18EES101J – ELECTRICAL AND ELECTRONICS ENGINEERING

Prepared By,

Mr.S.Balaji

Assistant Professor(sr.g)

Department of Electronics & Electronics Engineering

SRM Institute of Science and Technology, Ramapuram Campus

SYLLABUS

HOUR	TOPICS TO BE COVERED
UNIT 1 ELECTRICAL CIRCUITS	
1	Introduction to DC and AC circuits. Active and Passive two terminal elements
2	Ohms law, Voltage-Current relation, Power, Energy, R,L,C Circuits, Voltage and Current Sources
3	Kirchoff’s current law. Kirchoff's Voltage Law
4	Problem Solving Session,
5	Mesh Current Analysis, Nodal Voltage Analysis
6	Thevenin’s Theorem, Norton’s Theorem
7	Maximum Power Transfer Theorem, Star- Delta Transformation
8	Problem Solving Session
9	Resistive Circuit Analysis, Superposition, Convolution
10	RL Circuit Transient Analysis, RC & RLC Transient Analysis
11	Three Phase Systems, Connections, Relation between Line and Phase
12	Problem Solving Session

SYLLABUS

HOUR	TOPICS TO BE COVERED
UNIT 2 DC MACHINES AND AC MACHINES	
13	Sinusoids, Generation of AC, Average, RMS values, Form and peak factors, Analysis of single phase AC circuit, Real, Reactive, Apparent power, Power factor
14	Magnetic materials, B-H Characteristics Simple magnetic circuits, Faraday's laws, induced emfs and inductances.
15	1 - phase transformers: Construction, types, ideal, practical transformer. EMF equation, Regulation, Efficiency
16	Problem Solving Session
17	Construction, working of DC Generators, Types of DC generators
18	Characteristics of Generators, Armature reaction, Losses
19	Power stages of DC generators, Working and types of DC motors, Characteristics, Starters
20	Problem Solving Session
21	Construction, working of AC Generators, Types of AC generators
22	Characteristics of AC Generators, Losses, Single Phase and Three Phase Machines
23	Working and types of AC motors, Induction, Squirrel Cage, Synchronous
24	Problem Solving Session

SYLLABUS

HOUR	TOPICS TO BE COVERED
UNIT 3 ELECTRONICS DEVICES	
25	Safety measures in electrical systems, Types of wiring, wiring accessories
26	House wiring for staircase, fluorescent lamp, LED lamp & corridor wiring, Basic principles of earthing, Types of earthing. Grounding in DC circuits
27	Basic principles and classification of instruments, Moving coil and moving iron instruments
28	Problem Solving Session
30	Overview of Semiconductors, PN junction diode, Zener diode
31	Diode circuits: rectifiers, half and full wave, Bridge type rectifier, filter circuit
32	Clippers and clampers
33	Problem Solving Session
34	BJT construction, operation, BJT characteristics (CB, CE and CC configurations) and uses
35	JFET construction, operation, JFET characteristics (CS configuration) and uses. MOSFET construction, operation,
36	MOSFET characteristics (CS configuration) and uses- (qualitative analysis)
30	Problem Solving Session

SYLLABUS

HOUR	TOPICS TO BE COVERED
UNIT 4 TRANSDUCER	
37	Transducer function and requirements, Classification: Active and Passive
38	Displacement: Capacitive, Inductive, Variable Inductance, Linear Variable Differential Transformer
39	Electromechanical: Pressure, Flow, Accelerometer,
40	Potentiometer etc. Strain Gauge
41	Chemical: pH probes, Electro galvanic Sensor etc., Electroacoustic: Mic, Speaker, Piezoelectric, Sonar, Ultrasonic, Tactile, Geophones, Hydrophone
42	Electrooptical: LED, Laser, Photodiode, Photoresistor, Phototransistor
43	Photoconductive cell, photovoltaic cell,
44	solar cell, LED, infrared emitters, LCD, optocouplers
45	Thermoelectric: Resistance Temperature Detectors, Thermocouple, Thermistor
46	Electrostatic: Electrometer, Electromagnetic: Antenna, Hall effect, Magnetic Cartridge etc.,
47	Radio-acoustic: Geiger Muller Tubes,
48	Radio receiver, Radio transmitter

SYLLABUS

HOUR	TOPICS TO BE COVERED
UNIT 5 DIGITAL CIRCUITS	
49	Number systems, binary codes, Binary arithmetic
50	Boolean algebra, laws and theorems, Simplification of Boolean expression
51	Logic Gates and Operations, Simplification of Boolean expression
52	Simplification of Boolean expression
53	SOP and POS Expressions, Standard forms of Boolean expression
54	Simplify using Boolean Expressions, Minterm and Maxterm, K-Map Simple ReductionTechnique, Two, Three and Four Variable K-Map
55	Problem Solving Session (Minterm and Maxterm, K-Map Simple ReductionTechnique, Two, Three and Four Variable K-Map)
56	Principles of Communication, Block diagram of a Communication System
57	Amplitude Modulation, Frequency Modulation
58	Phase Modulation
59	Demodulation
60	Problem Solving Session

Electricity

Movement of electrons

Invisible force that provides

light, heat, sound, motion . . .

Electricity at the Atomic Level

Components of an Atom

Nucleus

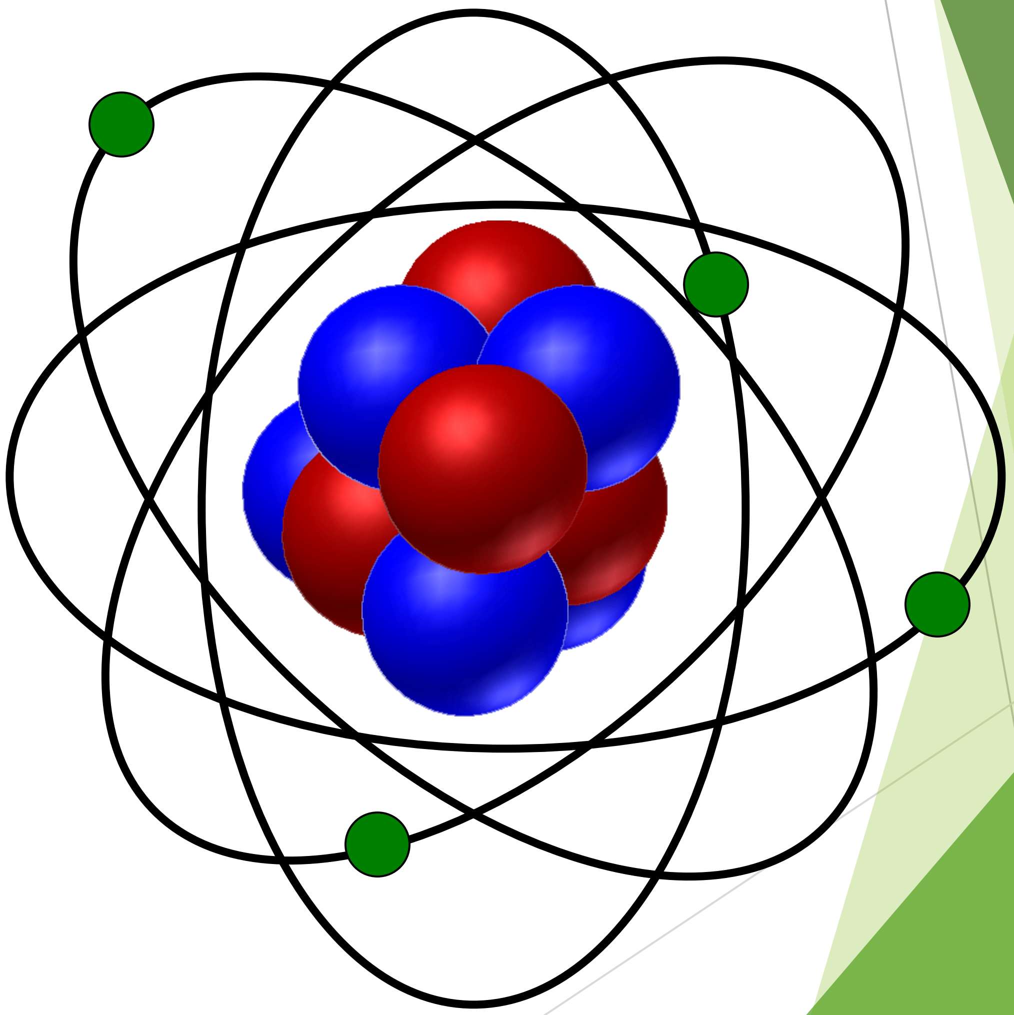
The center portion of an atom containing the protons and neutrons

Protons

Positively charged atomic particles

Neutrons

Uncharged atomic particles

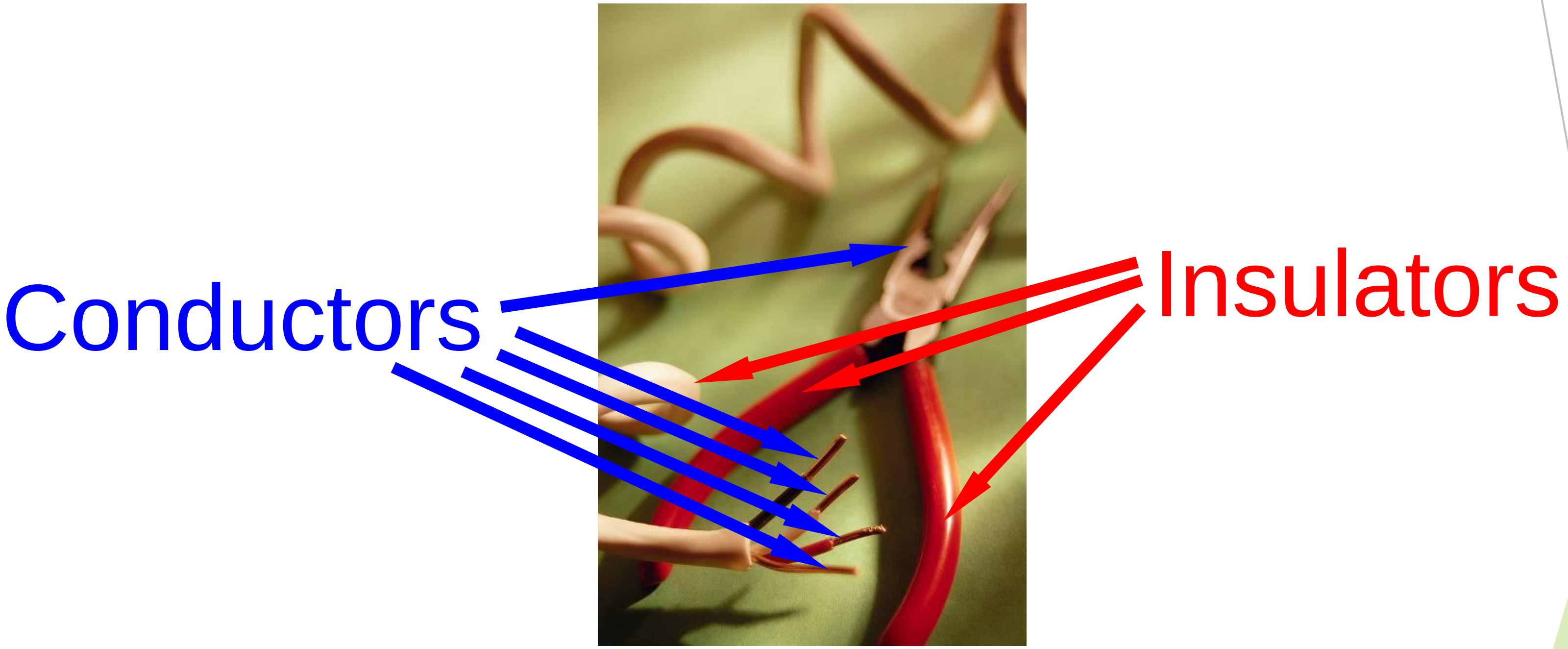


Conductors and Insulators

Conductors	Insulators
Electrons flow easily between atoms	Electron flow is difficult between atoms
1-3 valence electrons in outer orbit	5-8 valence electrons in outer orbit
Examples: Silver, Copper, Gold, Aluminum	Examples: Mica, Glass, Quartz

Conductors and Insulators

Identify conductors and insulators



Electrical Circuit

A system of conductors and components forming a complete path for current to travel

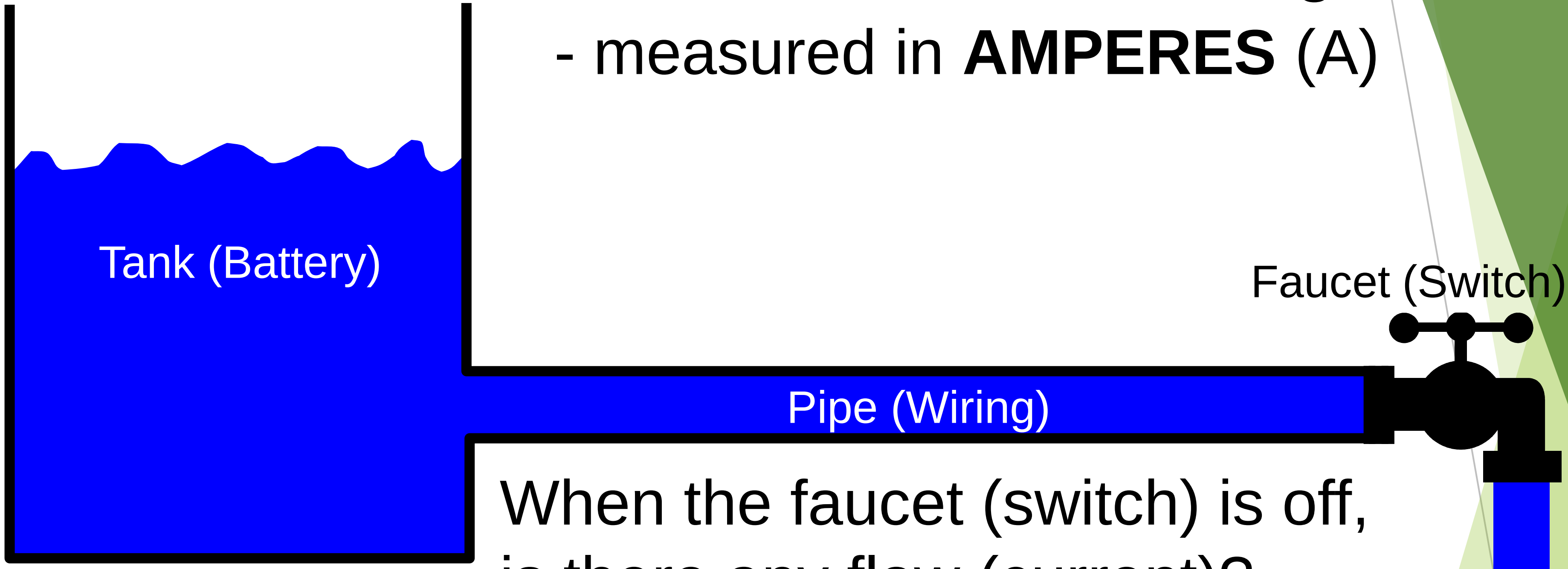
Properties of an electrical circuit include

Voltage	Volts	V
Current	Amps	A
Resistance	Ohms	Ω

Current

The *flow* of electric charge

- measured in **AMPERES** (A)



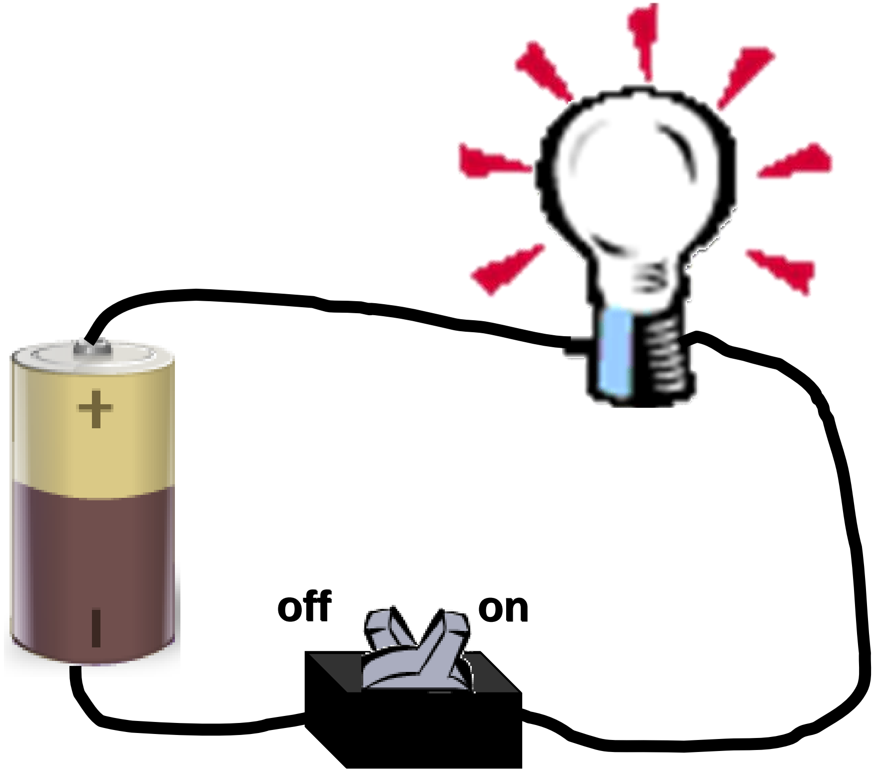
When the faucet (switch) is off, is there any flow (current)?

NO

When the faucet (switch) is on, is there any flow (current)?

