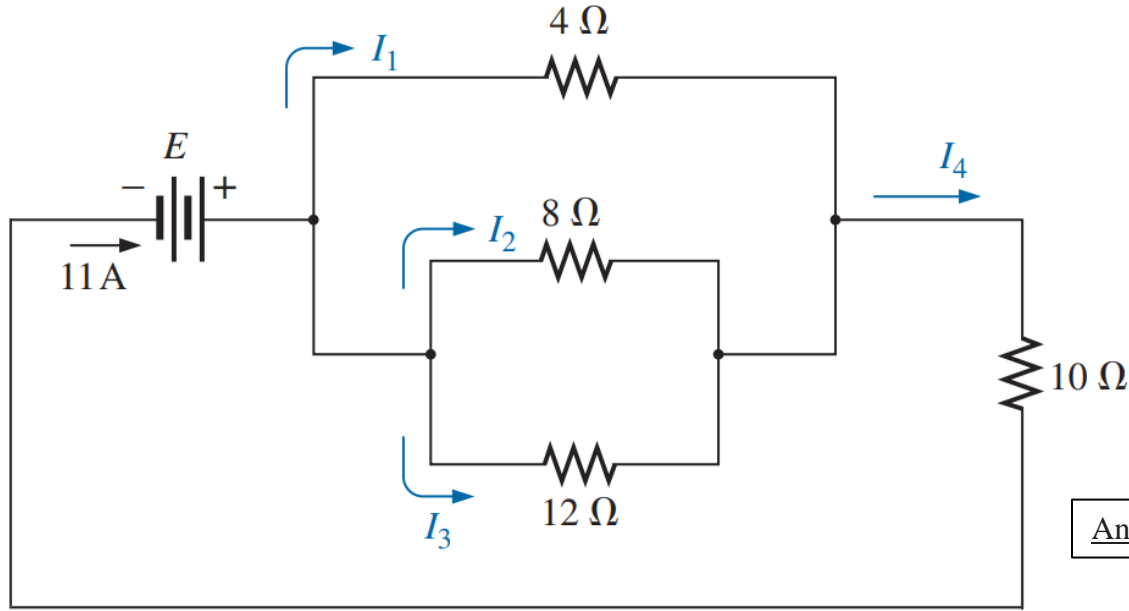
- Based solely on the resistor values, determine all the currents. Do not use Ohm's law.



Ans:  $I_T = 43.5\text{ A}$ ;  $I_2 = 4.5\text{ A}$ ;  $I_3 = 27\text{ A}$ ;  $I_4 = 3\text{ A}$

# Problem 12

- Determine the unknown currents. Do not use Ohm's law.

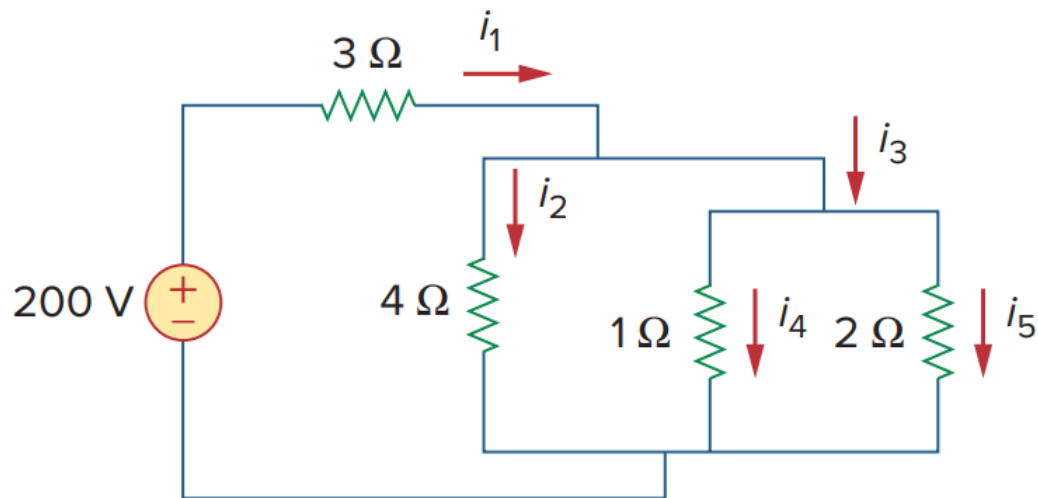


Ans:  $I_1 = 5\text{ A}$ ;  $I_2 = 3.6\text{ A}$ ;  $I_3 = 2.4\text{ A}$ ;  $I_4 = 11\text{ A}$



# Problem 13

- Determine the currents  $i_1$  to  $i_5$  using current division rule.



Ans:  $i_1 = 56\text{ A}$ ;  $i_2 = 8\text{ A}$ ;  $i_3 = 48\text{ A}$ ;  $i_4 = 32\text{ A}$ ;  $i_5 = 16\text{ A}$ .

# Practice Problems

- Additional practice problems can be found [here](#)

Thank you for your attention