UNIT I

KIRCHOFF'S LAW

INTRODUCTION KIRCHOFF'S LAW

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HISTORY OF KIRCHOFF'S LAW

INTRODUCTION

TYPES OF KIRCHOFF'S LAW

HISTORY OF KIRCHOFF'S LAW

Gustav Robert Kirchhoff (German physicist)

- described two laws that became central to electrical engineering in 1845
- The laws were generalized from the work of Georg Ohm
- It's can also be derived from Maxwell's equations, but were developed prior to Maxwell's work

INTRODUCTION

What ?

- A pair of laws stating general restrictions on the current and voltage in an electric circuit.

How ?

- The first of these states that at any given instant the sum of the voltages around any closed path, or loop, in the network is zero.
- The second states that at any junction of paths, or node, in a network the sum of the currents arriving at any instant is equal to the sum of the currents flowing away.

TYPES OF KIRCHOFF'S LAW

KVL

- Kirchoff Voltage Law

KCL

- Kirchoff Current Law

KIRCHOFF'S CURRENT LAW

INTRODUCTION KCL

NODES ANALYSIS

EXERCISE

INTRODUCTION OF KCL

1

Kirchhoff's Current Law is sometimes called "Kirchhoff's First Law" or "Kirchhoff's Junction Rule"

along with Kirchhoff's Voltage Law makes up the two fundamental laws of Electrical Engineering

2

In this lesson it will be shown how Kirchhoff's Current Law describes the current flow through a junction of a circuit

3

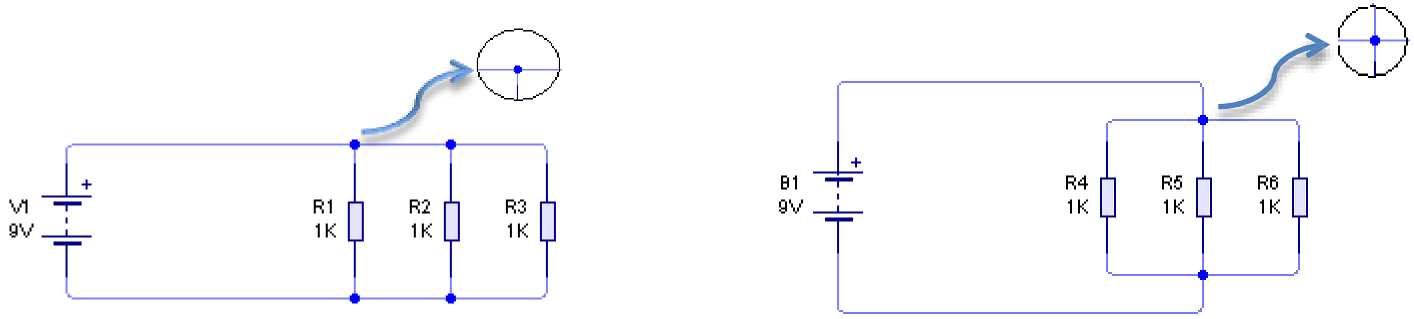
KCL helps to solve unknowns when working with electrical circuits

4

KCL with the addition of KVL and Ohm's Law will allow for the solution of complex circuits

Definition that will help in understanding Kirchhoff’s Current Law:

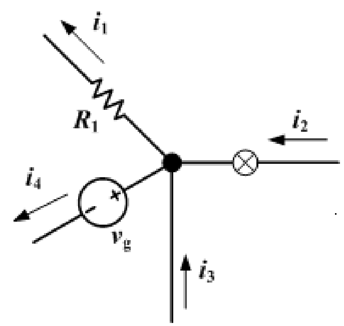
Junction - A junction is any point in a circuit where two or more circuit paths come together.



Examples of a Junction

- Kirchhoff's Current Law generally states:

The algebraic sum of all currents entering (+) and leaving (-) any point (junction) in a circuit must equal zero.

