UNIT 1: DC CIRCUITS

Lecture 3

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Kirchhoff's Law

- Ohm's law by itself is not sufficient to analyze circuits.
- However, when it is coupled with Kirchhoff's two laws, we have a sufficient, powerful set of tools for analyzing a large variety of electric circuits.
- These laws are:

1. Kirchhoff's Voltage Law (KVL)
2. Kirchhoff's Current Law (KCL)

Kirchhoff's Current Law (KCL)

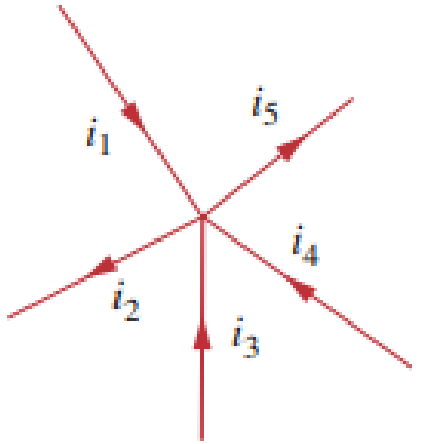
- It states that:

"the algebraic sum of currents entering a node is zero".

OR

" Sum of currents entering a node = Sum of currents leaving a node "

- Based on Law of Conservation of Charge.
- Mathematically, $\sum I = 0$



QUICK QUIZ (Poll 1)

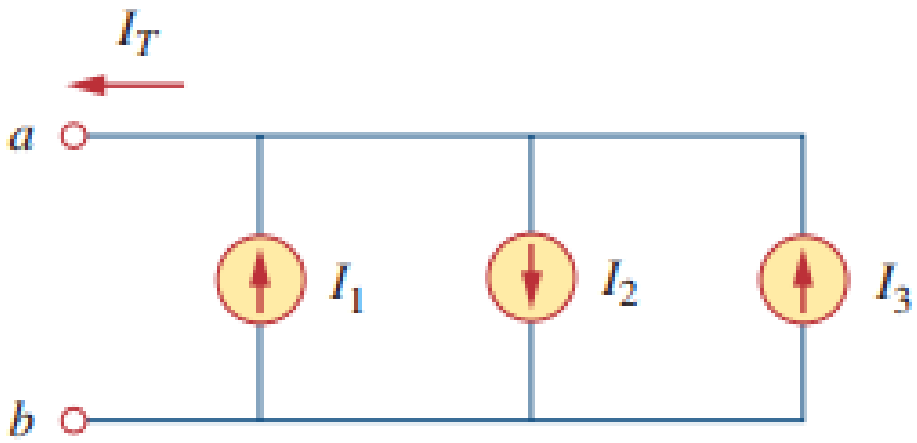
KCL equation for the given network is:

A. $I_1 + I_2 + I_3$

B. $I_1 + I_2 - I_3$

C. $I_1 - I_2 + I_3$

D. $-I_1 - I_2 + I_3$



Kirchhoff's Voltage Law (KVL)

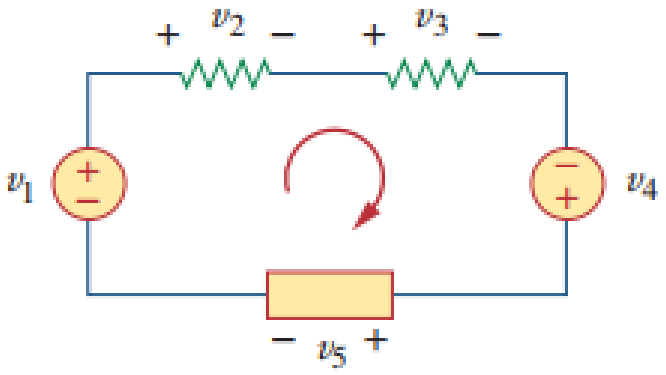
- It states that:

"algebraic sum of all voltages around a closed path (or loop) is zero."

OR

" Sum of voltage drops = Sum of voltage rises."

- Based on Law of Conservation of Energy
- Mathematically, $\sum V = 0$



Applications of Kirchhoff's Laws

- They can be used to analyze any electrical circuit.
- Computation of current and voltage of complex circuits.

Limitations of Kirchhoff's Laws

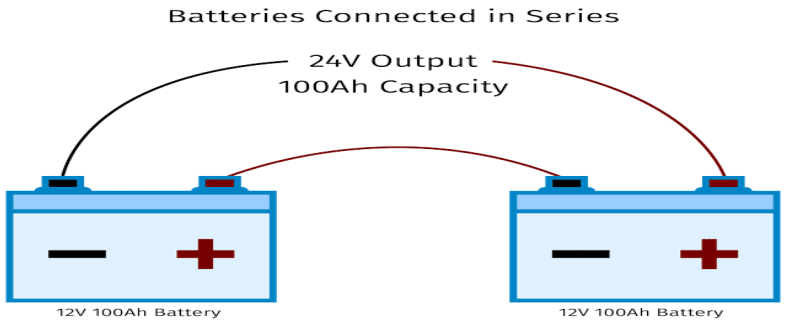
- The limitation of Kirchhoff's both laws is that it works under the assumption that there is no fluctuating magnetic field in the closed loop and the current flows only through conductors and wires.
- Size of the circuit must be smaller than the wavelength associated with signal

$$\frac{\partial \phi_B}{\partial t} = 0$$ Outside elements

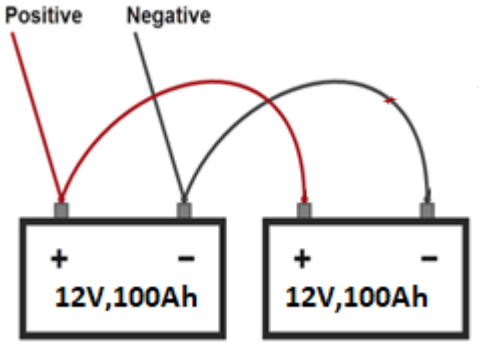
$$\frac{\partial q}{\partial t} = 0$$ Inside elements