YES

Current in a Circuit

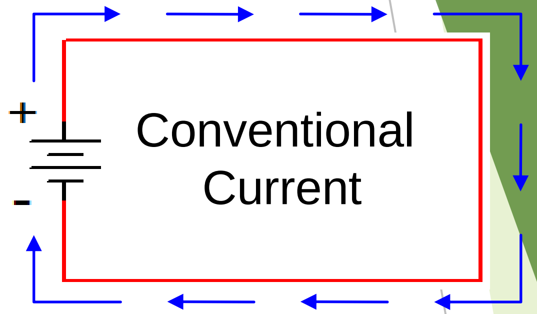


When the switch is off, there is no current.

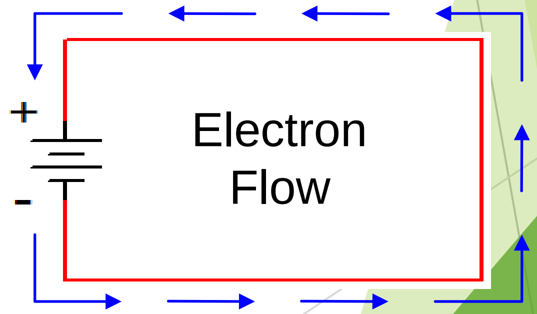
When the switch is on, there is current.

Current Flow

Conventional Current assumes that current flows out of the positive side of the battery, through the circuit, and back to the negative side of the battery. This was the convention established when electricity was first discovered, but it is incorrect!



Electron Flow is what actually happens. The electrons flow out of the negative side of the battery, through the circuit, and back to the positive side of the battery.

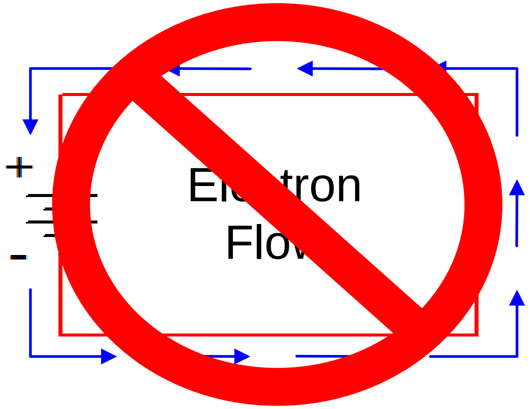


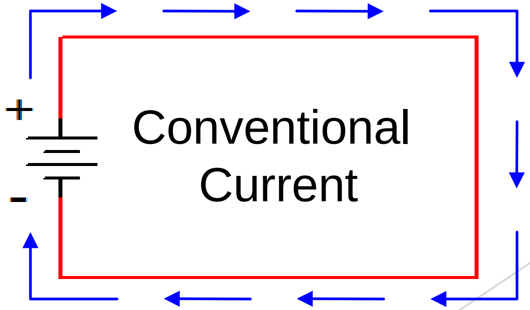
Engineering vs. Science

The direction that the current flows does not affect what the current is doing; thus, it doesn't make any difference which convention is used as long as you are consistent.

Both **Conventional Current** and **Electron Flow** are used. In general, the science disciplines use **Electron Flow,** whereas the engineering disciplines use **Conventional Current.**

Since this is an engineering course, we will use **Conventional Current** .

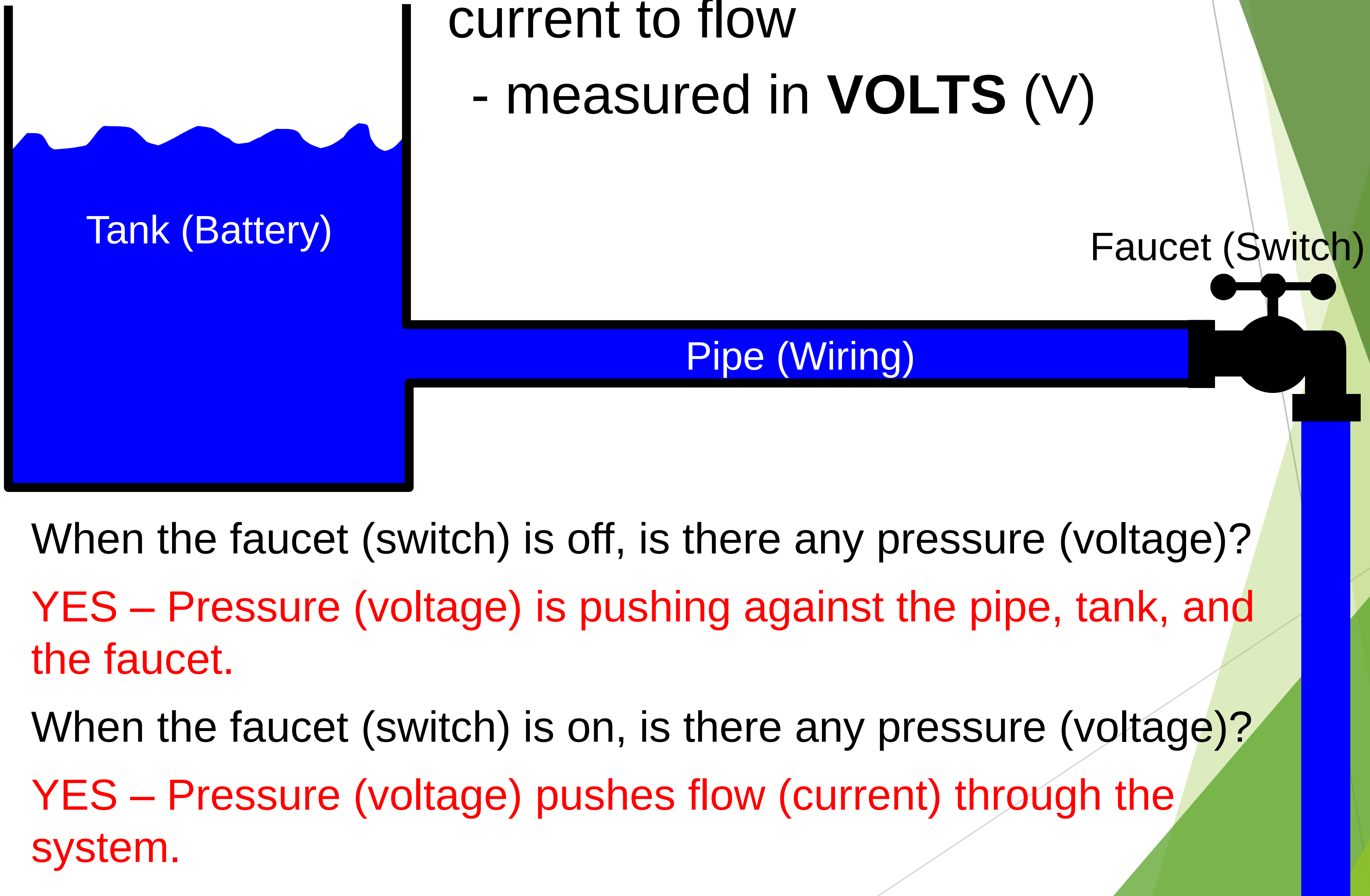




Voltage

The force *(pressure)* that causes current to flow

- measured in **VOLTS** (V)



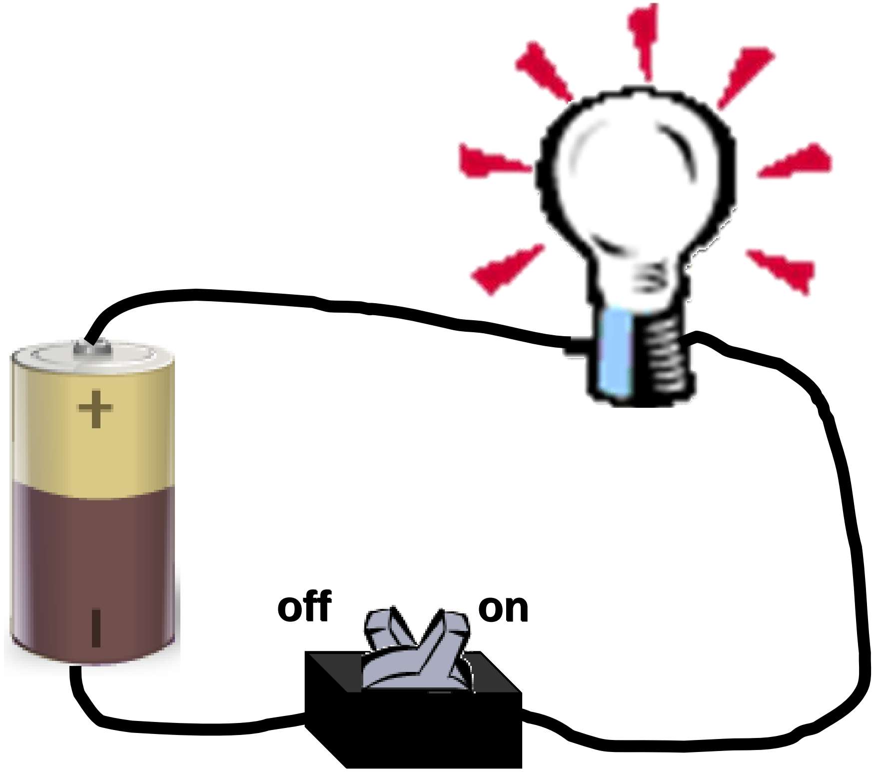
When the faucet (switch) is off, is there any pressure (voltage)?

YES – Pressure (voltage) is pushing against the pipe, tank, and the faucet.

When the faucet (switch) is on, is there any pressure (voltage)?

YES – Pressure (voltage) pushes flow (current) through the system.

Voltage in a Circuit

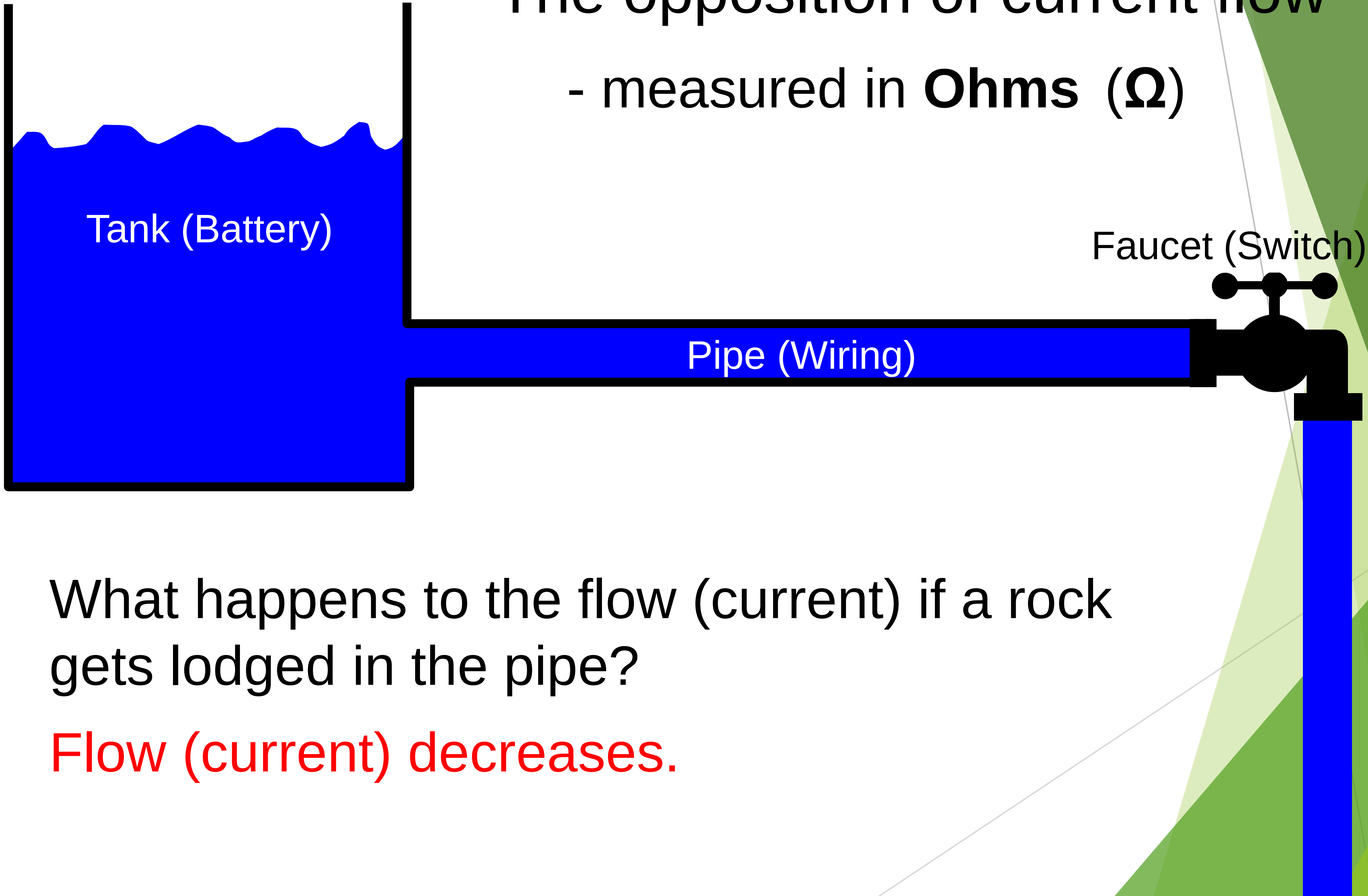


The battery provides voltage that will push current through the bulb when the switch is on.

Resistance

The opposition of current flow

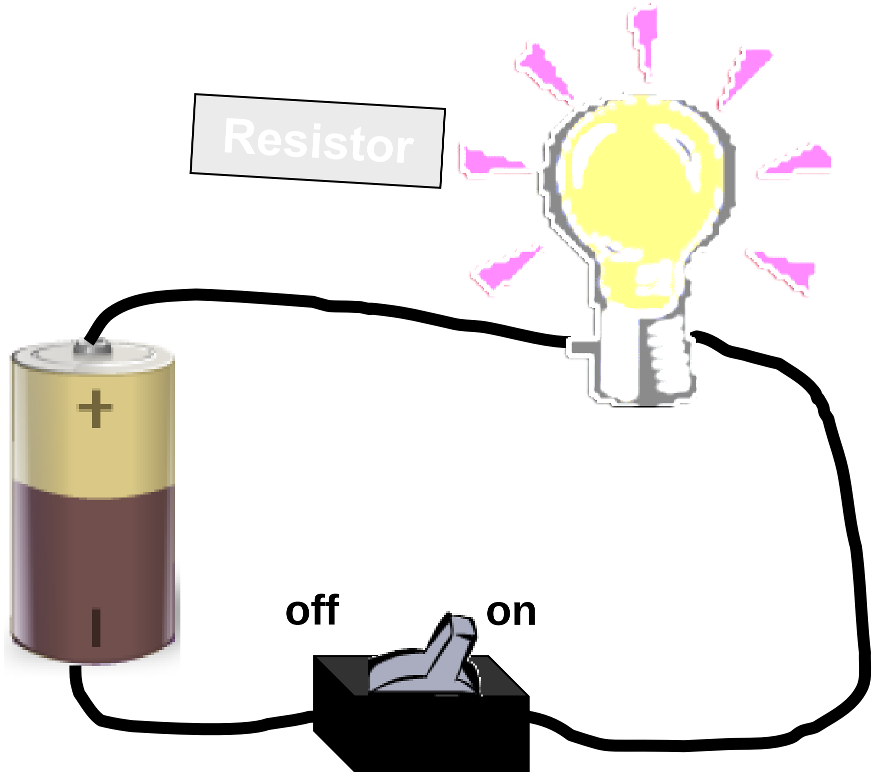
- measured in **Ohms** (**Ω**)



What happens to the flow (current) if a rock gets lodged in the pipe?

Flow (current) decreases.

Resistance in a Circuit

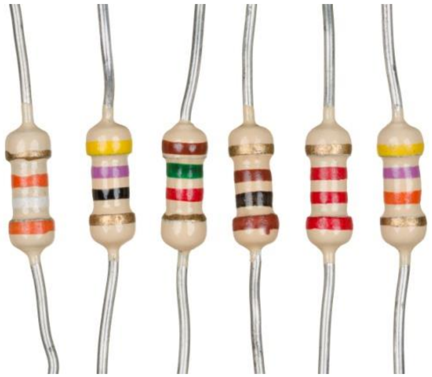


Resistors are components that create resistance.

Reducing current causes the bulb to become more dim.

CIRCUIT

- A closed conducting path through which an electric current flows or is intended to flow
- The various elements of an electric circuit, like resistance, inductance and capacitance which may be lumped or distributed.