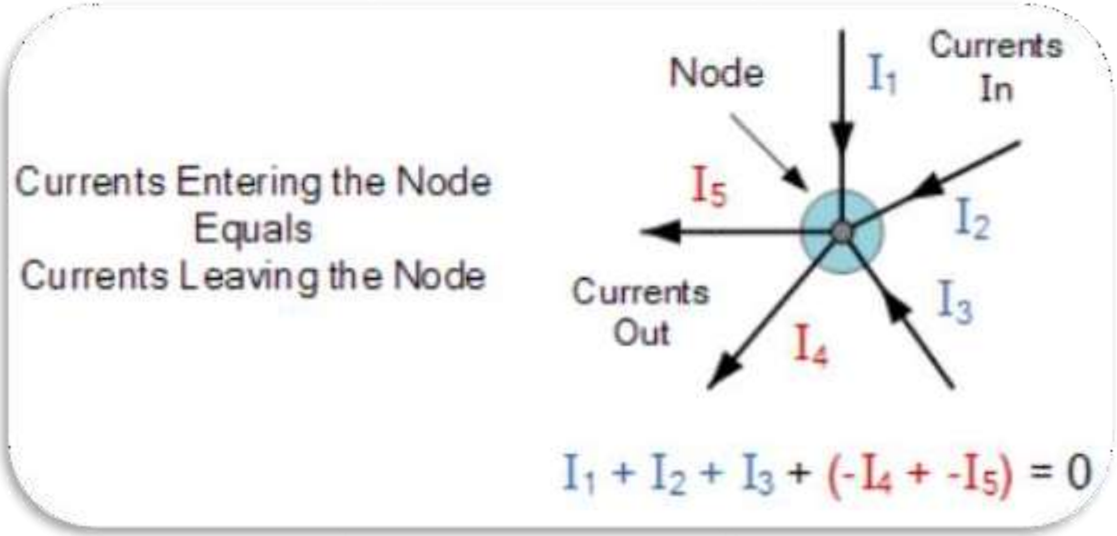


$$\sum_n i_n = i_1 + i_2 + i_3 + i_4 = 0$$

- Restated as:

The sum of the currents into a junction is equal to the sum of the currents out of that junction.

- The algebraic sum of all currents entering (+) and leaving (-) any point (junction) in a circuit must equal zero.



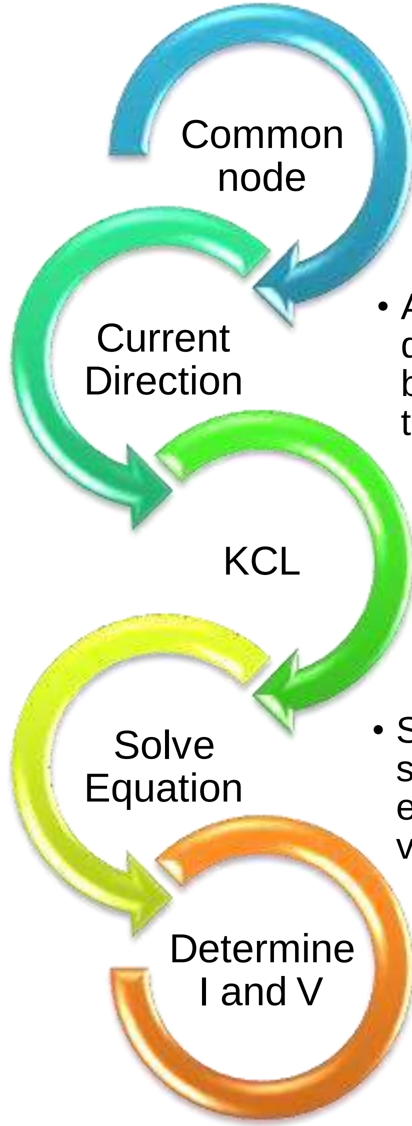
- Here, the 3 currents entering the node, I_1, I_2, I_3 are all positive in value and the 2 currents leaving the node, I_4 and I_5 are negative in value. Then this means we can also rewrite the equation as;

$$I_1 + I_2 + I_3 - I_4 - I_5 = 0$$

NODES ANALYSIS

Analysis using KCL to solve for voltages at each common node of the network and hence determine the currents though and voltages across each elements of the network.