wires resistors sources

Battery Voltage in series and parallel

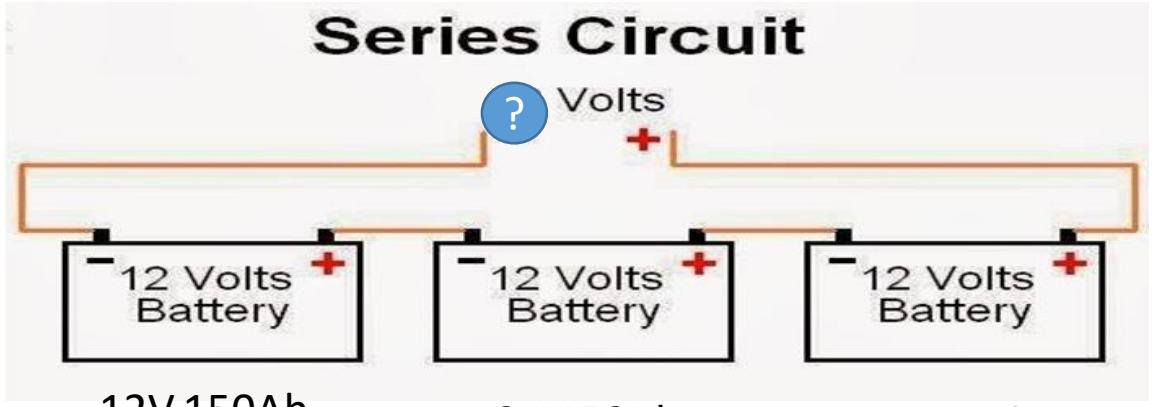


PARALLEL CONNECTION: Two or more elements are in parallel if they are connected to the same two nodes and consequently have the same voltage across them

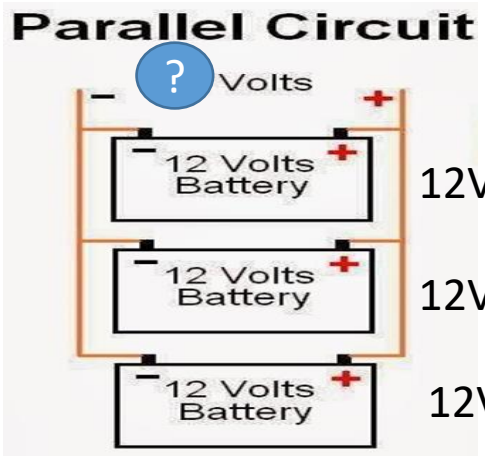


Quick Quiz (Poll2)