Resistors

Capacitors

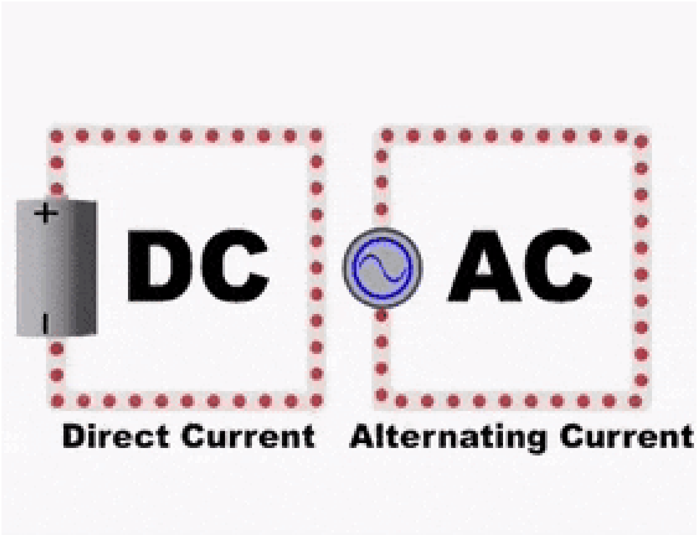
Inductor

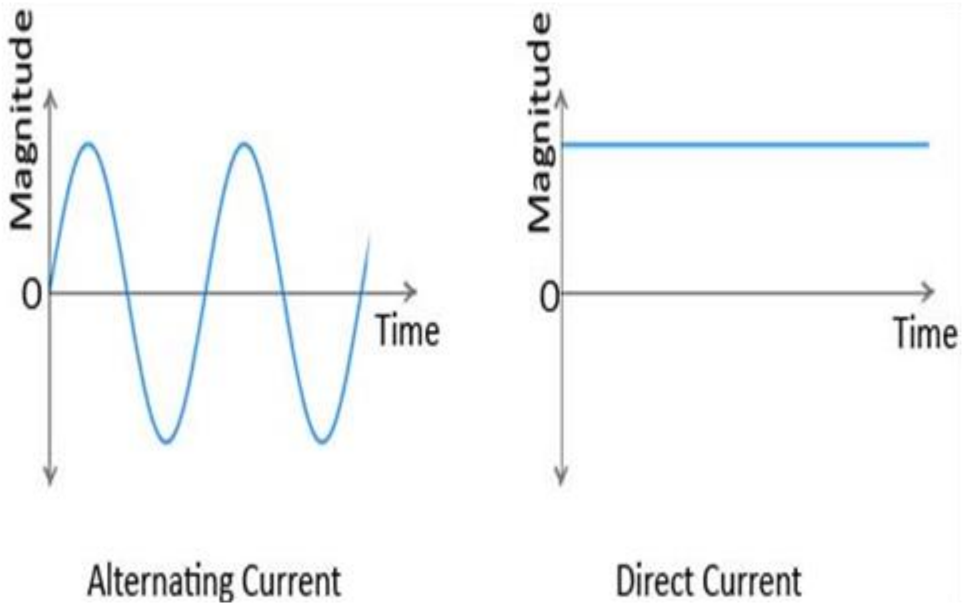
CIRCUITS - Types

- Linear Circuit
  - Is one whose parameters are constant (i.e. They do not change with voltage and current.
- Non-Linear Circuit
  - Is that circuit whose parameters change with voltage and current.
- Bilateral Circuit
  - Is one whose properties or characteristics are the same in either direction.
- Unilateral Circuit
  - Is that circuit whose properties or characteristics change with the direction of its operation.

ALTERNATING CURRENT

- A current that is constantly changing in amplitude and direction.





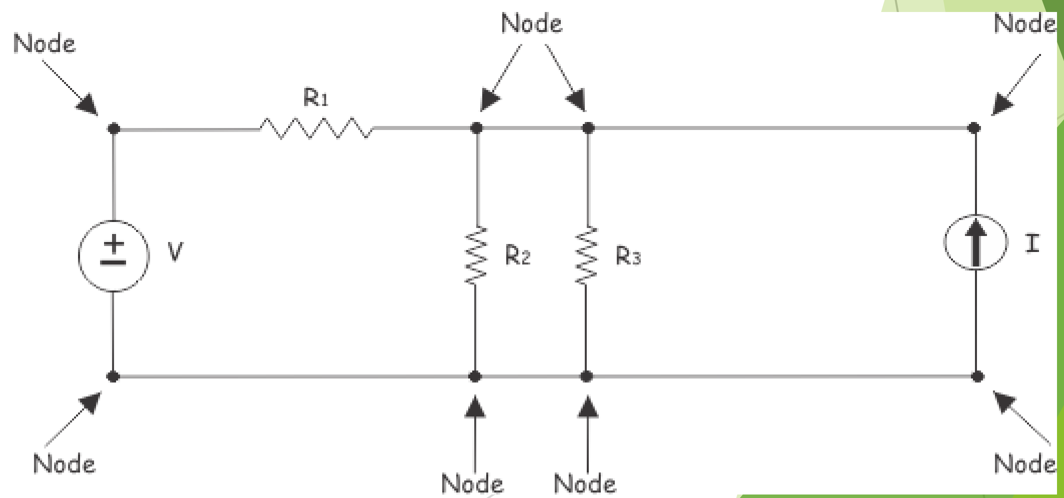
ELECTRICAL NETWORKS

- Connection of various electric elements in any manner
- **PASSIVE COMPONENT**
  - The circuit elements that receive energy (or absorb energy) and either convert it into heat or store it in an electric field or a magnetic field are called **passive circuit elements**.

- **Active components**
  - are devices that can amplify an electric signal and produce power. Any characteristic active component will comprise an oscillator, transistor or an integrated circuit.

ELECTRICAL NETWORKS

- Node
  - A junction in a circuit where two or more circuit elements and/or branches are connected together.
- Branch
  - Part of a network which lies between two junctions.
- Loop
  - A closed path in a circuit in which no element or node is encountered more than once.
- Mesh
  - A loop that contains no other loop within it.

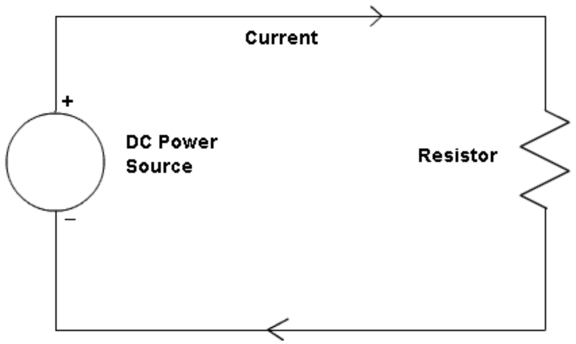


OHM'S LAW

- One of the most fundamental law in electrical circuits relating voltage, current and resistance
- Developed in 1827 by German physicist Georg Simon Ohm
- According to Ohm's Law, the current (I) flowing in an electrical circuit is directly is directly proportional to the applied voltage (V) and inversely proportional to the equivalent resistance (R) of the circuit and mathematically expressed as

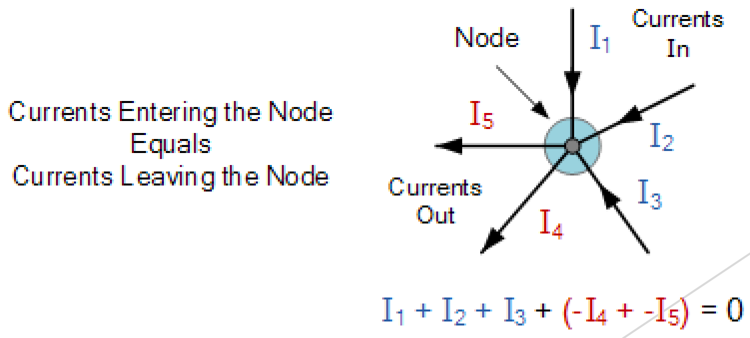
$$V = IR$$

$$I = \frac{V}{R}$$



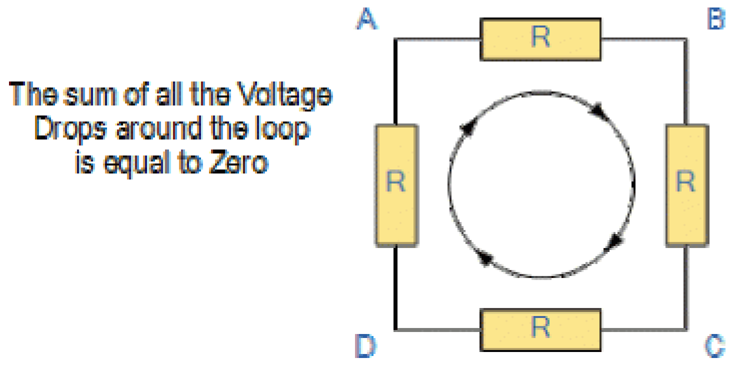
KIRCHHOFF'S LAW

- More comprehensive than Ohm's Law and is used in solving electrical
- Termed as "Laws of Electric Networks"
- Formulated by German physicist Gustav Robert Kirchhoff
- **Kirchhoff's Current Law (KCL)**
  - In any electrical network, the algebraic sum of the current meeting at a point (or junction) is zero
  - In short the sum of currents entering a node equals the sum of currents leaving the node
    - Current towards the node, positive current
    - Current away from the node, negative current



KIRCHHOFF’S LAW

- KIRCHHOFF’S VOLTAGE LAW
  - The algebraic sum of the products of currents and resistances in each of the conductors in any closed path (or mesh) in a network PLUS the algebraic sum of the emfs in the path is zero.”

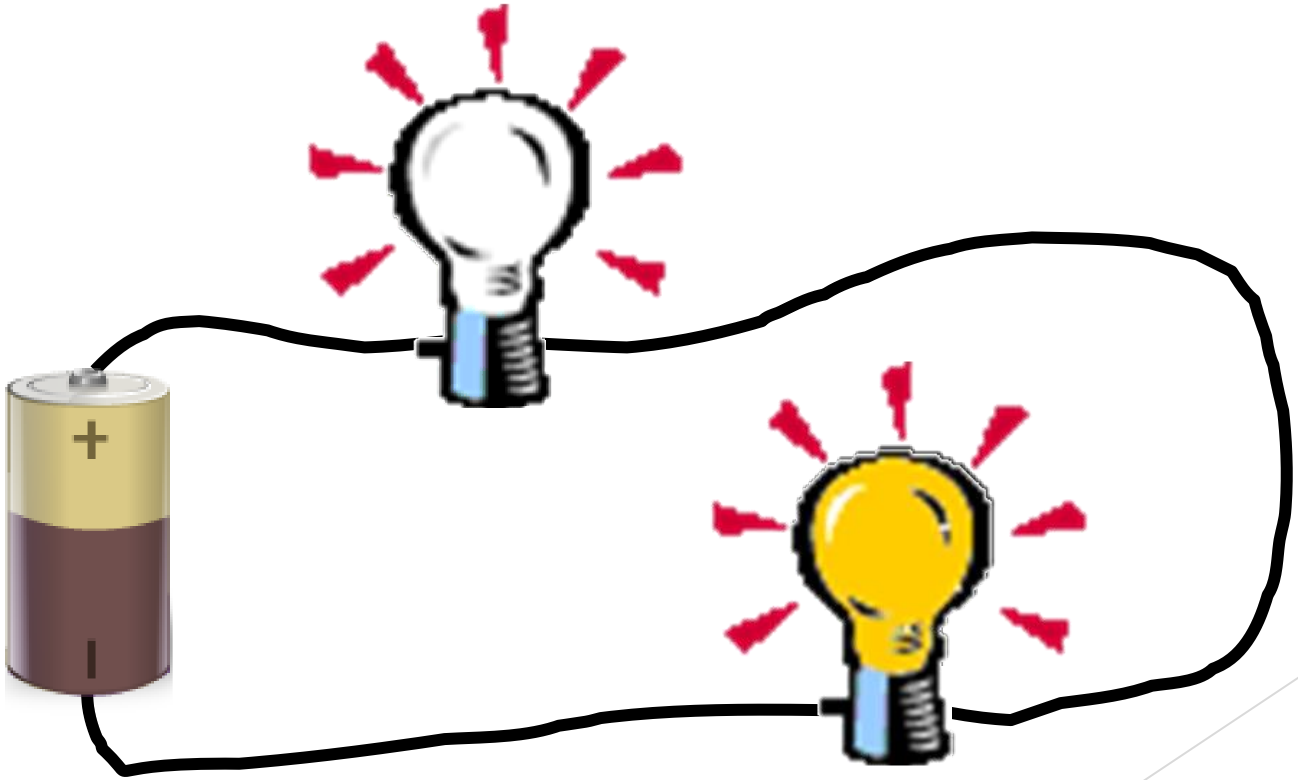


$$V_{AB} + V_{BC} + V_{CD} + V_{DA} = 0$$

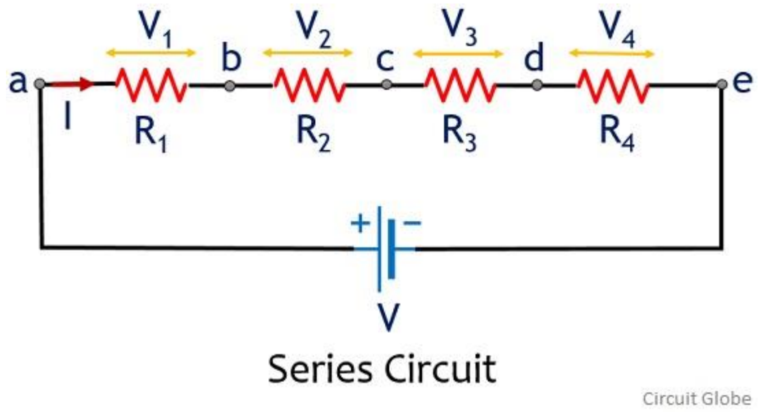
Series Circuits

A circuit that contains only one path for current flow

If the *path* is open anywhere in the circuit, current stops flowing to all components.



SERIES RESISTANCE



$$V = V_1 + V_2 + V_3 + V_4$$

We Know V = IR, Therefore

$$I_T R_{eq} = I_1\ R_1 + I_2 R_2 + I_3 R_3 + I_4 R_4$$

Since in Series Circuit Current flowing is same

$I_1 = I_2 = I_3 = I_4 = I_T$

$$I_T R_{eq} = I_T\ R_1 + I_T R_2 + I_T R_3 + I_T R_4$$

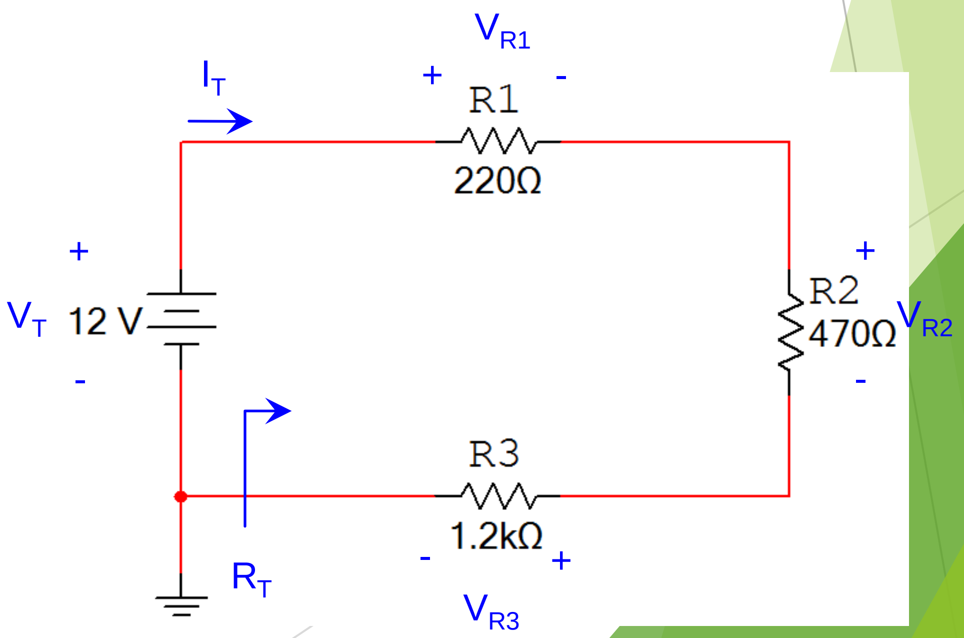
$$I_T R_{eq} = I_T(\ R_1 + R_2 + R_3 + R_4)$$

$$R_{eq} = R_1 + R_2 + R_3 + R_4$$

Series Circuits

Characteristics of a series circuit

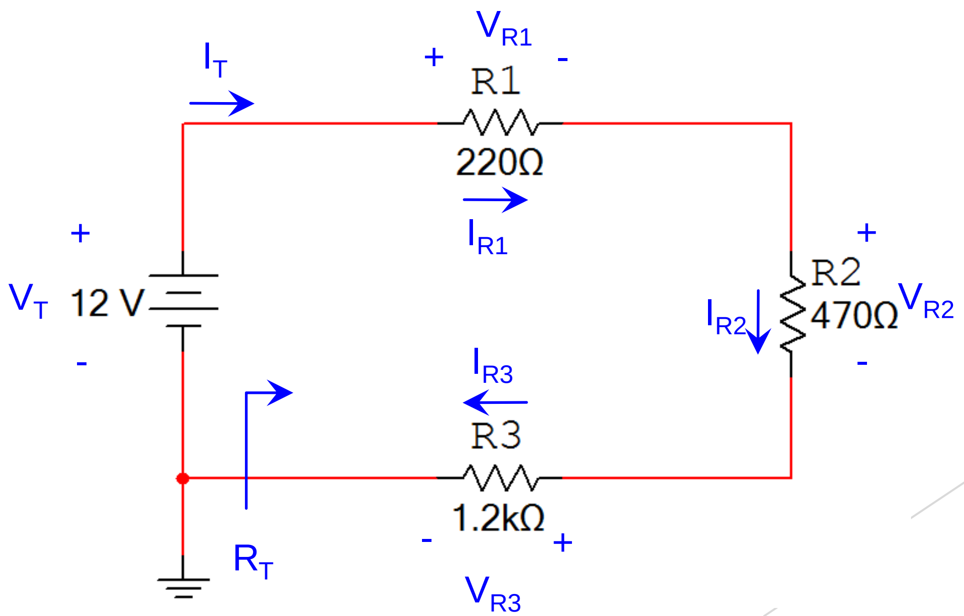
- The current flowing through every series component is equal.
- The total resistance (R_T) is equal to the sum of all of the resistances (i.e., $R_1 + R_2 + R_3$).
- The sum of all of the voltage drops ($V_{R1} + V_{R2} + V_{R3}$) is equal to the total applied voltage (V_T). This is called *Kirchhoff's* Voltage Law.



Example: Series Circuit

For the series circuit shown, use the laws of circuit theory to calculate the following:

- The total resistance (R_T)
- The current flowing through each component (I_T, I_{R1}, I_{R2}, & I_{R3})
- The voltage across each component (V_T, V_{R1}, V_{R2}, & V_{R3})
- Use the results to verify Kirchhoff's Voltage Law.