Nodes Analysis Procedure

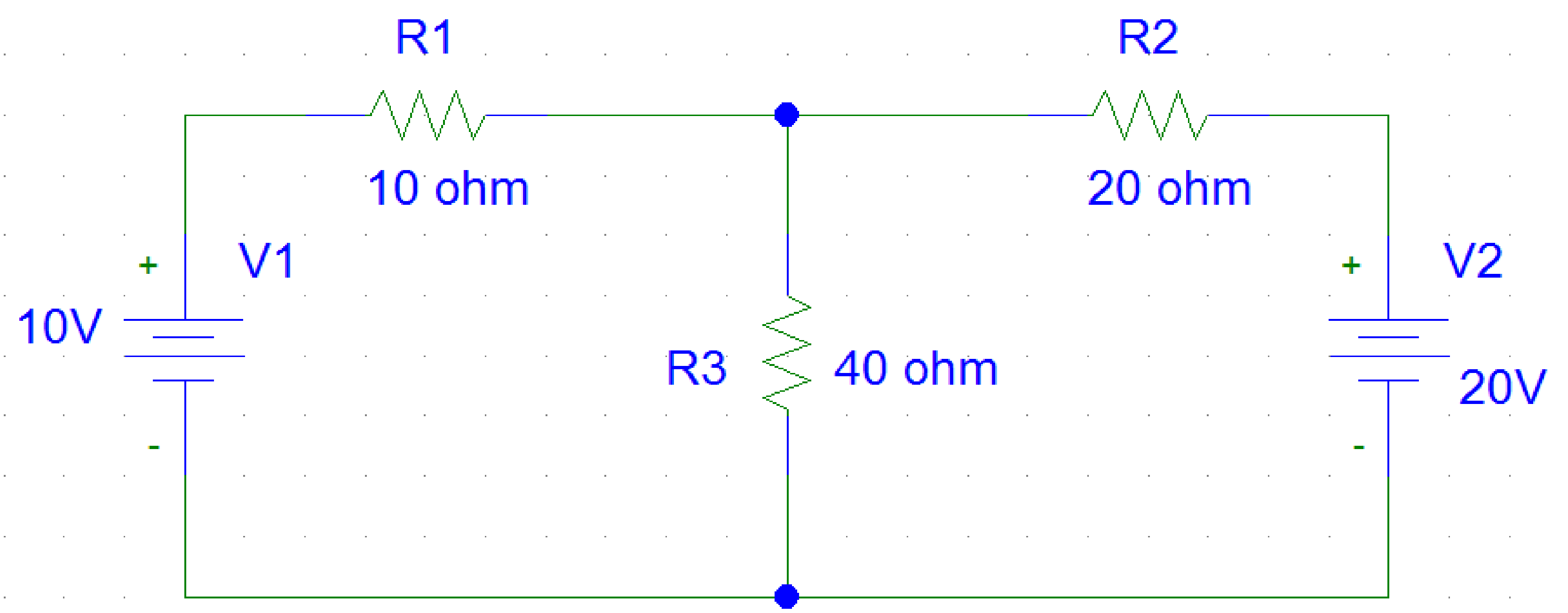


- Determine the number of common nodes and reference node within the network
- Assign current and its direction to each distinct branch of the nodes in the network
- Apply KCL at each of the common nodes in the network
- Solve the resulting simultaneous linear equation for the node voltage
- Determine the currents through and voltages across each elements in the network

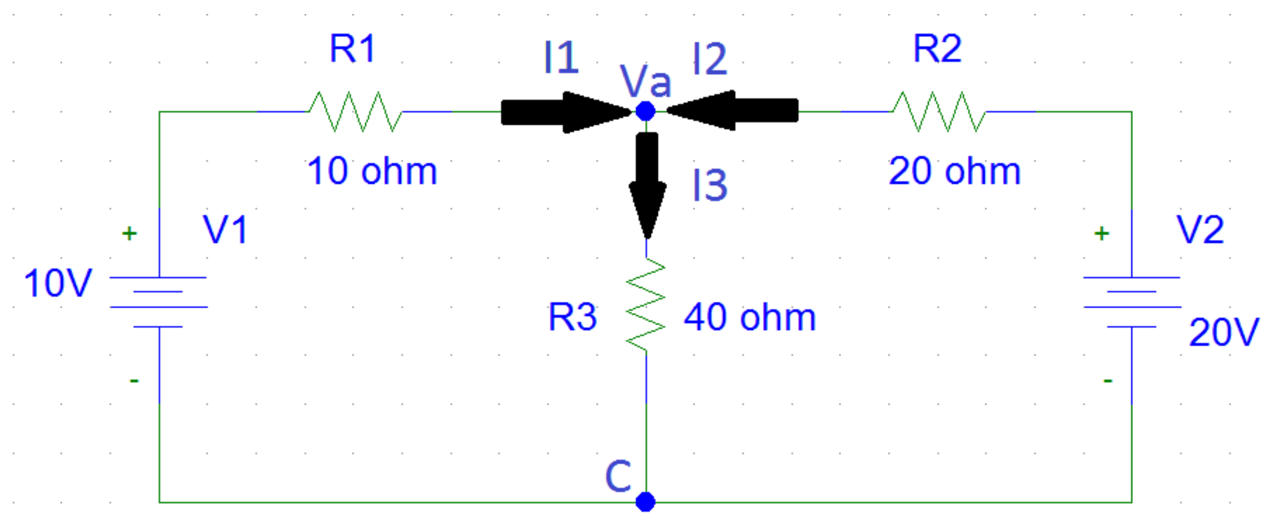
EXERCISE

Example 1:

Find the current flow through each resistor using node analysis for the circuit below.



EXERCISE



REMEMBER THE STEPS EARLIER??

Determine the number of common nodes and reference node within the network.