Find the energy of the 3 battery in series and parallel



12V,150Ah 12V,150Ah 12V,150Ah

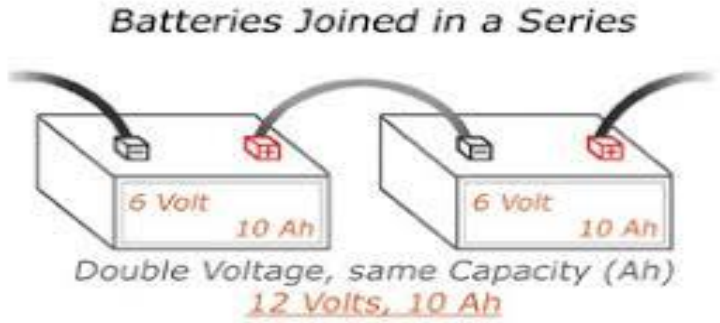


12V,150Ah

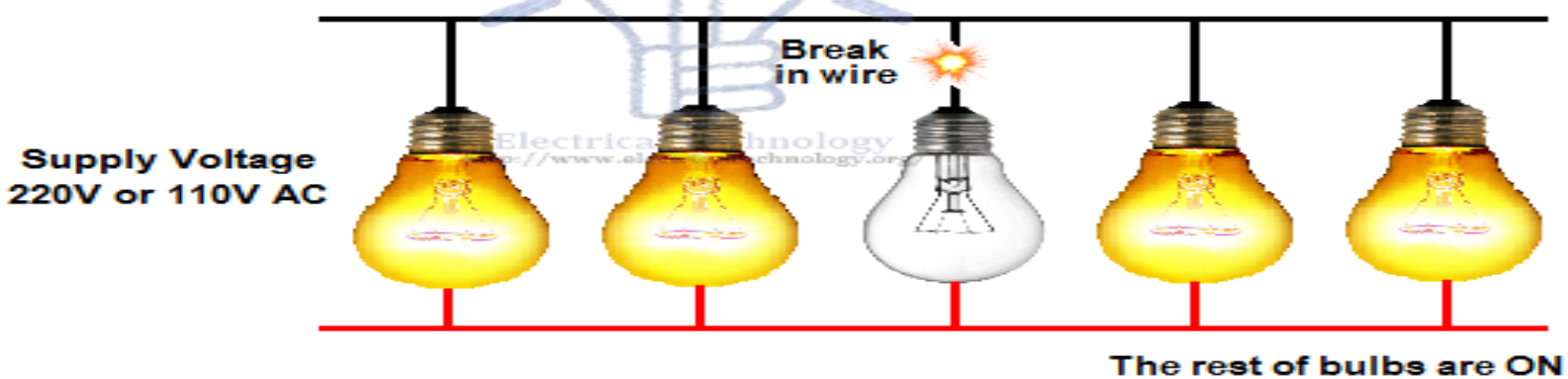
12V,150Ah

12V,150Ah

A) 4500kWh, 4500kWh
B) 5400Wh, 5400Wh
C) 5400kWh, 5400kWh
D) None of the above



Series Connection



Parallel Connection

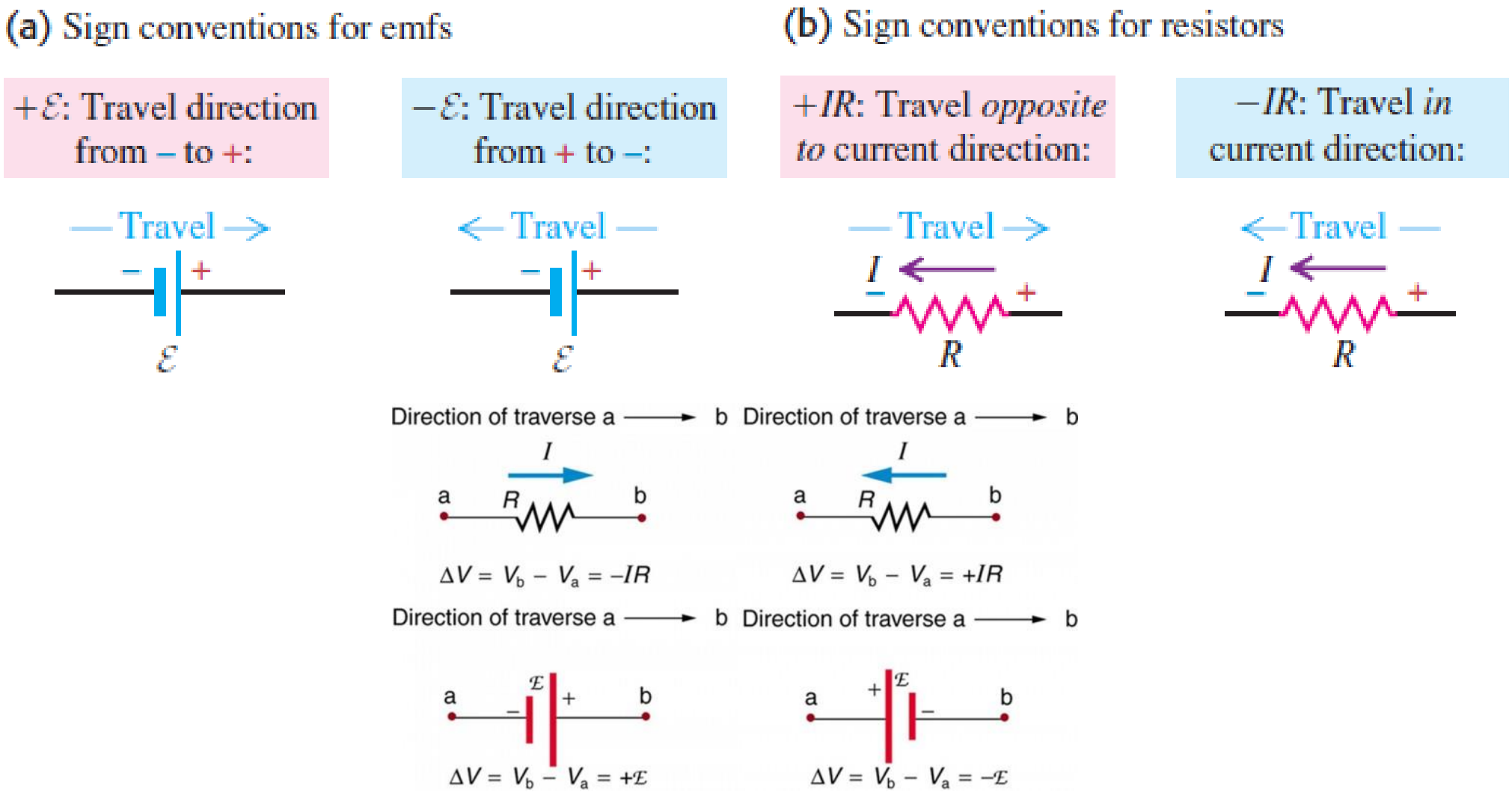
Why Parallel Connection is Preferred over Series Connection?

QUICK QUIZ (Poll 3)

- In a car a 2 volt, 6 cells are connected in series ,then how much voltage is provided by battery to car. In other way if 2 Volt ,6 cells are connected in parallel then how much voltage is provided by battery to car.

A)2V ,2V B)3V,6V C)12V,2V D) 0V,12V

Sign Convention for KVL



Let us Recall!

- Taking Clockwise direction (Def. 1):