Example: Series Circuit

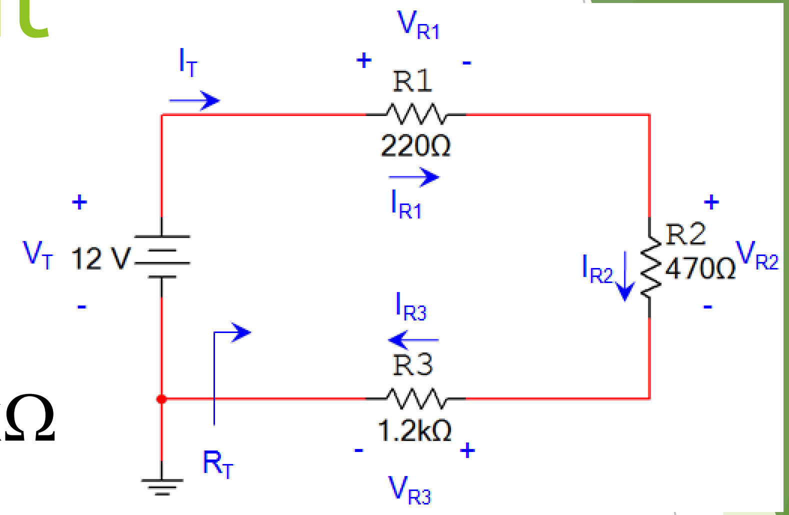
Solution:

Total Resistance:

$$R_T = R1 + R2 + R3$$

$$R_T = 220\ \Omega + 470\ \Omega + 1.2\ k\Omega$$

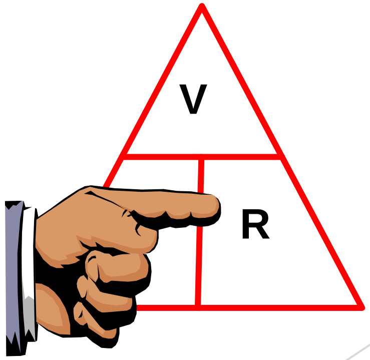
$$R_T = 1900\ \Omega = 1.9\ k\Omega$$



Current <u>Through</u> Each Component:

$$I_T = \frac{V_T}{R_T} \quad \text{(Ohm's Law)}$$

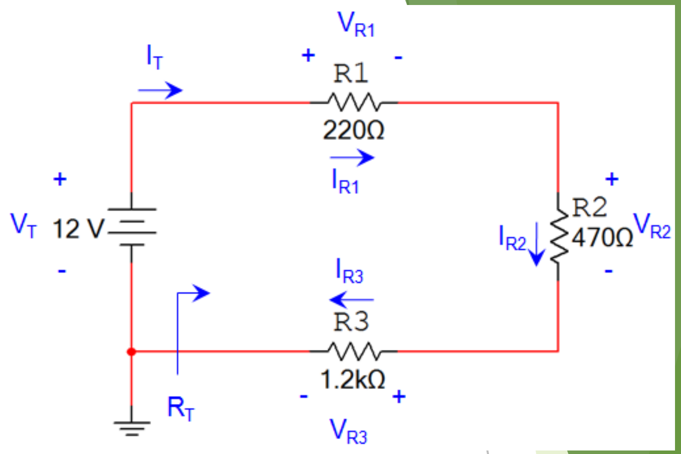
$$I_T = \frac{12\ v}{1.8\underline{9}\ k\Omega} = 6.3\ mAmp$$



Since this is a series circuit:

$$I_T = I_{R1} = I_{R2} = I_{R3} = 6.3\ mAmp$$

Example: Series Circuit

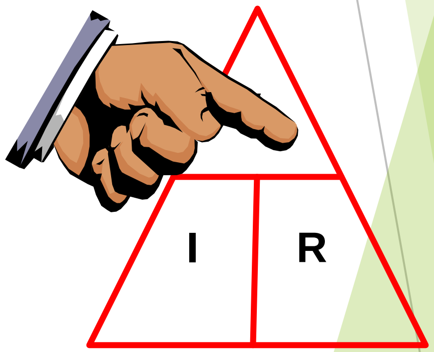


Solution:

Voltage <u>Across</u> Each Component:

$$V_{R1} = I_{R1} \times R1 = \quad \text{(Ohm's Law)}$$

$$V_{R1} = 6.3\underline{49}\text{ mA} \times 220\ \Omega = 1.3\underline{97}\text{ volts}$$



$$V_{R2} = I_{R2} \times R2 \quad \text{(Ohm's Law)}$$

$$V_{R2} = 6.3\underline{49}\text{ mA} \times 470\ \Omega = 2.9\underline{84}\text{ volts}$$

$$V_{R3} = I_{R3} \times R3 \quad \text{(Ohm's Law)}$$

$$V_{R3} = 6.3\underline{49}\text{ mA} \times 1.2\text{ K}\ \Omega = 7.6\underline{19}\text{ volts}$$

Example: Series Circuit

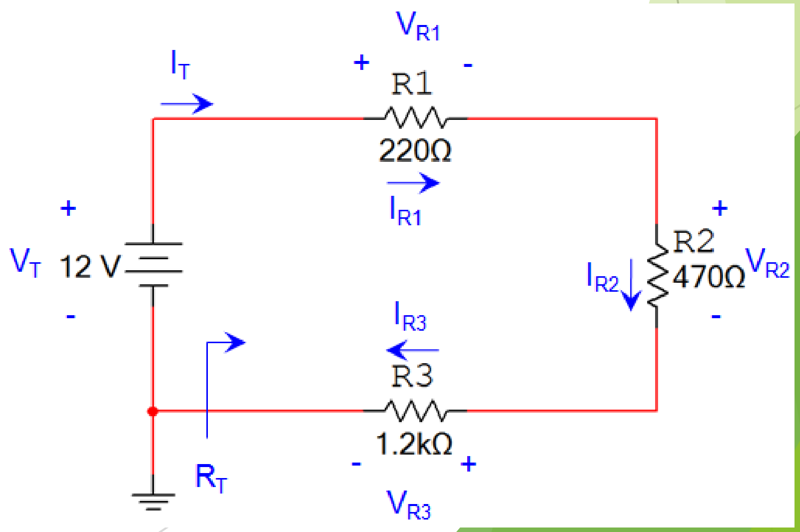
Solution:

Verify Kirchhoff's Voltage Law:

$$V_T = V_{R1} + V_{R2} + V_{R3}$$

$$12\text{ v} = 1.3\underline{97}\text{ v} + 2.9\underline{84}\text{ v} + 7.6\underline{19}\text{ v}$$

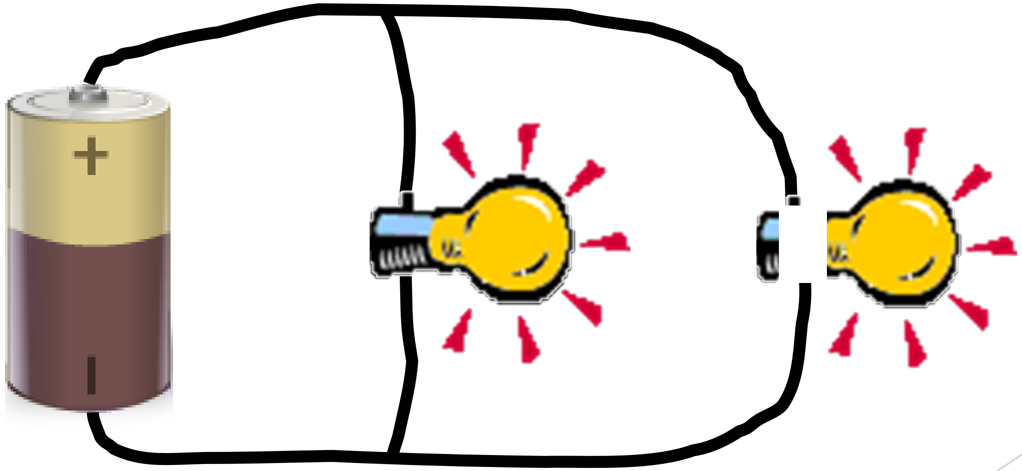
$$12\text{ v} = 12\text{ v}$$



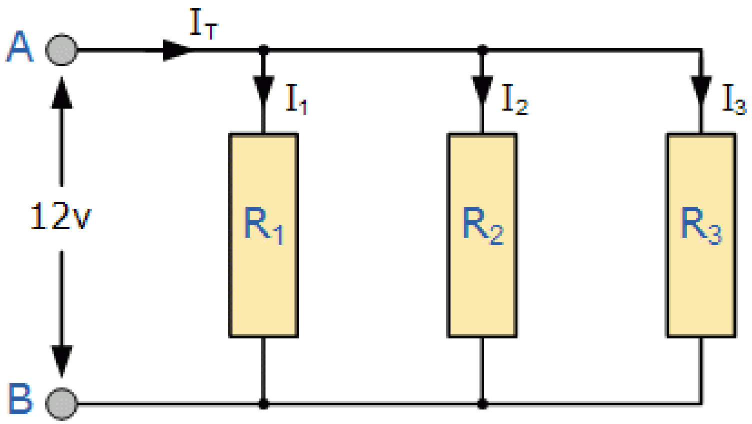
Parallel Circuits

A circuit that contains more than one path for current flow

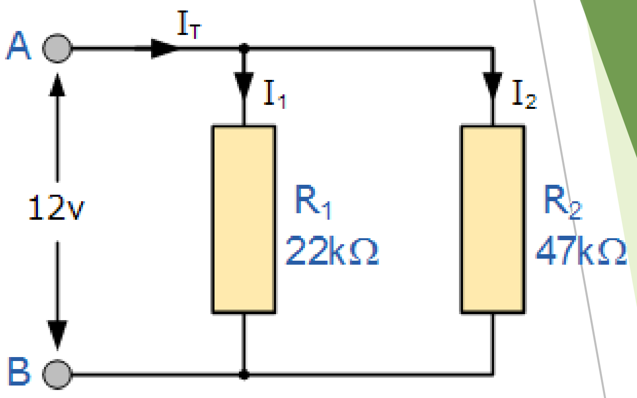
If a component is removed, then it is possible for the current to take another path to reach other components.



PARALLEL CIRCUIT



- $I_T = I_1 + I_2 + I_3$
- We know $I = \frac{V}{R}$
- $\therefore \frac{V}{R_T} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$
- $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$
- $\frac{1}{R_T} = \frac{R_2R_3 + R_1R_3 + R_1R_2}{R_1R_2R_3}$
- $R_T = \frac{R_1R_2R_3}{R_2R_3 + R_1R_3 + R_1R_2}$



- $I_T = I_1 + I_2 + I_3$
- We know $I = \frac{V}{R}$
- $\therefore \frac{V}{R_T} = \frac{V}{R_1} + \frac{V}{R_2}$
- $\frac{V}{R_T} = V(\frac{1}{R_1} + \frac{1}{R_2})$
- $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$
- $R_T = \frac{R_1R_2}{R_1 + R_2}$

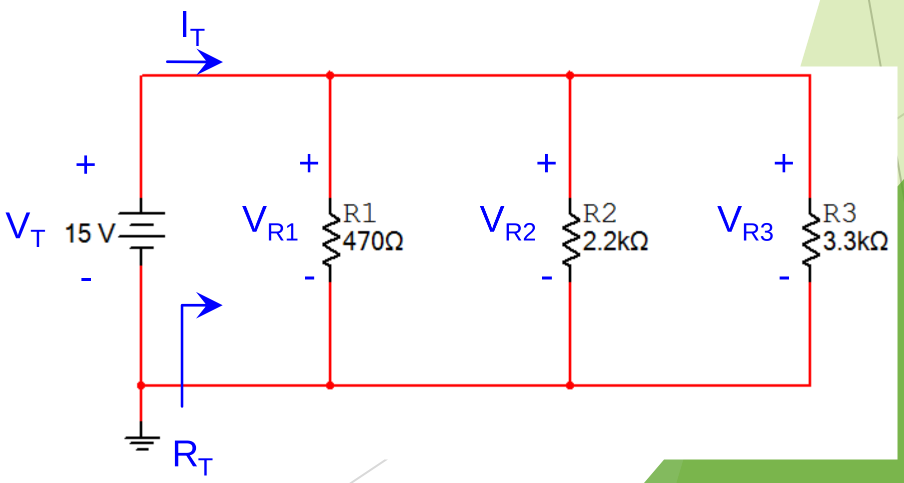
Parallel Circuits

Characteristics of a Parallel Circuit

- The voltage across every parallel component is equal.
- The total resistance (R_T) is equal to the reciprocal of the sum of the reciprocal:

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \qquad R_T = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

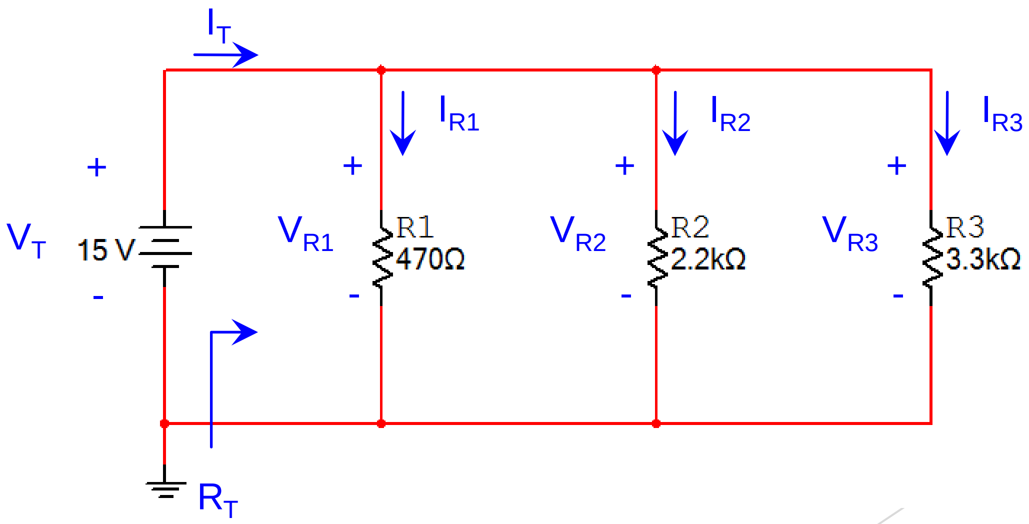
- The sum of all of the currents in each branch ($I_{R1} + I_{R2} + I_{R3}$) is equal to the total current (I_T). This is called *Kirchhoff's* Current Law.



Example Parallel Circuits

For the parallel circuit shown, use the laws of circuit theory to calculate the following:

- The total resistance (R_T)
- The voltage across each component (V_T, V_{R1}, V_{R2}, & V_{R3})
- The current flowing through each component (I_T, I_{R1}, I_{R2}, & I_{R3})
- Use the results to verify Kirchhoff's Current Law.

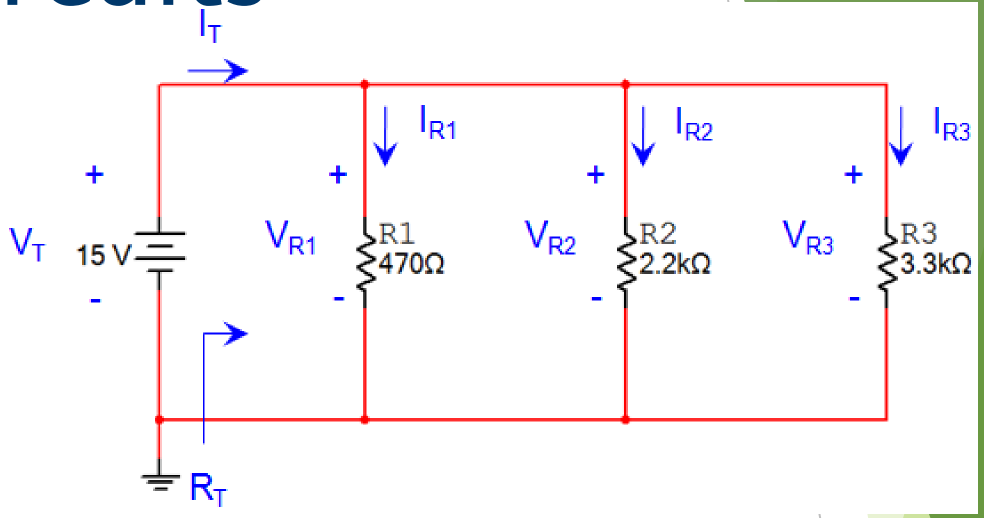


Example Parallel Circuits

Solution:

Total Resistance:

$$R_T = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$



$$R_T = \frac{1}{\frac{1}{470\ \Omega} + \frac{1}{2.2\ k\Omega} + \frac{1}{3.3\ k\Omega}}$$

$$R_T = 34\underline{6.59}\ \Omega = 350\ \Omega$$

Voltage <u>Across</u> Each Component:

$$\text{Since this is a parallel circuit :}$$

$$V_T = V_{R1} = V_{R2} = V_{R3} = 15\ \text{volts}$$

Example Parallel Circuits

Solution:

Current <u>Through</u> Each Component

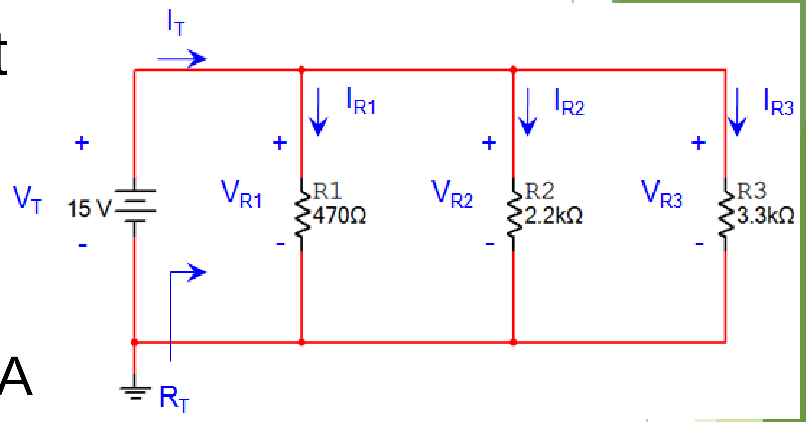
$$I_{R1} = \frac{V_{R1}}{R1} \qquad \text{(Ohm's Law)}$$