1 common node (Va) and 1 reference node C

Assign current and its direction to each distinct branch of the nodes in the network (refer o the figure)

Apply KCL at each of the common nodes in the network

KCL: I1 + I2 = I3

$$\frac{(10-Va)}{10} + \frac{(20-Va)}{20} = \frac{Va}{40}$$

$$1-\frac{Va}{10}+1-\frac{Va}{20}=\frac{Va}{40}$$

$$\frac{Va}{40}+\frac{Va}{10}+\frac{Va}{20}=2$$

$$Va\left(\frac{1}{40}+\frac{1}{10}+\frac{1}{20}\right)=2$$

$$Va\left(\frac{7}{40}\right)=2$$

$$Va = 11.428V$$

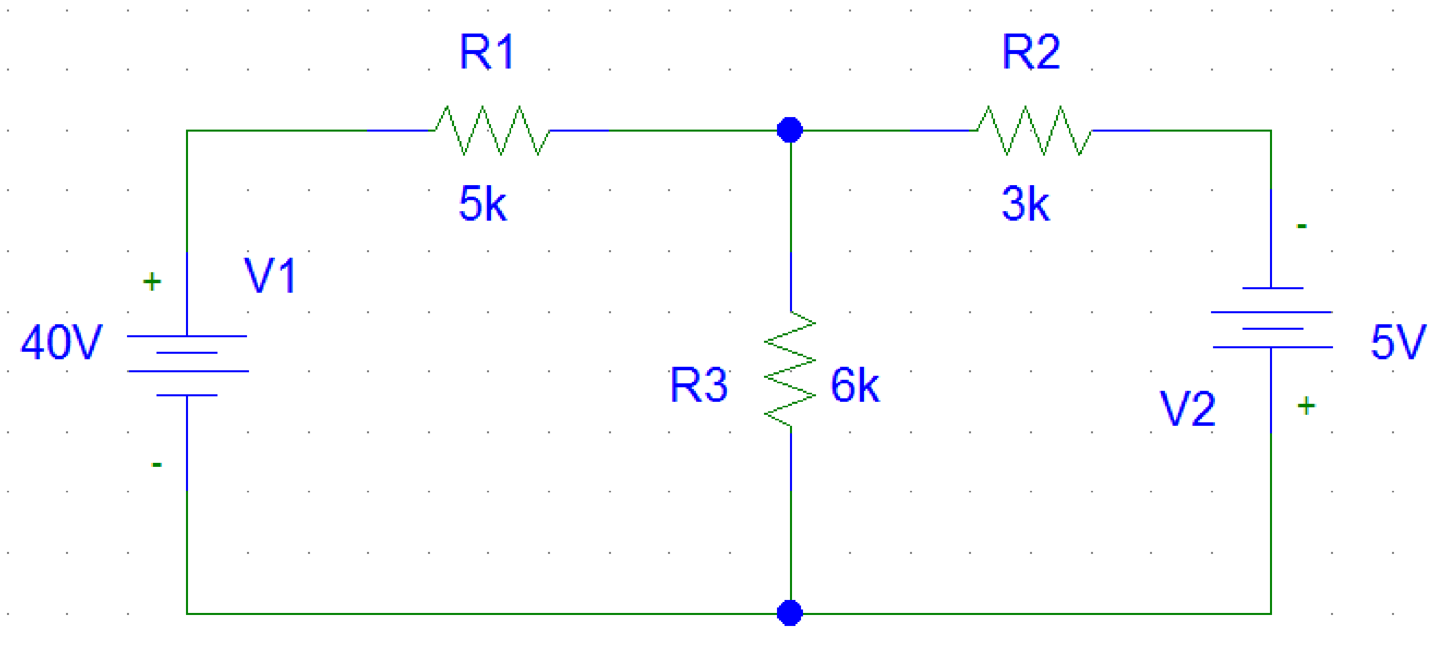
$$I_1 = \frac{(10-11.428)}{10} = -0.143A$$

$$I_2 = \frac{(20-11.428)}{20} = 0.429A$$

$$I_3 = \frac{11.428}{40} = 0.286V$$

Example 2:

Find the current flow through each resistor using node analysis for the circuit below.



$$\frac{(40 - Va)}{5k} = \frac{(Va - (-55))}{3k} + \frac{Va}{6k}$$

$$\frac{40}{6k} - \frac{Va}{6k} = \frac{Va}{3k} + \frac{55}{3k} + \frac{Va}{6k}$$

$$\frac{(-Va)}{5k} - \frac{Va}{3k} - \frac{Va}{6k} = \frac{55}{3k} - \frac{40}{5k}$$

$$-Va\left(\frac{1}{5k} + \frac{1}{3k} + \frac{1}{6k}\right) = \frac{55}{3k} - \frac{40}{5k}$$

$$-Va\,(700 \times 10^{-6}) = 10.33 \times 10^{-3}$$

$$Va = -14.757V$$

$$I_1 = \frac{(40 - (-14.757))}{5k} = 10.95mA$$

$$I_2 = \frac{(-14.757 + 55)}{3k} = 13.41mA$$

$$I_3 = \frac{(-14.757)}{6k} = -2.46mA$$