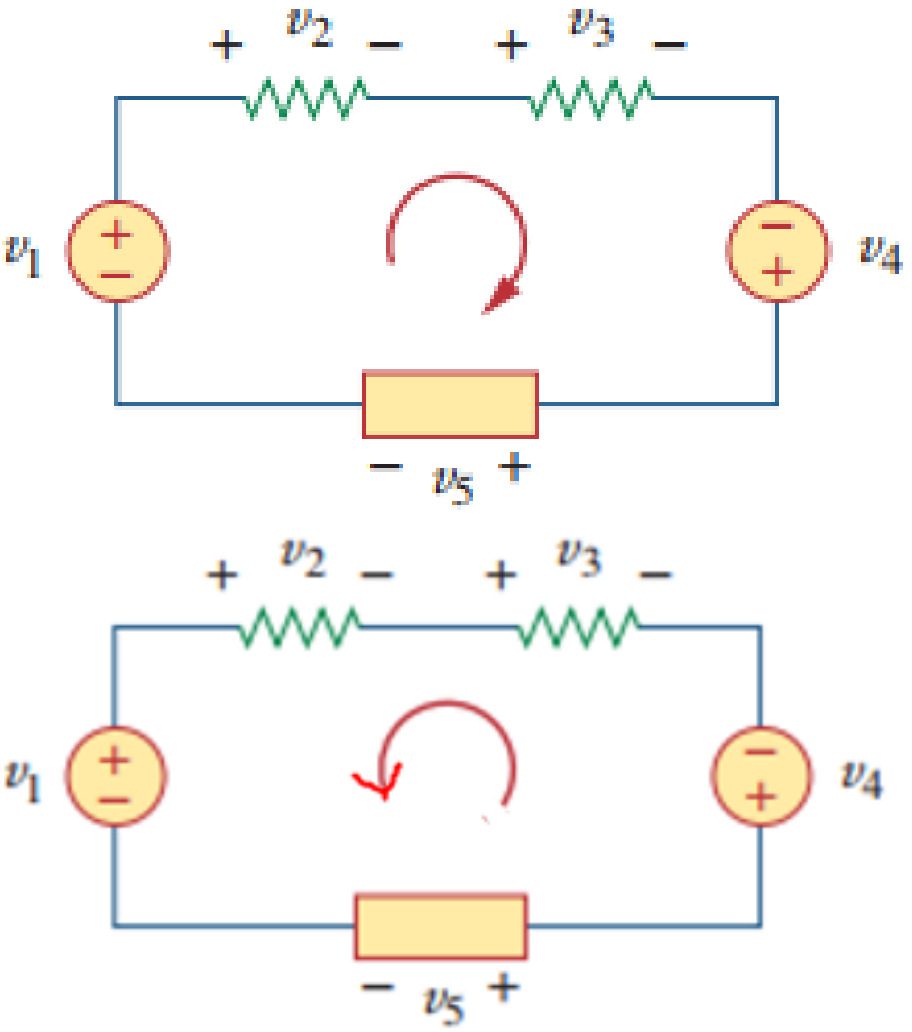
$$+V_1 - V_2 - V_3 + V_4 - V_5 = 0$$

- Taking Anti-clockwise direction(Def. 1):

$$-V_4 + V_3 + V_2 - V_1 + V_5 = 0$$

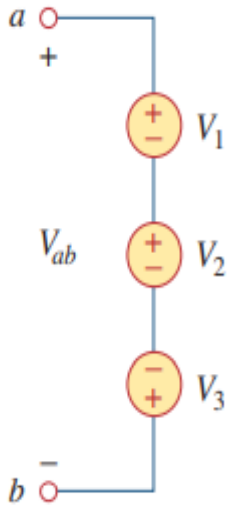
- Voltage rise = Voltage drop

$$+V_1 + V_4 = V_2 + V_3 + V_5$$



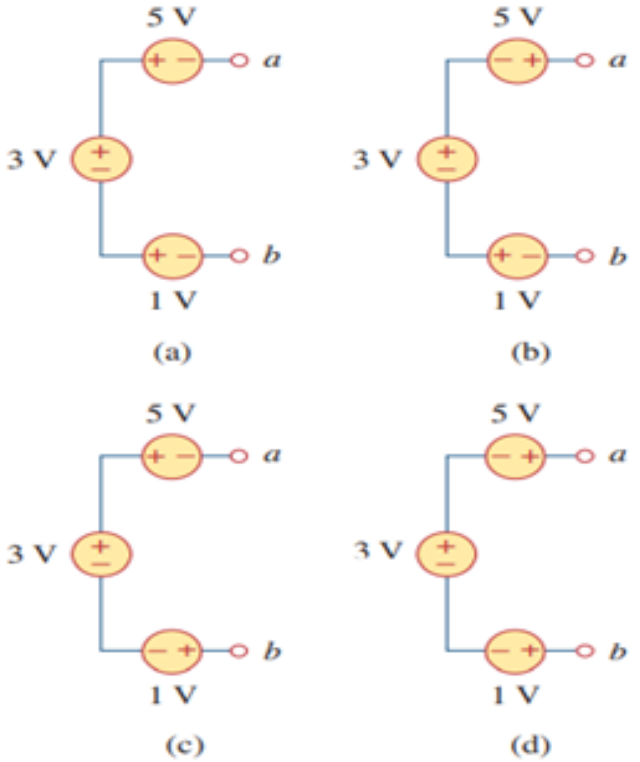
QUICK QUIZ (Poll 4)

Q . Write the equation



Q. Which of the following circuit will give Vab =7V

A) A
B) B
C) C
D) d



QUICK QUIZ (Poll 2)

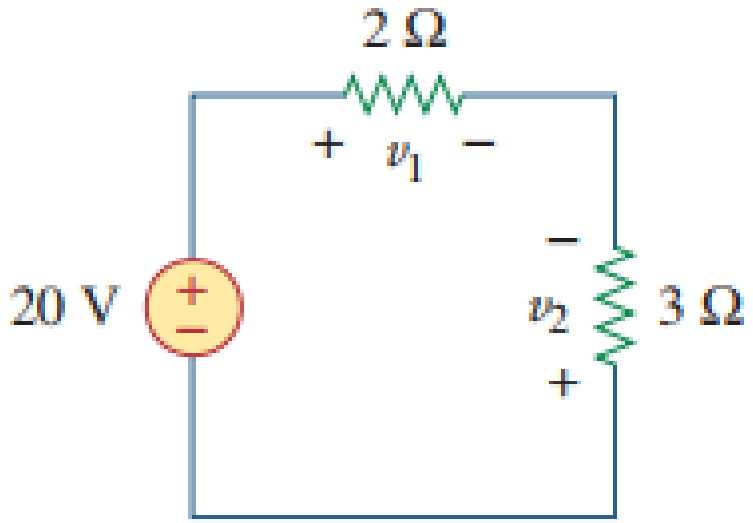
Find voltages V_1 and V_2 in the given circuit:

A. $V_1 = 16\ V\ and\ V_2 = 12\ V$

B. $V_1 = 16\ V\ and\ V_2 = -8\ V$

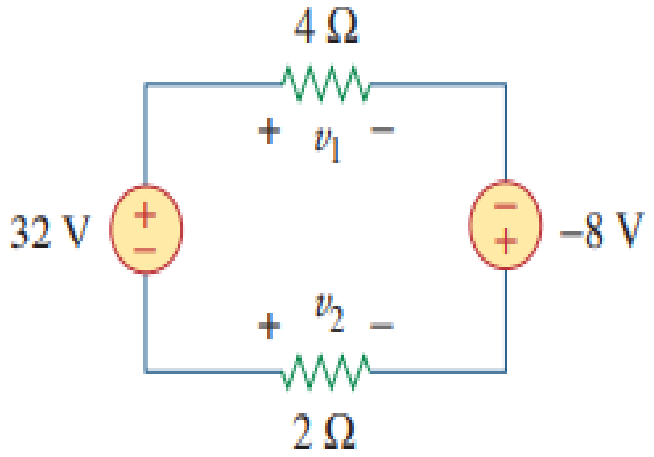
C. $V_1 = 8\ V\ and\ V_2 = -12\ V$

D. $V_1 = -12\ V\ and\ V_2 = 8\ V$

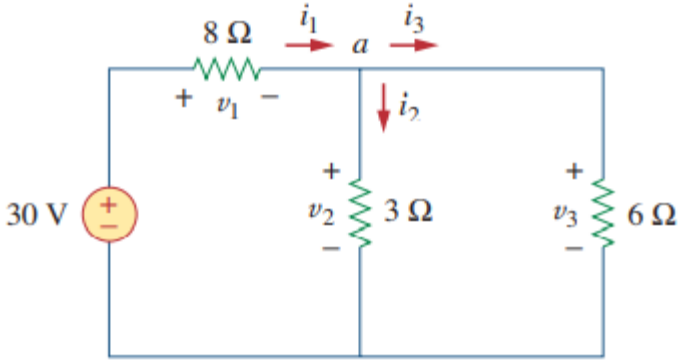


Practice !

Find the voltages V1 and V2

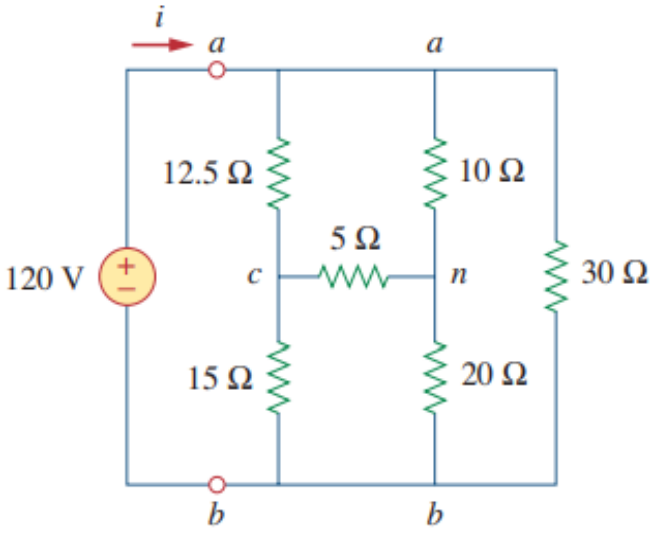


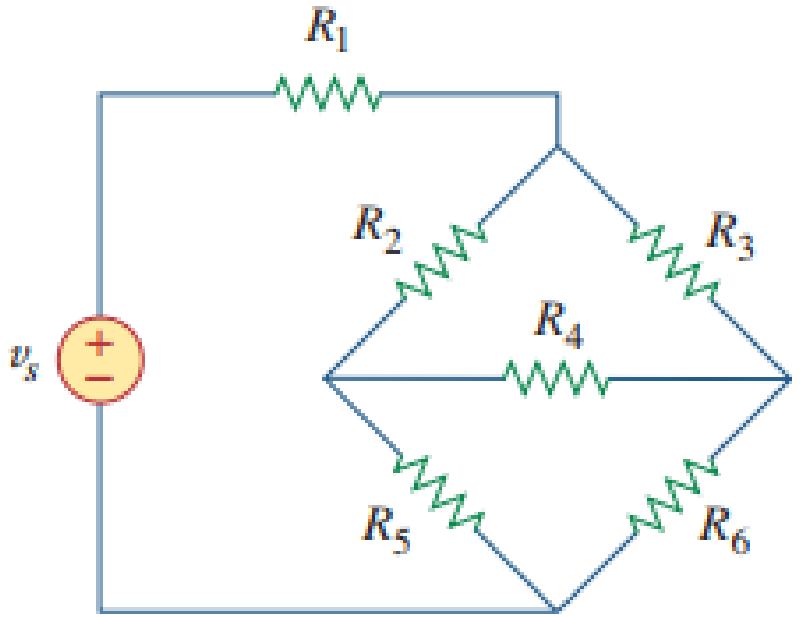
Find the voltages and current in given circuit



Star Delta Transformation

- Situations often arise in circuit analysis when the resistors are neither in parallel nor in series. For example, consider the bridge shown in the figure.