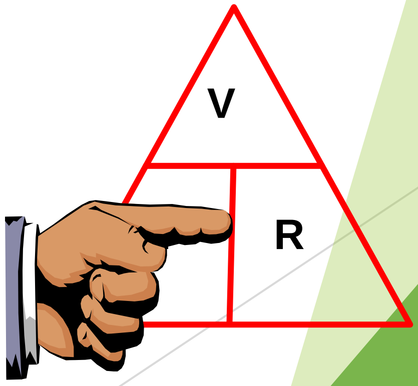
$$I_{R1} = \frac{V_{R1}}{R1} = \frac{15\text{ v}}{470\ \Omega} = 31.\underline{915}\text{ mA}=32\text{ mA}$$

$$I_{R2} = \frac{V_{R2}}{R2} = \frac{15\text{ v}}{2.2\text{ k}\ \Omega} = 6.8\underline{18}\text{ mA} = 6.8\text{ mA}$$

$$I_{R3} = \frac{V_{R3}}{R3} = \frac{15\text{ v}}{3.3\text{ k}\ \Omega} = 4.5\underline{45}\text{ mA}= 4.5\text{mA}$$

$$I_{T} = \frac{V_{T}}{R_{T}} = \frac{15\text{ v}}{346.\underline{59}\ \Omega} = 43.\underline{278}\text{ mA} = 43\text{ mA}$$





Example Parallel Circuits

Solution:

Verify Kirchhoff's Current Law:

$$I_T = I_{R1} + I_{R2} + I_{R3}$$

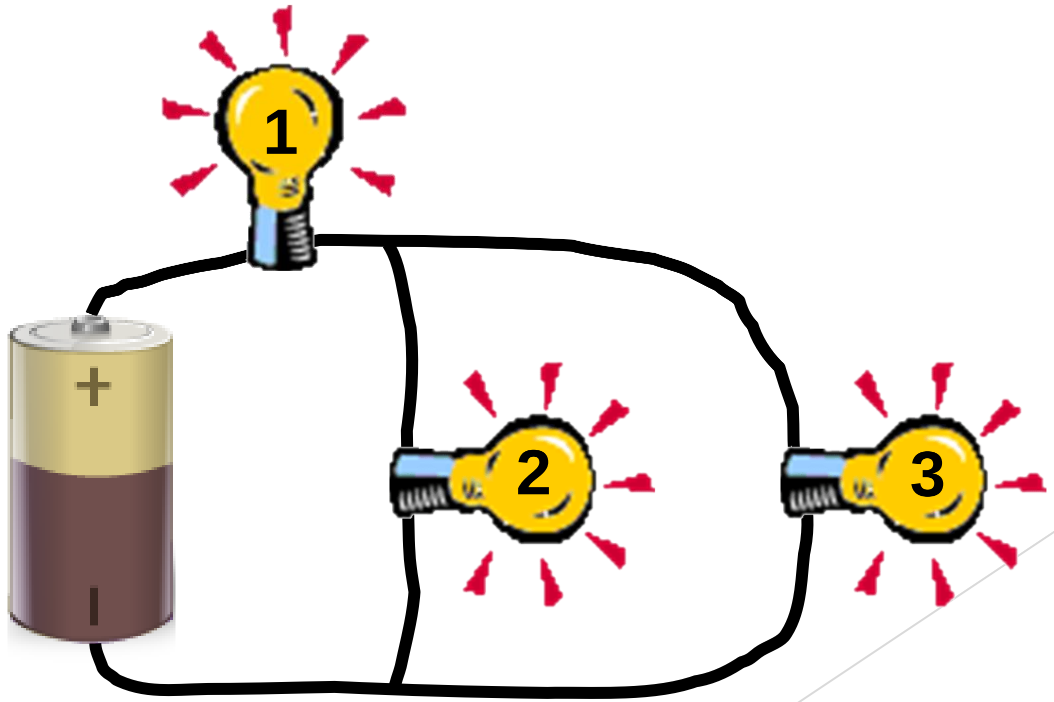
$$43.\underline{278}\ \text{mA} = 31.\underline{915}\ \text{mA} + 6.8\underline{18}\ \text{mA} + 4.5\underline{45}\ \text{mA}$$

$$43.\underline{278}\ \text{mA}\ (43\ \text{mA}) = 43.\underline{278}\ \text{mA}\ (43\text{mA})$$

Combination Circuits

Contain both series and parallel arrangements

What would happen if you removed light 1? light 2? light 3?



Electrical Power

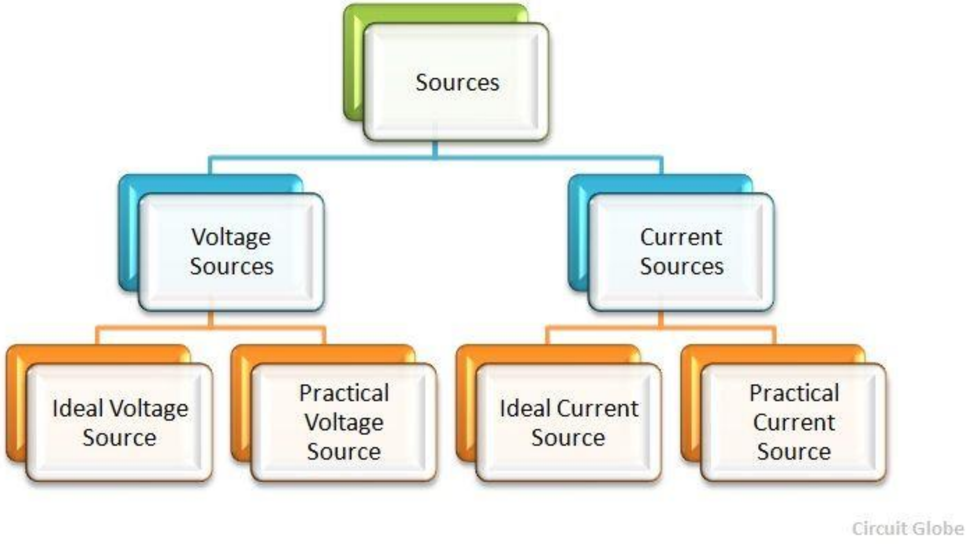
Electrical power is directly related to the amount of current and voltage within a system.

$$P = I \bullet V$$

Power is measured in watts

SOURCE

- A Source is a device which converts mechanical, chemical, thermal or some other form of energy into electrical energy. In other words, the source is an active network element meant for generating electrical energy.

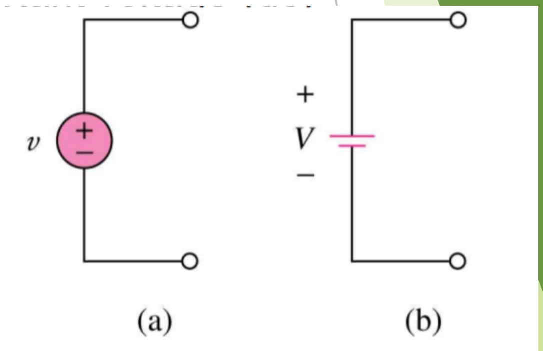


Ideal AND PRACTICAL Voltage Source

- Independent sources: An (ideal) independent source is an active element that provides a specified voltage or current that is independent of other circuit elements and/or how the source is used in the circuit.
- Symbol for independent voltage source

  (a) Used for constant or time-varying voltage

  (b) Used for constant voltage (dc)



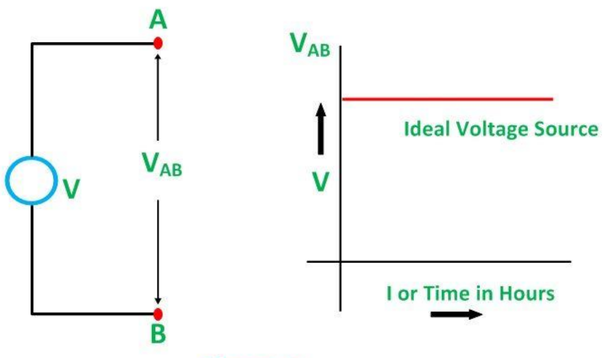


Figure A

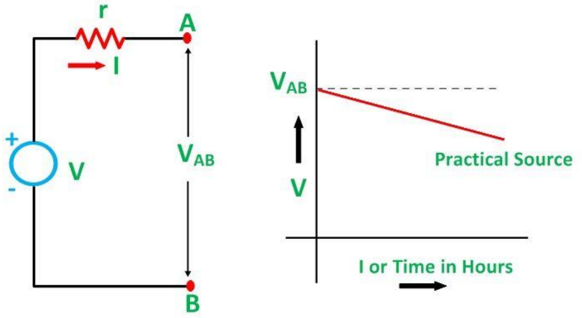


Figure B

Ideal Current Source

- Equivalent representation of ideal independent current sources whose current i(t) is maintained under all voltage requirements of the attached circuit:

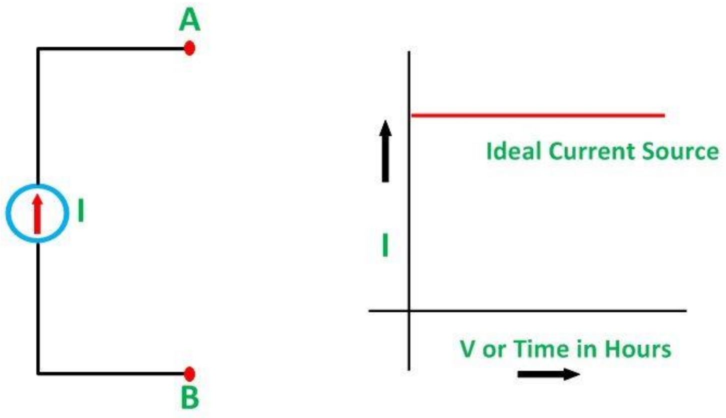


Figure C

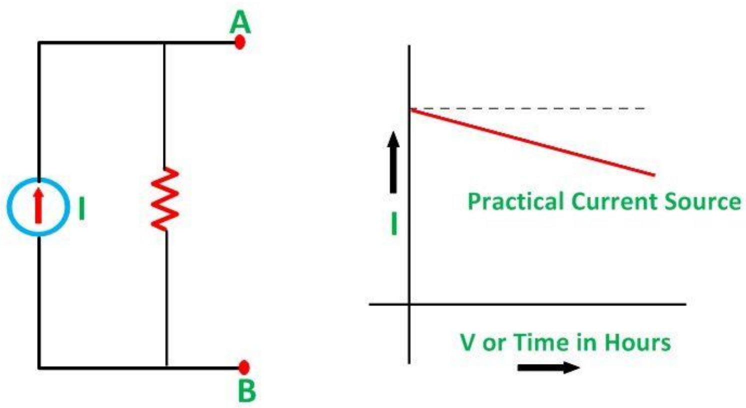
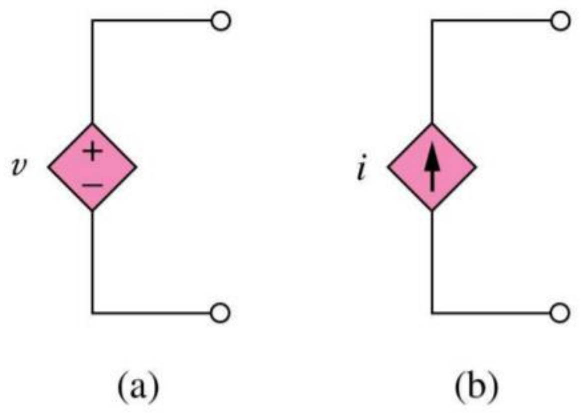


Figure D

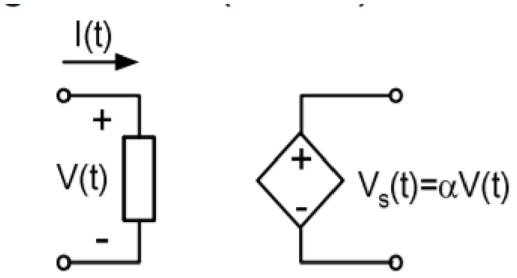
Ideal Dependent (Controlled) Source

- An ideal dependent (controlled) source is an active element whose quantity is controlled by a voltage or current of another circuit element.
- Dependent sources are usually presented by diamond-shaped symbols:

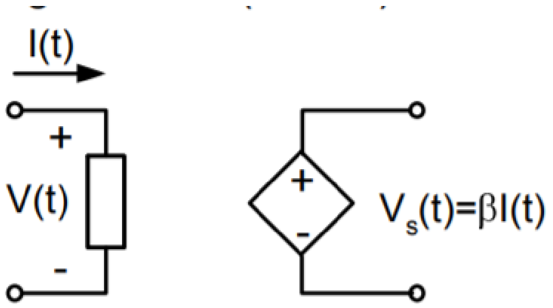


Dependent (Controlled) Source

- There are four types of dependent sources:
- Voltage-controlled voltage source (VCVS)

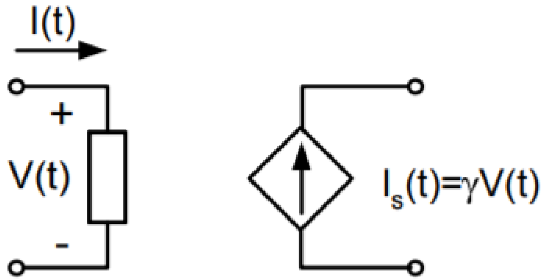


- Current-controlled voltage source (CCVS)

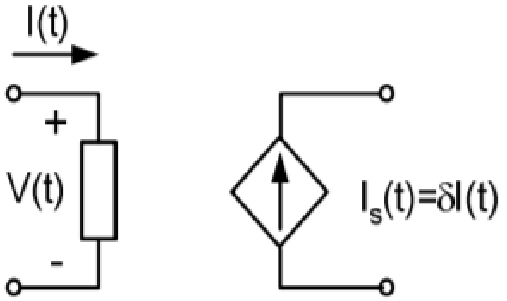


Dependent (Controlled) Source

- Dependent (Controlled) Source

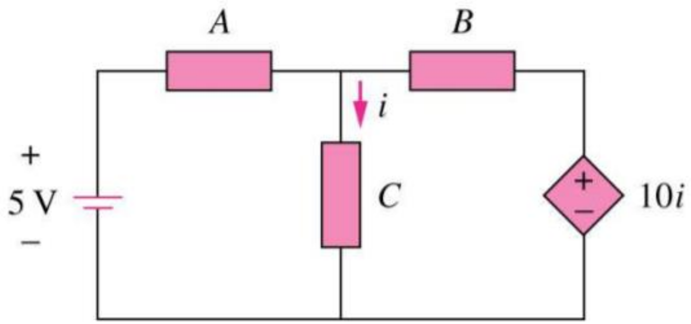


- Current-controlled current source (CCCS)

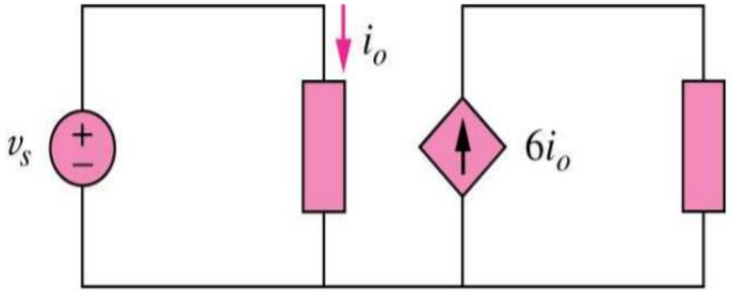


Example: Dependent Source

- In the following circuits, identify the type of dependent sources:



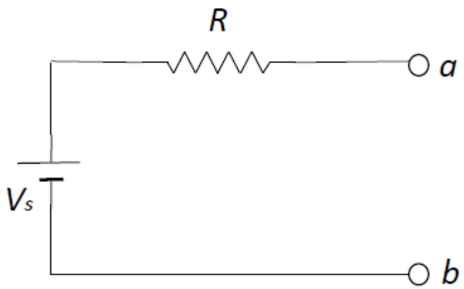
Current Dependent Voltage Source



Current Dependent Current Source

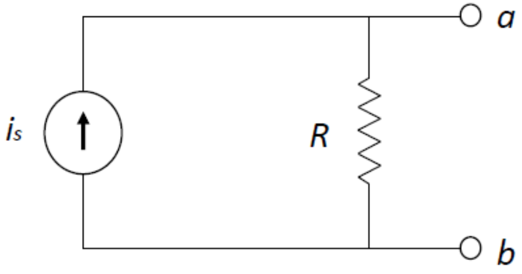
SOURCE TRANSFORMATION

- It is process of in which the circuit can be simplify or modified which make our circuit more is to solve
- If any circuit is having the voltage source in series it can be converted into current source with parallel with that resistance . This process can be reciprocated



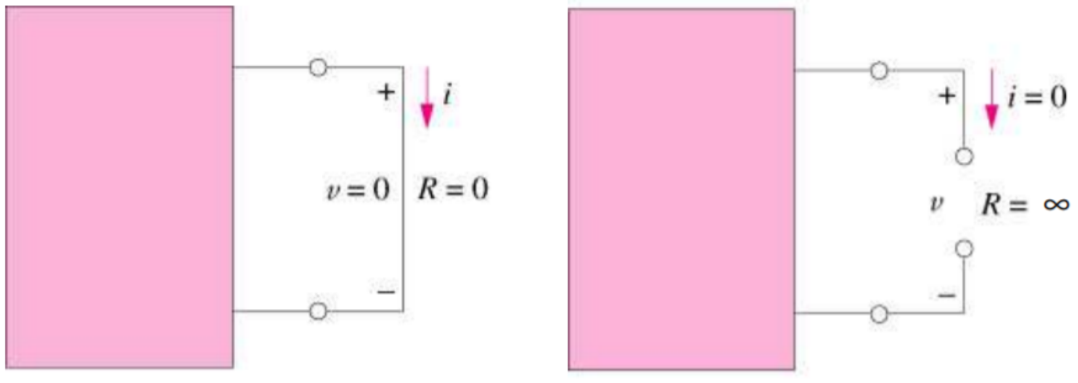
$$V = I * R$$

$$I = \frac{V}{R}$$

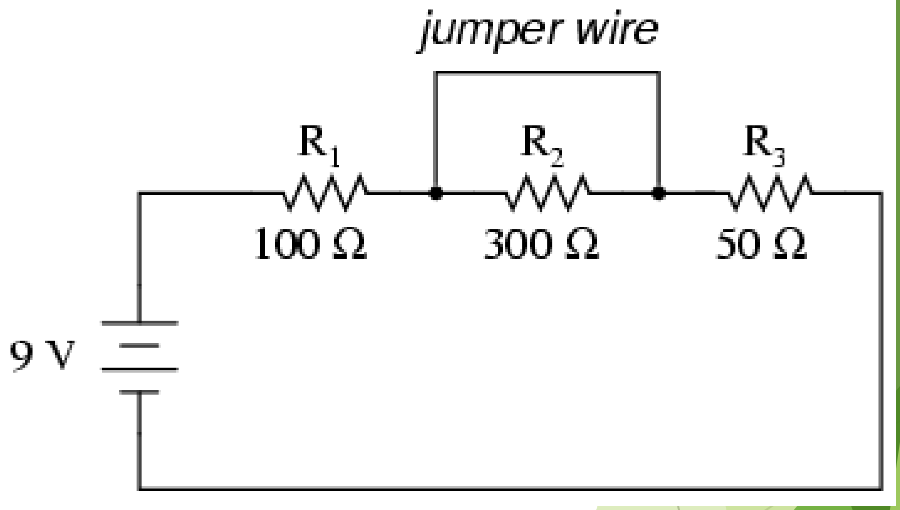


Short and Open Circuits

- A device with zero resistance is called short circuit and a device with zero conductance (i.e., infinite resistance) is called open circuit.



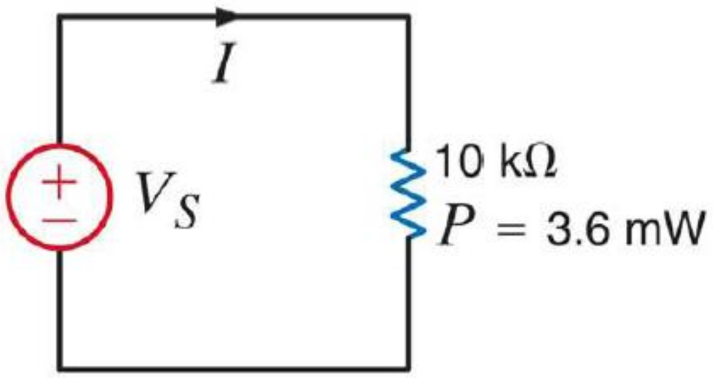
(a) (b)



$$R_T = 100\Omega + 50\Omega$$
$$R_T = 150\Omega$$

Example

- The power absorbed by the 10-kΩ resistor in the following circuit is 3.6 mW. Determine the voltage and the current in the circuit.



We Know, P=VI

Similarly V = IR

$$P = I^2R$$

$$3.6 * 10^{-3} = I^2 * 10 * 10^3$$

$$I^2 = \frac{3.6*10^{-3}}{10 * 10^3}$$

$$I^2 = 0.36 * 10^{-6}$$

$I =$ 0.00189=1.89mA

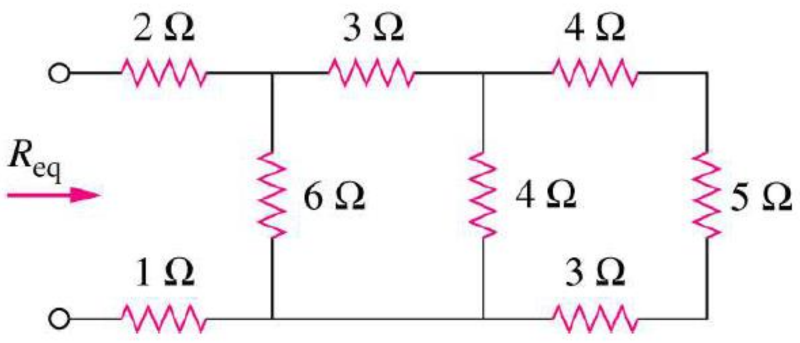
Since we Know I

$$V = \frac{P}{I} = \frac{3.6 * 10^{-3}}{1.89 * 10^{-3}}$$

$$V = 1.9V$$

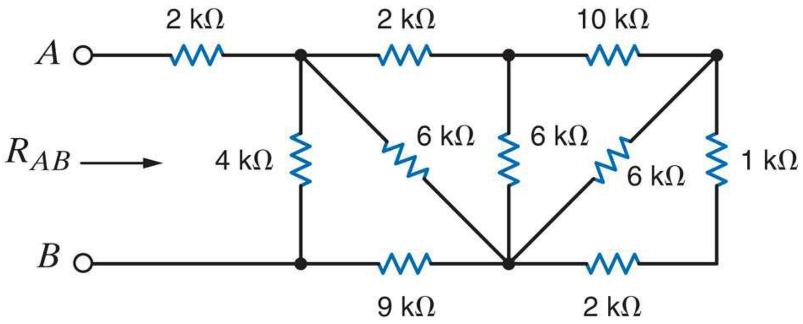
Example

- In the following circuit find Req:



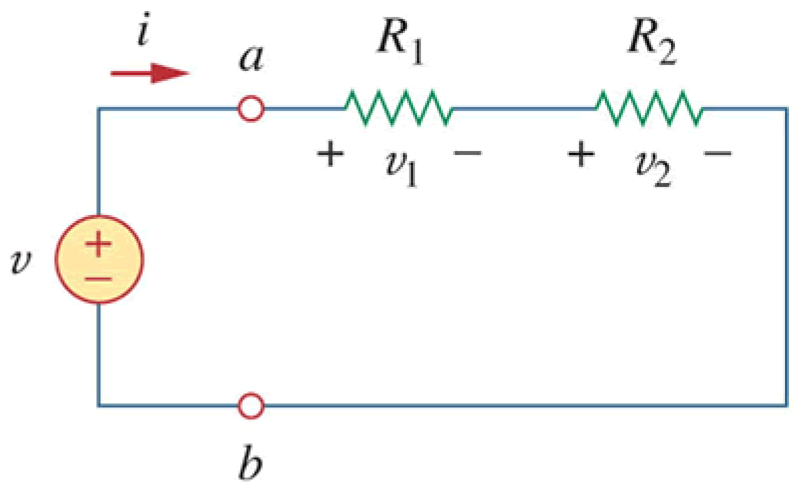
Example

- In the following circuit find the resistance seen between the two terminal s A and B, i.e., RAB



Voltage Division Rule

- For resistors in series, the total voltage across them is divided among the resistors in direct proportion to their resistances.



$From\ Ohms\ Law, V = I * R\ and\ I = \frac{V}{R}$

$In\ a\ Series\ Circuit, V = V_1 + V_2$

$V_1 = I * R_1$

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

$Substitute\ in\ the\ previous\ equation\ we\ get$

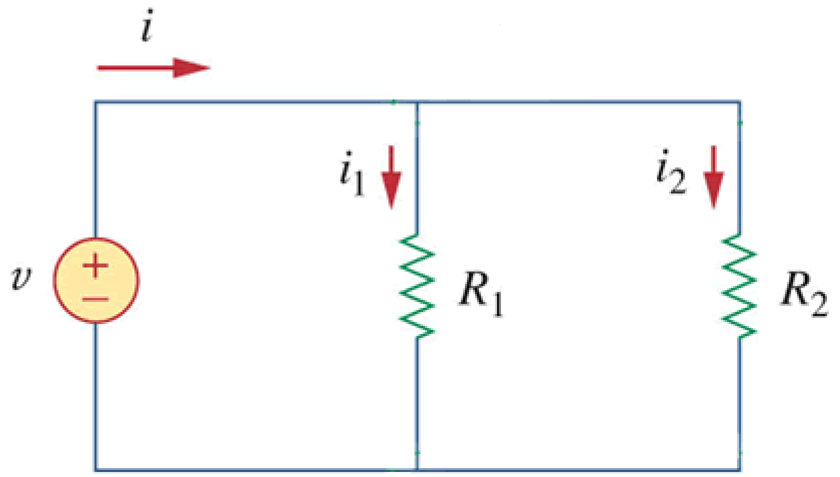
$$v_1 = \frac{R_1}{R_1 + R_2} v$$

Similarly

$$v_2 = \frac{R_2}{R_1 + R_2} v$$

Current Division RULE

- For resistors in parallel, the total current through them is shared by the resistors in *inverse proportion* to their resistances.



$From\ Ohms\ Law, V = I * R\ and\ I = \frac{V}{R}$

$In\ a\ Parallel\ Circuit, I = I_1 + I_2$

$$I_1 = \frac{V}{R_1}$$

$But\ \ V = I * R_T = I * \left(\frac{R_1 R_2}{R_1 + R_2}\right)$

$Substitute\ in\ the\ previous\ equation\ we\ get$

$$i_1 = \frac{R_1 R_2}{R_1(R_1 + R_2)} i$$

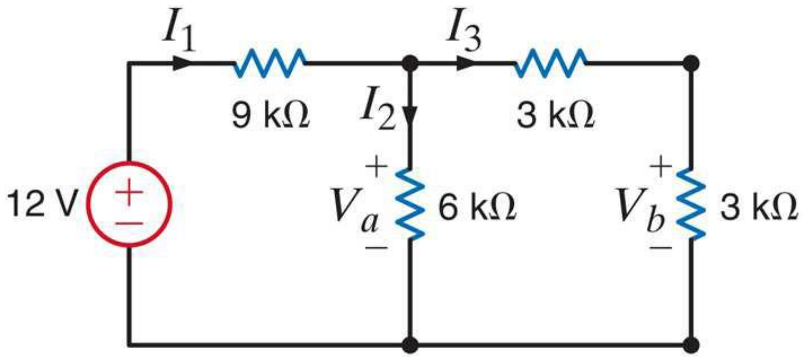
$$i_1 = \frac{R_2}{(R_1 + R_2)} i$$

Similarly

$$i_2 = \frac{R_1}{(R_1 + R_2)} i$$

Example

- In the following circuit find I1, I2, I3, Va, and Vb.

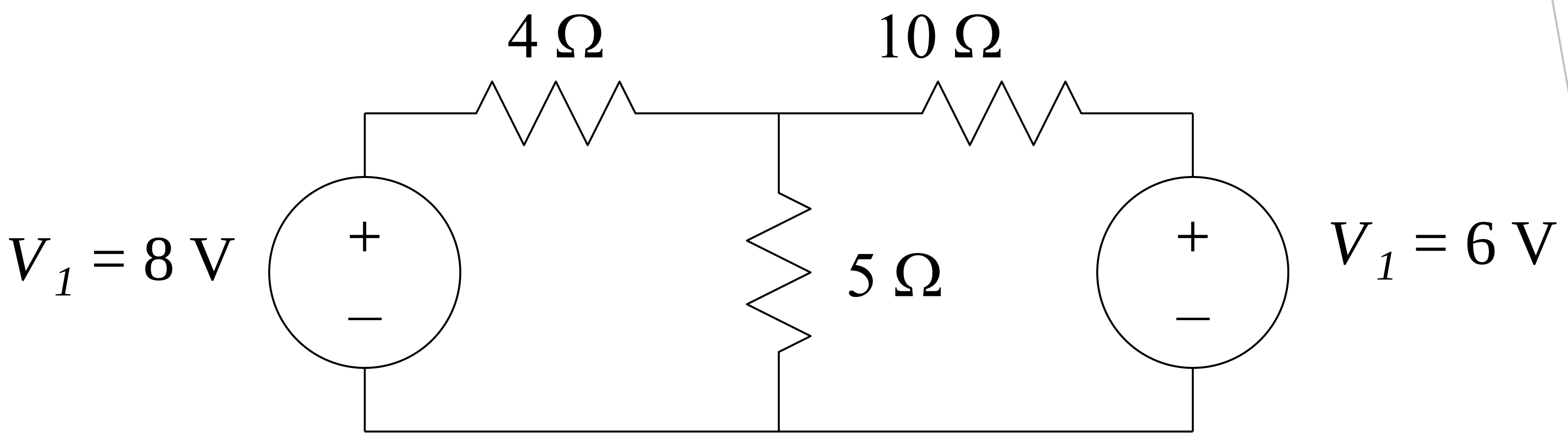


MESH CURRENT (LOOP)

INTRODUCTION

- Branch currents and branch voltages in a network can be found by the application of ohms law, KCL and KVL.
- For the solution of complicated networks the direct application of these basic methods is laborious.
- Mesh-current and node-voltage methods reduce the number of unknown variables and the number of simultaneous equations needed to describe a network.
- Nodal analysis by applying KCL at each non-reference node.
- Loop analysis by applying KVL around loops in the circuit.
- Loop (mesh) analysis results in a system of linear equations which must be solved for unknown currents.

MESH CURRENT (LOOP) ANALYSIS A mesh is defined as a closed path around a circuit that does not contain any other closed path within it.



For the above network, find the current flowing through the 5 Ω Resistor using mesh analysis.

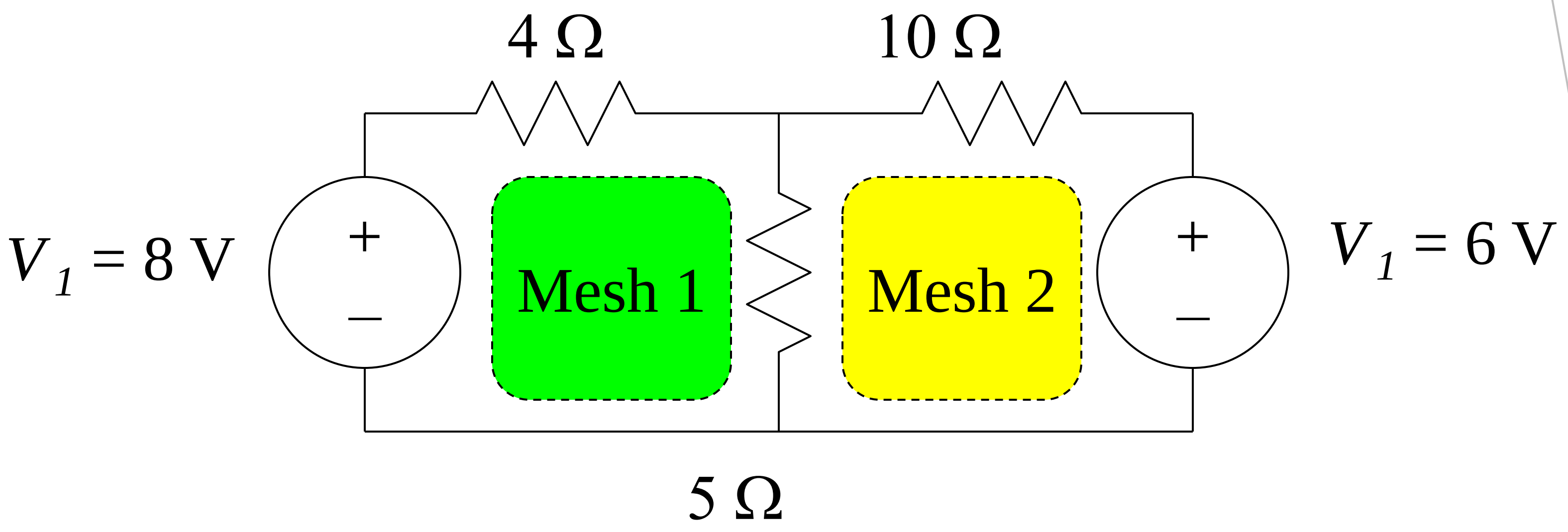
Steps of Mesh Analysis

1. Identify mesh (loops).

   (number of loop = number of equations)

2. Assign a current direction to each mesh (clock or anti-clock wise) with polarity.
3. Apply KVL around each loop to get an equation in terms of the loop currents.
4. Solve the resulting system of linear equations using Cramer’ rule .