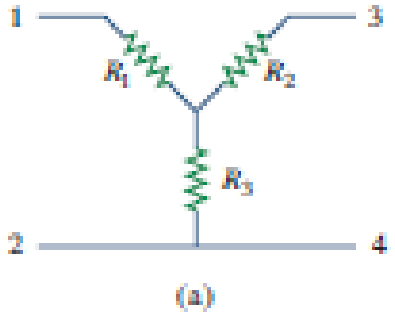


Star Delta Transformation

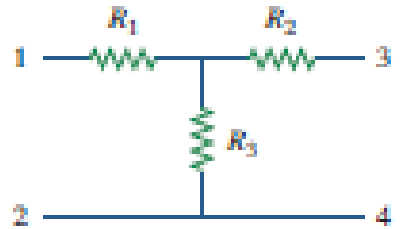
There are two types of such circuits

1. Star Connection
2. Delta Connection

STAR

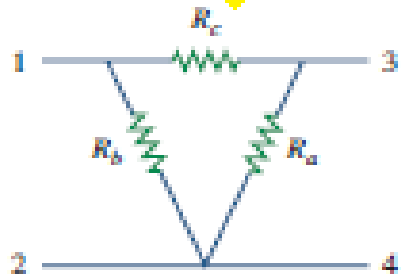


(a)

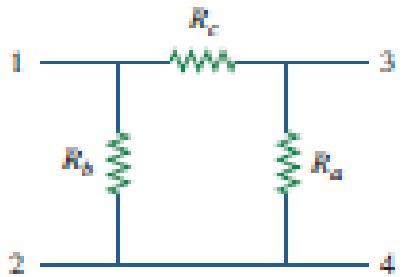


(b)

DELTA



(a)



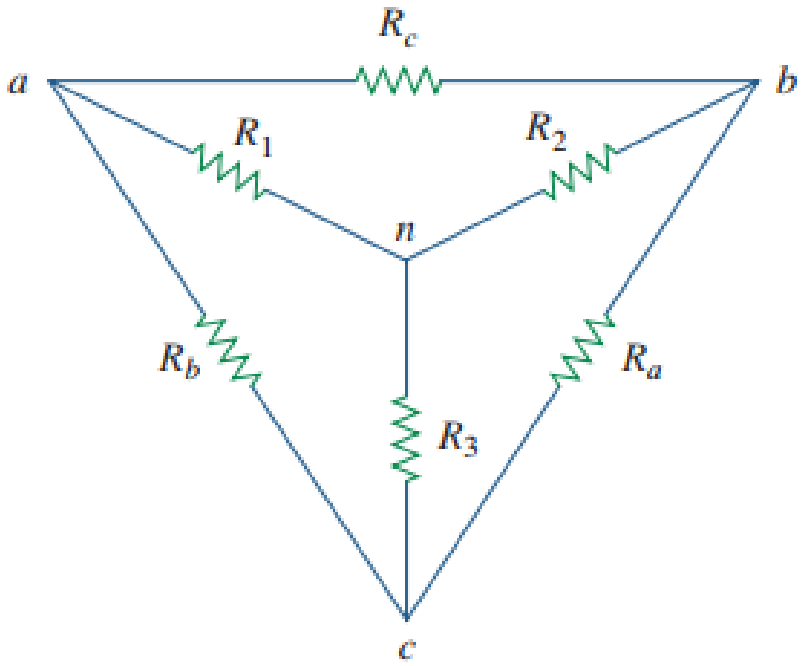
(b)

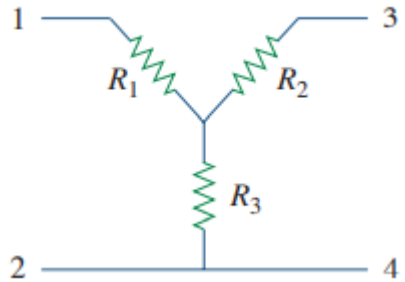
1.Delta to Star Conversion

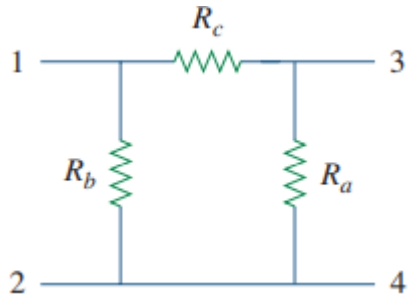
$$R_1 = \frac{R_b R_c}{R_a + R_b + R_c}$$

$$R_2 = \frac{R_c R_a}{R_a + R_b + R_c}$$

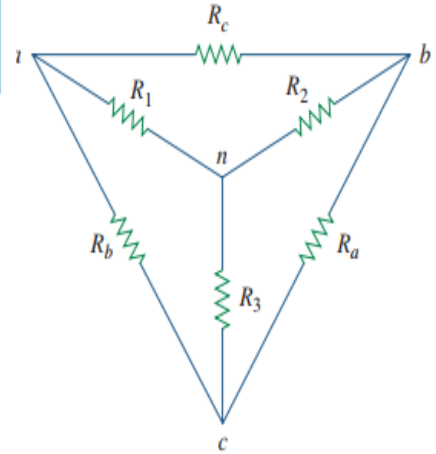
$$R_3 = \frac{R_a R_b}{R_a + R_b + R_c}$$