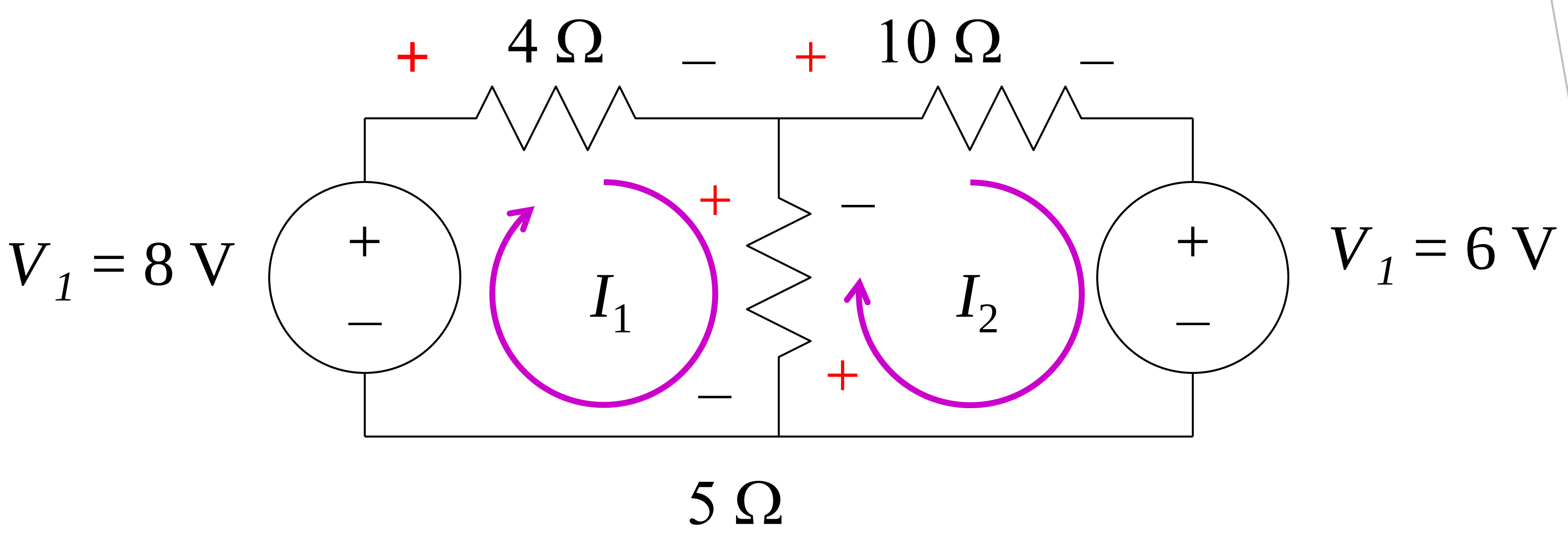
1. Identifying the Meshes



number of loop = number of equations

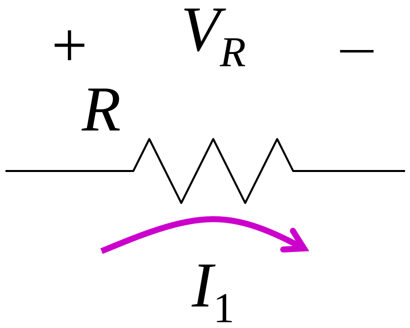
2=2

2.Assign a current direction to each mesh. (clock or anti-clock wise)

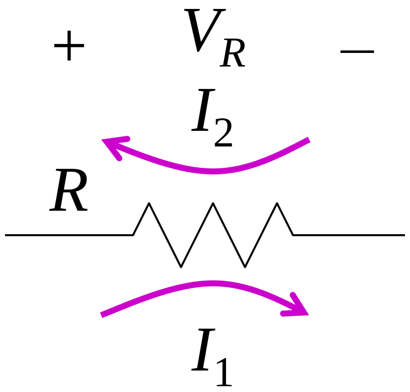


Mark the polarity for passive components present in the circuit.

Voltages from Mesh Currents

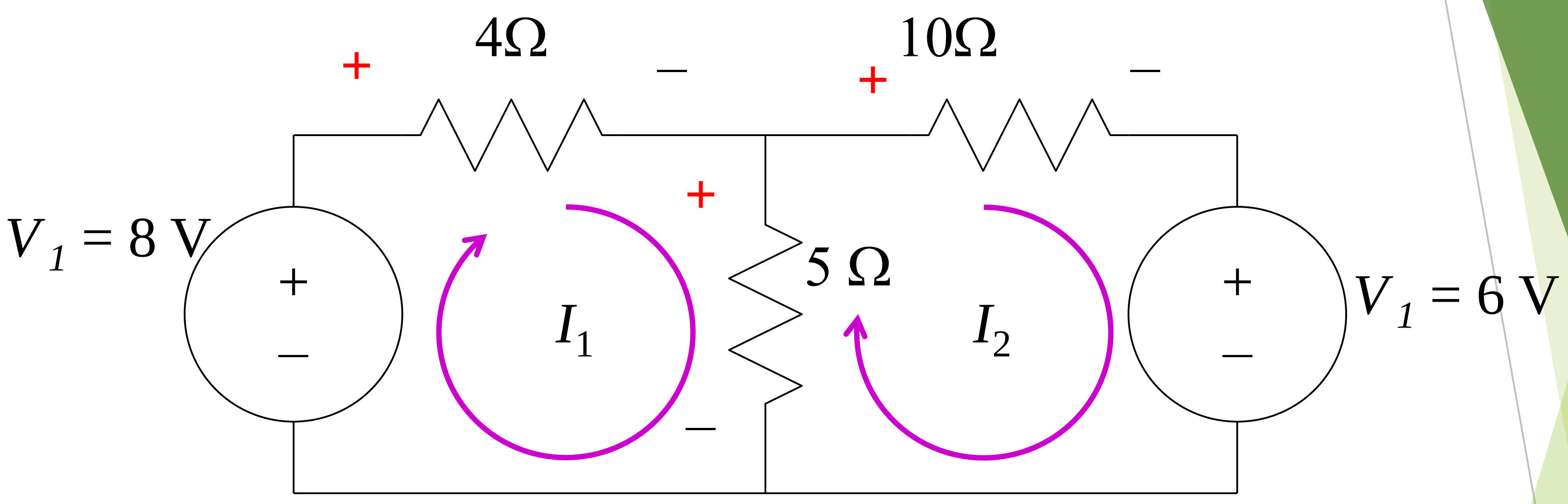


$$I_1 \, R$$



$$(I_1 - I_2) \, R$$

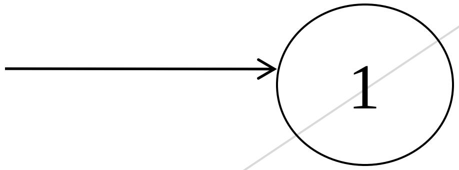
PROBLEM 1: DETERMINE LOOP CURRENTS



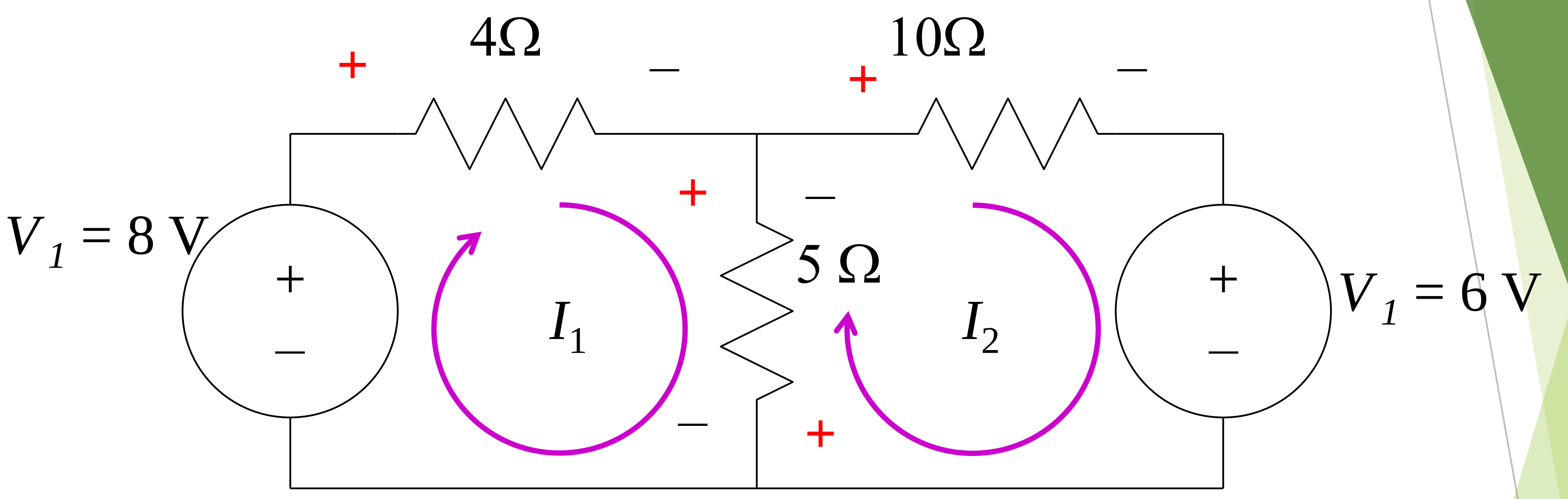
$$4I_1 + 5(I_1 - I_2) - 8 = 0$$

$$4I_1 + 5I_1 - 5I_2 - 8 = 0$$

$$8 = 9I_1 - 5I_2$$



3.KVL Around Mesh 2 (one way)



$$10\,I_2 + 6 + 5(I_2 - I_1) = 0$$

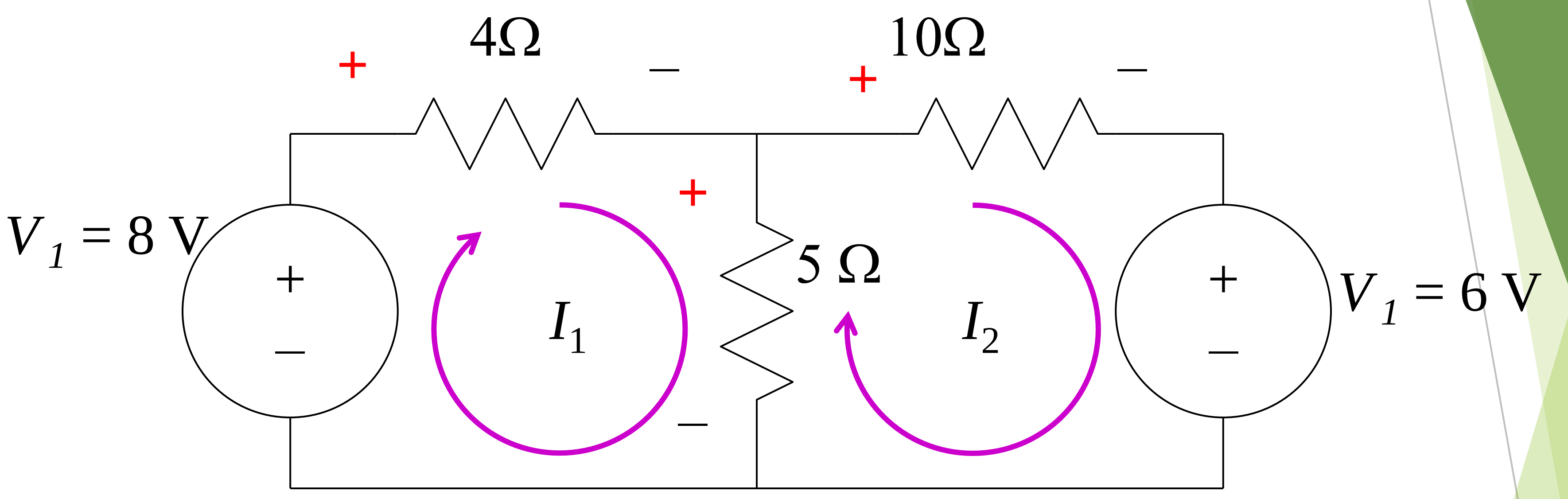
$$10\,I_2 + 6 + 5I_2 - 5I_1 = 0$$

$$15\,I_2 + 6 - 5I_1 = 0$$

$$-6 = -5I_1 + 15I_2$$

$\longrightarrow$ 2

3.KVL Around Mesh 2 (second way)



$$10\,I_2 + 6 - 5(I_1 - I_2) = 0$$

$$10\,I_2 + 6 + 5I_2 - 5I_1 = 0$$

$$15\,I_2 + 6 - 5I_1 = 0$$

$$-6 = -5I_1 + 15I_2$$

$\longrightarrow$ 2

Matrix Notation

- The two equations can be combined into a single matrix/vector equation.

$$\begin{bmatrix} R11 & R12 \\ R21 & R22 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} V_1 \\ V_2 \end{bmatrix}$$

$8 = 9\,I_1 - 5I_2$

$-6 = -5I_1 + 15I_2$

$$\begin{bmatrix} 9 & -5 \\ -5 & 15 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} 8 \\ -6 \end{bmatrix}$$

$$\Delta = \begin{vmatrix} 9 & -5 \\ -5 & 15 \end{vmatrix} = (9X15) - (-5X - 5)$$

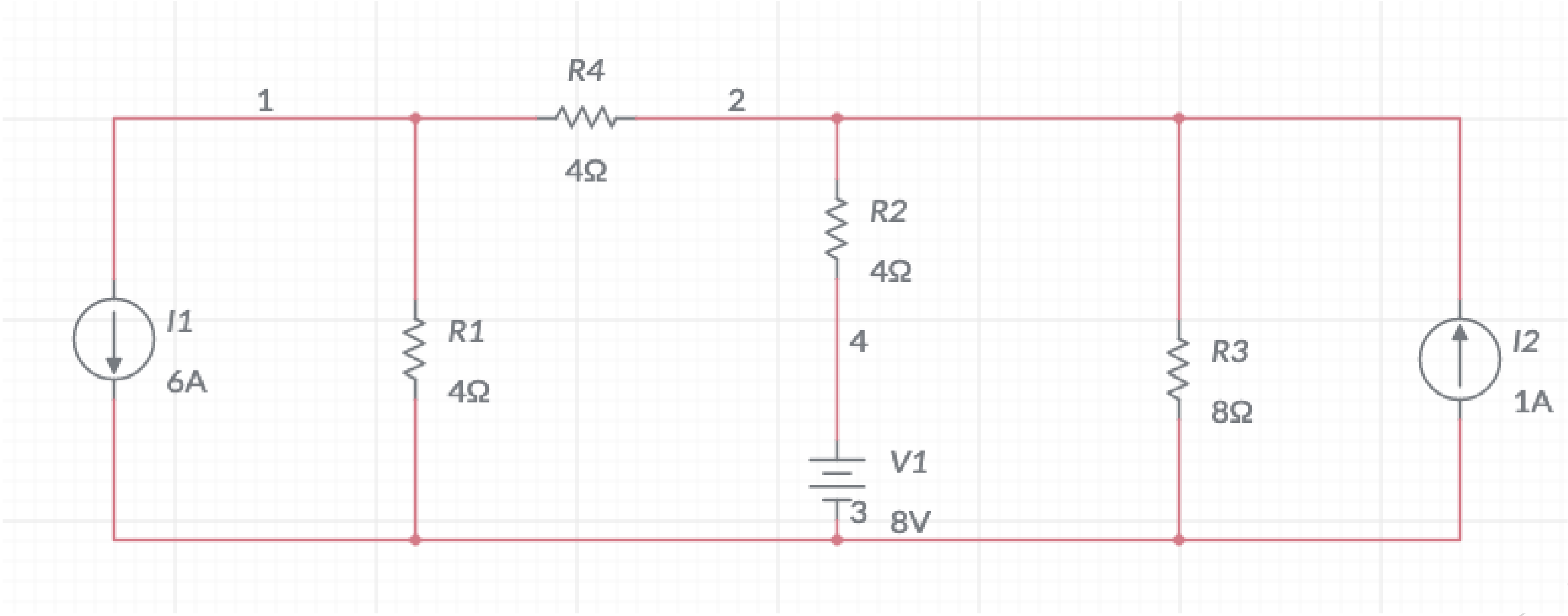
$$= 135\text{-}25$$

$$= 110$$

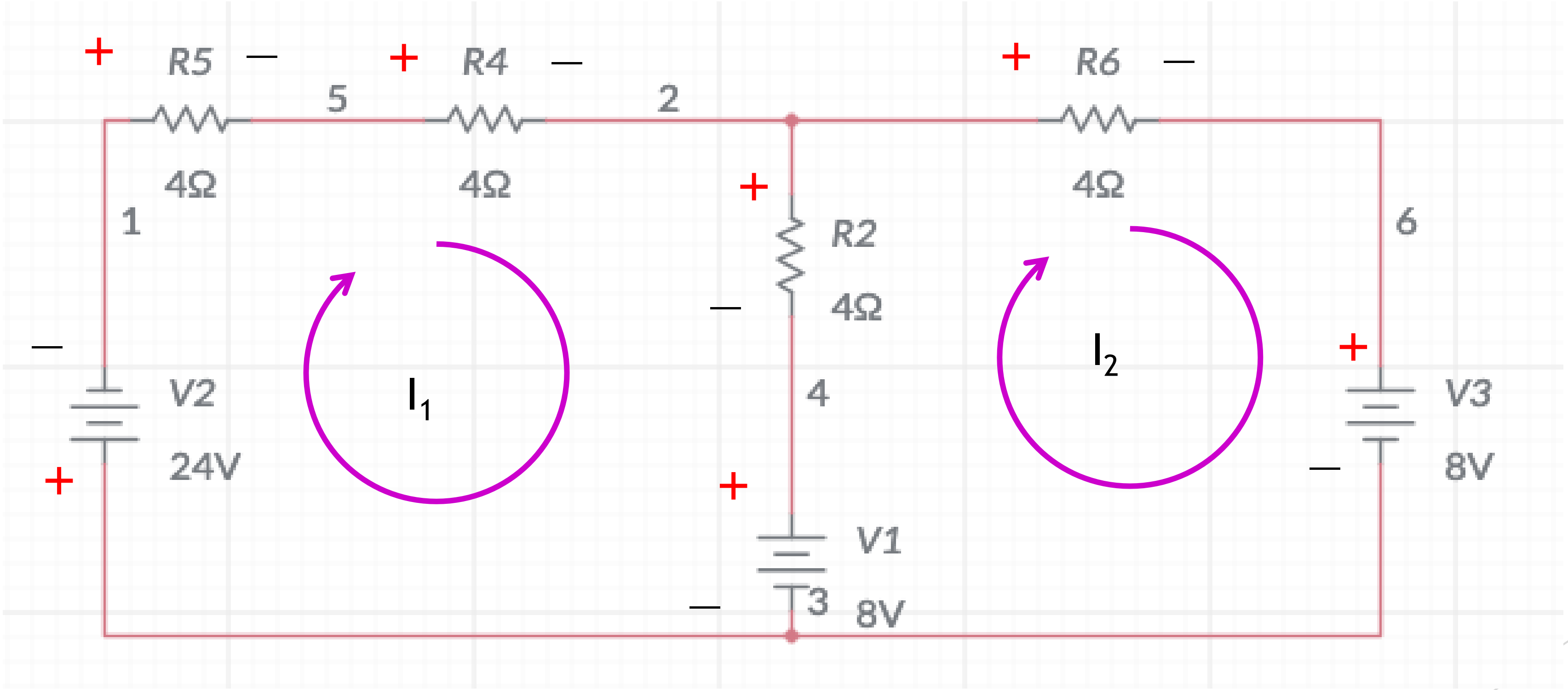
Matrix Notation

- $$\Delta_{I_1} = \begin{vmatrix} 8 & -5 \\ -6 & 15 \end{vmatrix} = (8X15) - (-5X - 6)$$
$$= 120 - 30 = 90$$
$$\Delta_{I_1} = 90$$
$$\Delta_{I_2} = \begin{vmatrix} 9 & 8 \\ -5 & -6 \end{vmatrix} = (9X - 6) - (8X - 5)$$
$$= -54 + 40 = -14$$
$$\Delta_{I_2} = -14$$
$$I_1 = \frac{\Delta_{I_1}}{\Delta} = \frac{90}{110} = 0.81A$$
$$I_2 = \frac{\Delta_{I_2}}{\Delta} = \frac{-14}{110} = -0.12A$$

Determine the current flowing through 4Ω resistor.