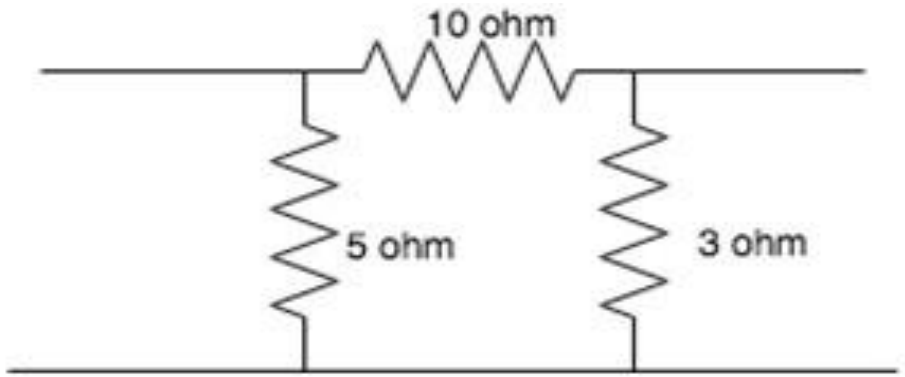
$$R_1 = \frac{R_b R_c}{R_a + R_b + R_c}$$



QUICK QUIZ (Poll 1)

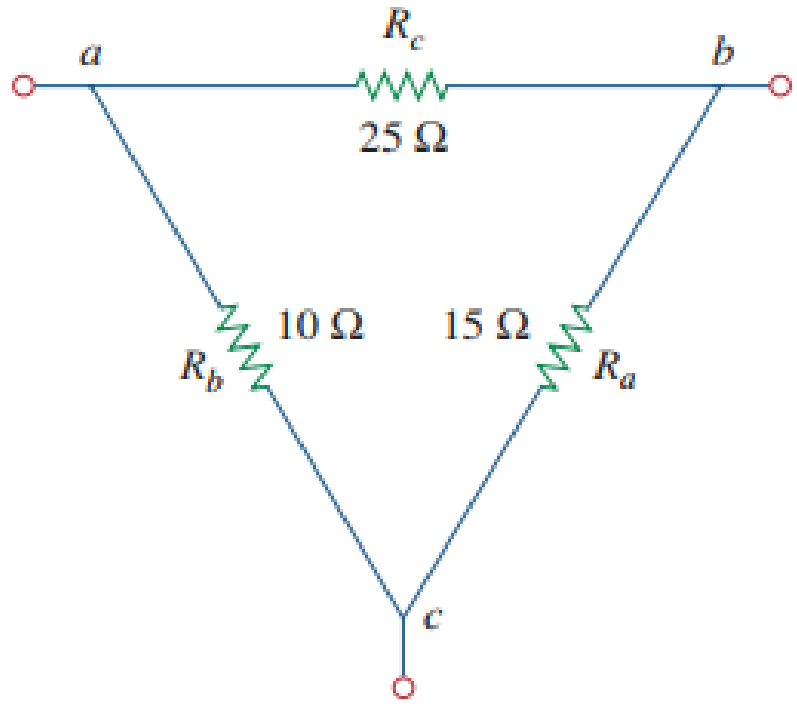
Is this a Star Connection?

A)Yes
B)No



Practice Problem

Q: Convert Δ network into a Y network?



Practice Problem

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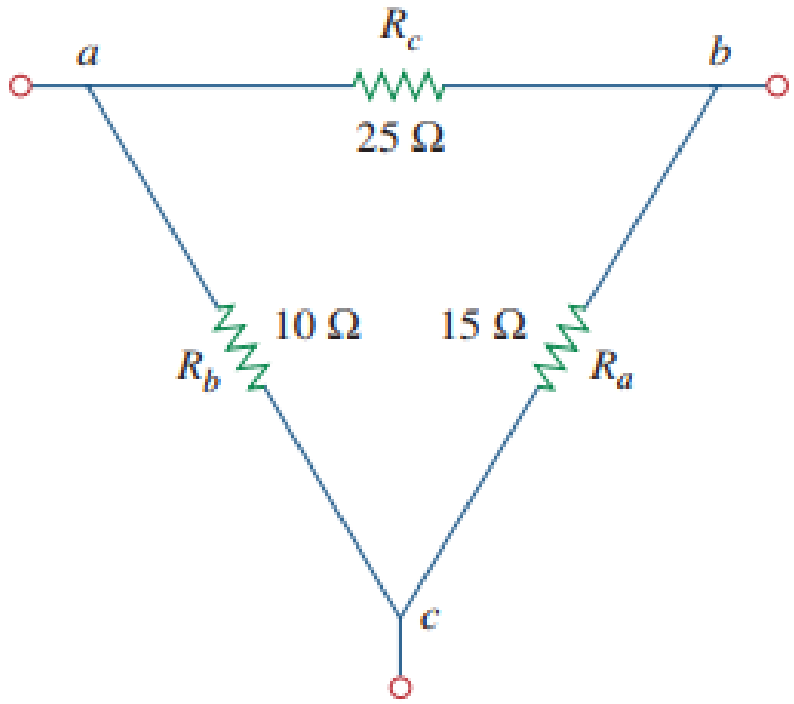


$$R_1 = \frac{R_b R_c}{R_a + R_b + R_c} = \frac{10 \times 25}{15 + 10 + 25} = \frac{250}{50} = 5\ \Omega$$

$$R_2 = \frac{R_c R_a}{R_a + R_b + R_c} = \frac{25 \times 15}{50} = 7.5\ \Omega$$

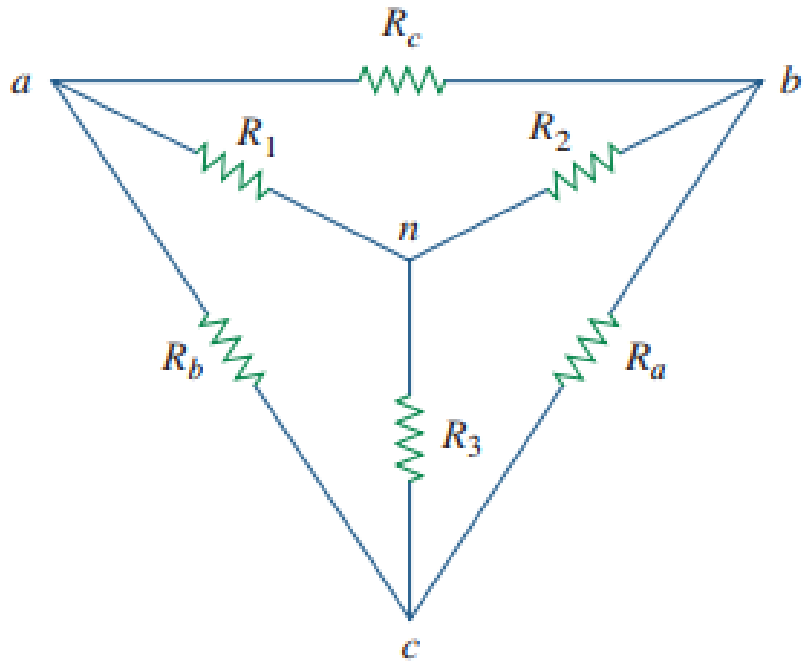
$$R_3 = \frac{R_a R_b}{R_a + R_b + R_c} = \frac{15 \times 10}{50} = 3\ \Omega$$

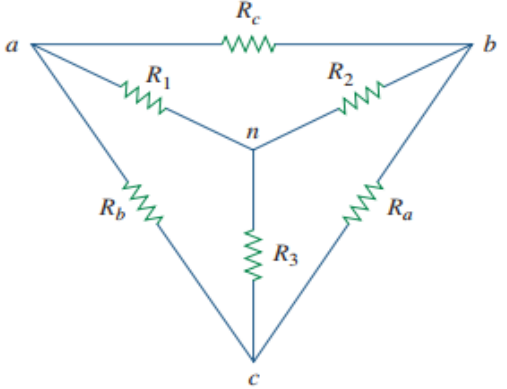
Star to Delta Conversion

$$R_a = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_1}$$

$$R_b = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_2}$$

$$R_c = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_3}$$





$$R_1 = \frac{R_b R_c}{R_a + R_b + R_c}$$

$$R_2 = \frac{R_c R_a}{R_a + R_b + R_c}$$

$$R_3 = \frac{R_a R_b}{R_a + R_b + R_c}$$

Delta to Y transformation

QUICK QUIZ (Poll 1)

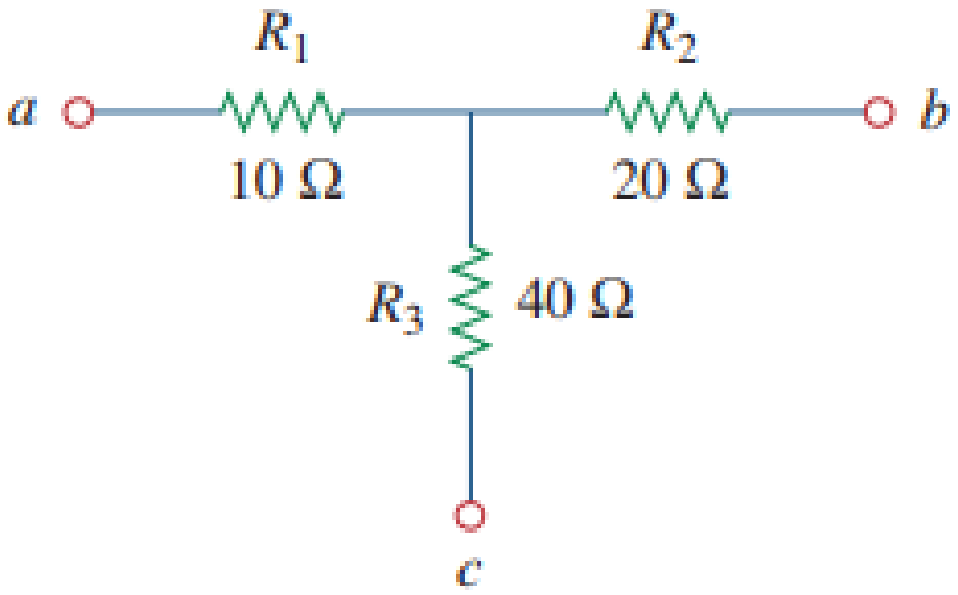
Resistance R_{bc} for the Δ network of the corresponding Figure is:

A. 140

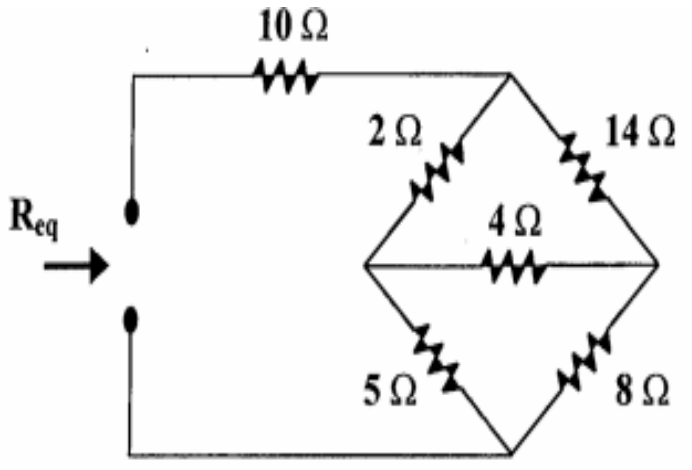
B. 70

C. 35

D. 100



Practice



QUICK QUIZ (Poll 2)

Q: If $R_a = R_b = R_c = R$ in a Δ network , then $R_1 = R_2 = R_3$=?

A. 3R

B. R/3

C. R

D. R/2