Redraw the circuit



Solution

- Loop 1
- $4I_1 + 4I_1 + 4(I_1 - I_2) + 8 + 24 = 0$
- $4I_1 + 4I_1 + 4I_1 - 4I_2 + 32 = 0$
- $12I_1 - 4I_2 = -32$

- Loop 2
- $8I_2 + 8 - 8 - 4(I_1 - I_2) = 0$
- $8I_2 - 4I_1 + 4I_2 = 0$
- $-4I_1 + 12I_2 = 0$

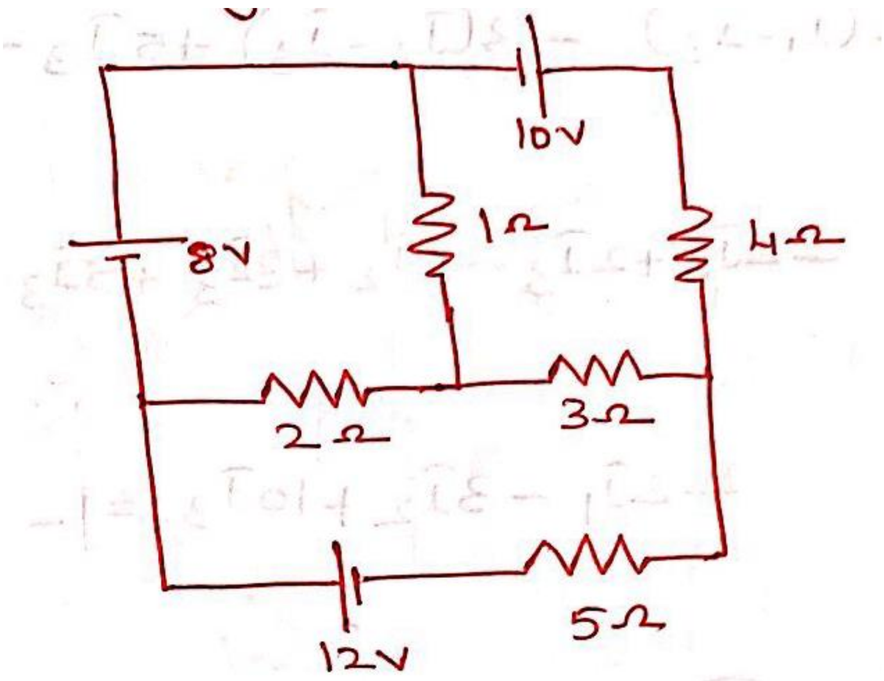
$$\Delta = \begin{vmatrix} 12 & -4 \\ -4 & 12 \end{vmatrix}$$
= 144 - 16
= 128

$$\Delta_{I_1} = \begin{vmatrix} -32 & -4 \\ 0 & 12 \end{vmatrix}$$
$$= -32\ X\ 12$$
$$= -384$$

$$\Delta_{I_2} = \begin{vmatrix} 12 & -32 \\ -4 & 0 \end{vmatrix}$$
$$= -(-32\ X\ -4)$$
$$= -128$$

$$I_1 = \frac{\Delta_{I_1}}{\Delta} = \frac{-384}{128}$$
$$I_1 = -3A$$
$$I_2 = \frac{\Delta_{I_2}}{\Delta} = \frac{-128}{128}$$
$$I_2 = -1A$$
$$(I_1 - I_2) = -2A$$

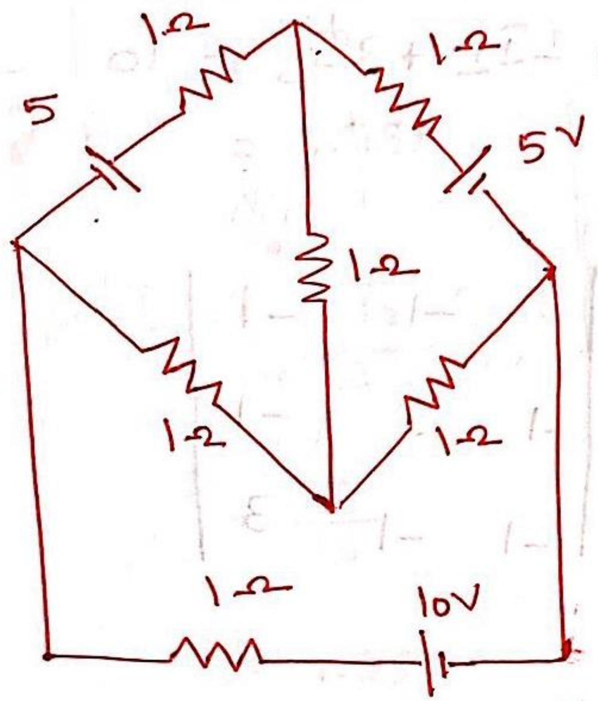
Determine current through 5Ω resistor using mesh analysis



- $\Delta_{I_3} = 538$
- $\Delta = 159$
- $I_3 = \frac{\Delta_{I_3}}{\Delta} = \frac{538}{159}$
- $I_{5\Omega} = I_3 = 3.38A$

Determine Loop Current for the circuit shown Below

- Loop 1
  - $3I_1 - I_2 - I_3 = 5$
- Loop 2
  - $-I_1 + 3I_2 - I_3 = -5$
- Loop 3
  - $-I_1 - I_2 + 3I_3 = 10$
- $\Delta = 16$
- $\Delta_{I_1} = 60$
- $\Delta_{I_2} = 20$
- $\Delta_{I_3} = 80$
- $I_1 = \frac{\Delta_{I_1}}{\Delta} = \frac{60}{16} = 3.75A$
- $I_2 = \frac{\Delta_{I_2}}{\Delta} = \frac{20}{16} = 1.25A$
- $I_3 = \frac{\Delta_{I_3}}{\Delta} = \frac{80}{16} = 5A$



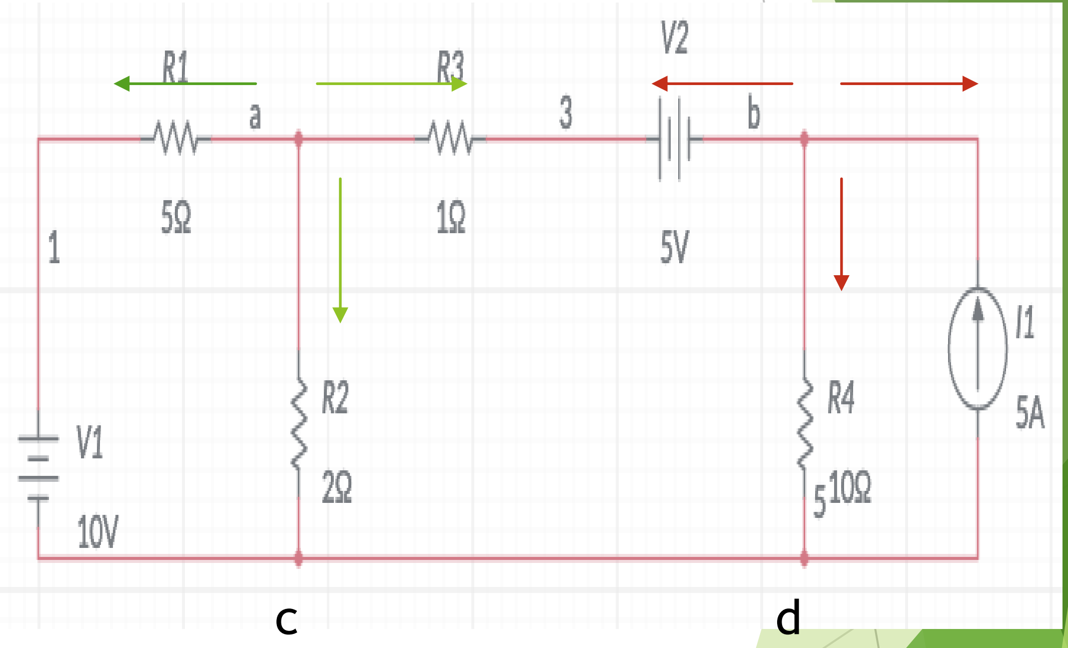
NODAL ANALYSIS

NODAL ANALYSIS (IT USES KCL)

- STEP 1
  - Find the total Number of nodes in the given circuit, assume one node to be grounded which has 0V.
- STEP 2
  - Assume all currents are leaving their respective nodes
- STEP 3
  - By using KCL obtain the equation
- STEP 4
  - Solve the equations and determine the nodal voltages

Determine the current flowing through 10Ω resistor

- NODE A
- $\frac{V_a-0-10}{5}+\frac{V_a-0}{2}+\frac{V_a-V_b-5}{1}=0$
- $0.2(V_a-10)+0.5V_a+V_a-V_b-5=0$
- $1.7V_a-V_b-7=0$
- $1.7V_a-V_b=7$
- NODE B
- $\frac{V_b-V_a+5}{1}+\frac{V_b-0}{10}-5=0$
- $V_b-V_a+5+0.1V_b=5$
- $-V_a+1.1V_b=0$
- $\Delta=0.87, \Delta_{V_a}=7.7, \Delta_b=7$
- $V_a=8.85V, V_b=8.045V$

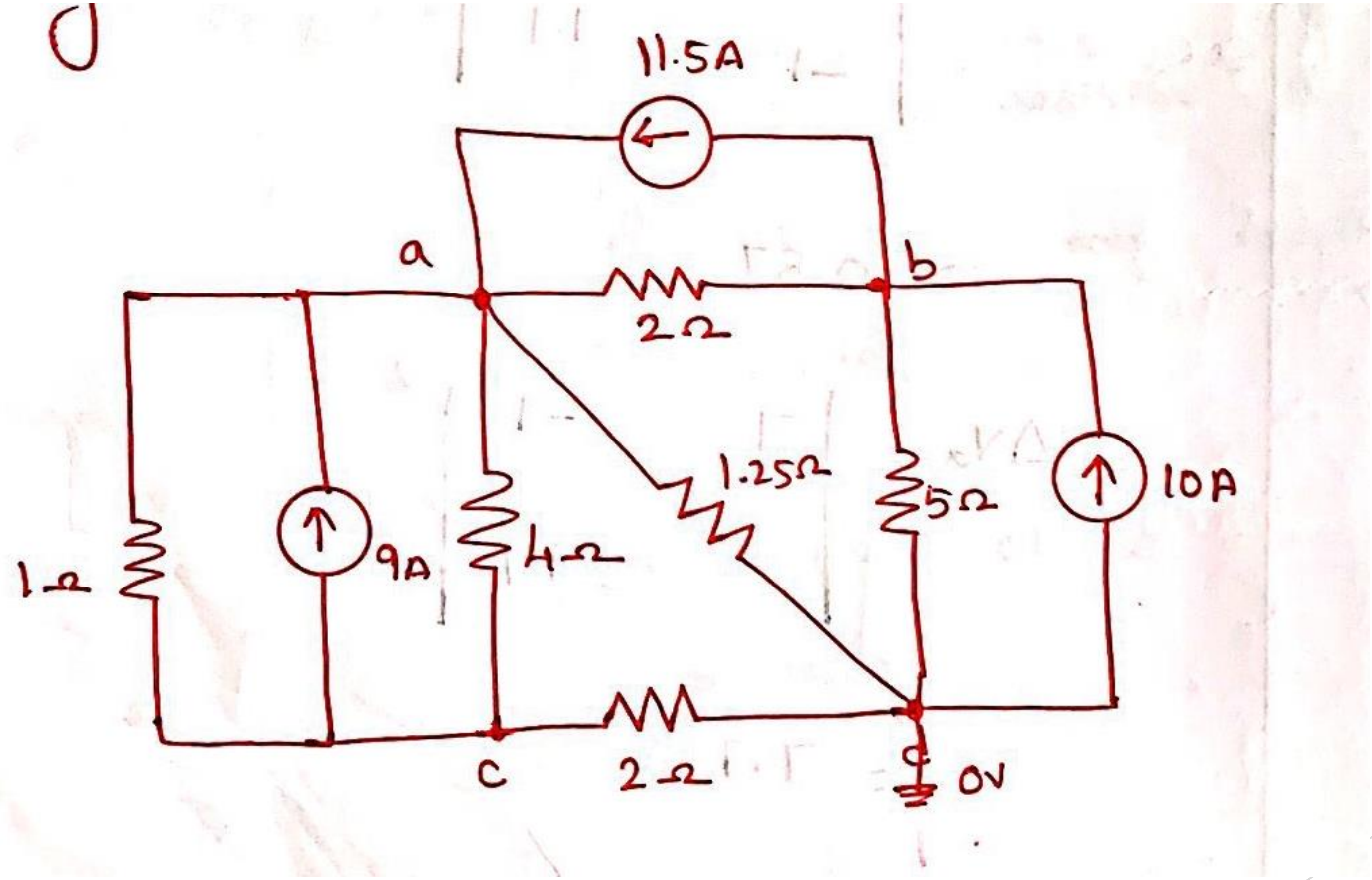


Current through 10Ω is

$$\frac{V_b}{10}=\frac{8.045}{10}$$

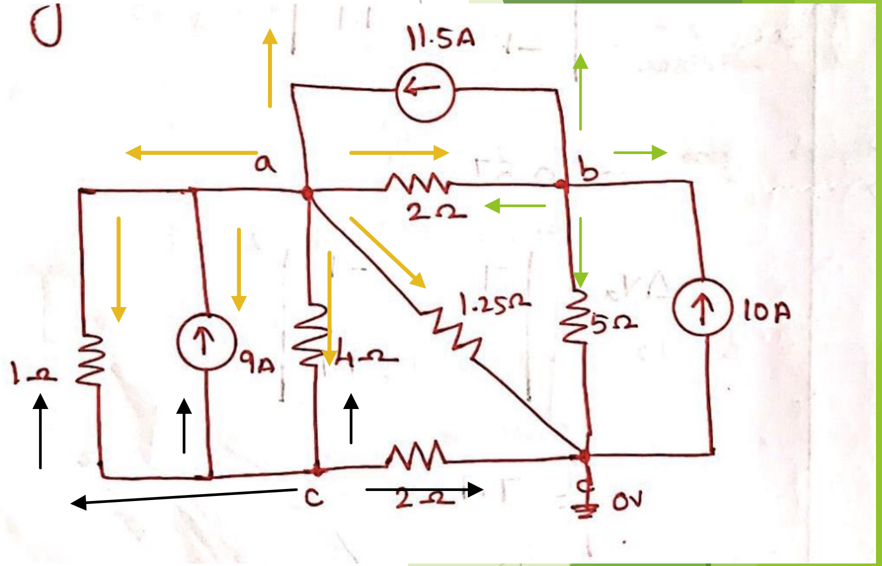
$$I_{10\Omega}=0.8A$$

Determine Node Voltage for the following circuit



Solution

- *Node A*
- $\frac{V_a - V_c}{1} - 9 + \frac{V_a - V_c}{4} + \frac{V_a - V_b}{2} + \frac{V_a - 0}{1.25} - 11.5 = 0$
- $V_a - V_c + 0.25(V_a - V_c) + 0.5(V_a - V_b) + 0.8V_a - 20.5 = 0$
- $\mathbf{2.55V_a - 0.5V_b - 1.25V_c = 20.5}$
- *Node B*
- $\frac{V_b - V_a}{2} + 11.5 + \frac{V_b - 0}{5} - 10 = 0$
- $0.5(V_b - V_a) + 11.5 + 0.2V_b - 10 = 0$
- $\mathbf{-0.5V_a + 0.7V_b = -1.5}$
- *Node C*
- $\frac{V_c - V_a}{1} + 9 + \frac{V_c - V_a}{4} + \frac{V_c - 0}{2} = 0$
- $V_c - V_a + 9 + 0.25(V_c - V_a) + 0.5V_c = 0$
- $\mathbf{-1.25V_a + 1.75V_c = -9}$



Solution

- $\Delta = \begin{vmatrix} 2.55 & -0.5 & -1.25 \\ -0.5 & 0.7 & 0 \\ -1.25 & 0 & 1.75 \end{vmatrix} = 1.592$

- $\Delta_{V_a} = \begin{vmatrix} 20.5 & -0.5 & -1.25 \\ -1.5 & 0.7 & 0 \\ -9 & 0 & 1.75 \end{vmatrix} = 15.92$

- $\Delta_{V_b} = \begin{vmatrix} 2.55 & 20.5 & -1.25 \\ -0.5 & -1.5 & 0 \\ -1.25 & -9 & 1.75 \end{vmatrix} = 7.9625$

- $\Delta_{V_c} = \begin{vmatrix} 2.55 & -0.5 & 20.5 \\ -0.5 & 0.7 & -1.5 \\ -1.25 & 0 & -9 \end{vmatrix} = 3.185$

- $V_a = 10V$
- $V_b = 5V$
- $V_c = 2V$

- $\mathbf{2.55V_a - 0.5V_b - 1.25V_c = 20.5}$
- $\mathbf{-0.5V_a + 0.7V_b = -1.5}$
- $\mathbf{-1.25V_a + 1.75V_c = -9}$

THANK YOU