02

CHAPTER

BIOPHYSICS LECTURE (2)

المحاضرة الثانية

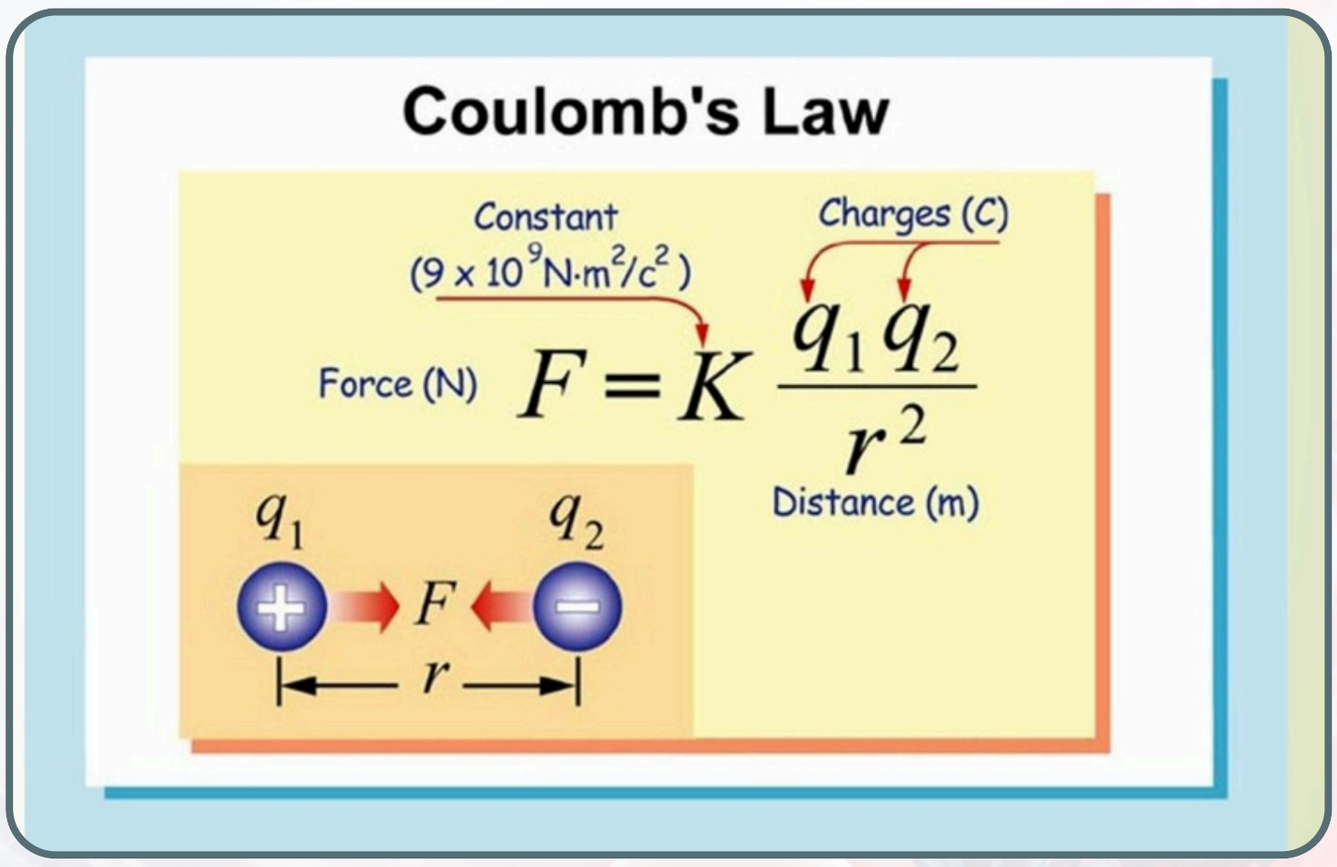
TOPICS

1. Coulomb's Law
2. Ohm's Law
3. SERIES CIRCUIT RESISTANCE
4. Series Circuit Voltage and Current
5. Parallel Circuits

Scientific content prepared by

Booknerd Team

Coulomb's Law

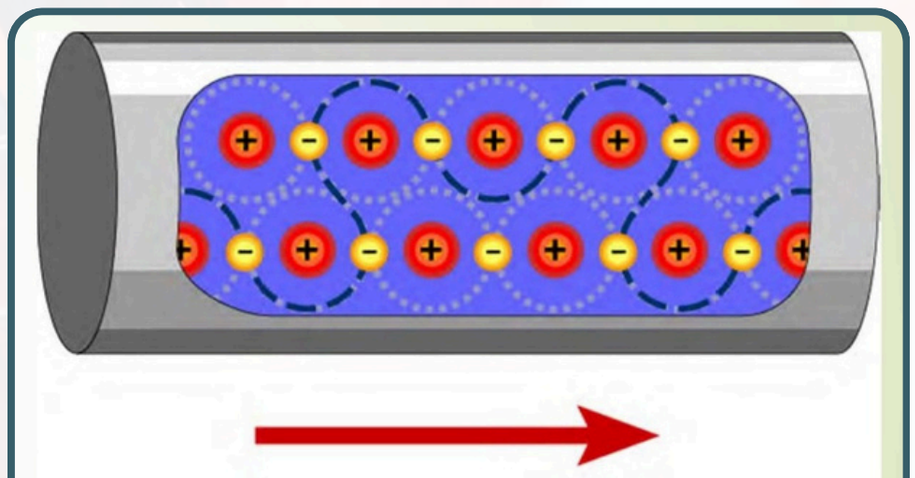


- Coulomb's law relates the force between two single charges separated by a distance.

Current

- Electricity is the flow of electrons in a conductor from one atom to the next atom in the same general direction.
- This flow of electrons is referred to as current and is designated by the symbol "I".

- Current is measured in amperes, which is often shortened to "amps". The letter "A" is the symbol for amps.
- Current that constantly flows in the same direction is called direct current (DC). Current that periodically changes direction is called alternating current (AC).

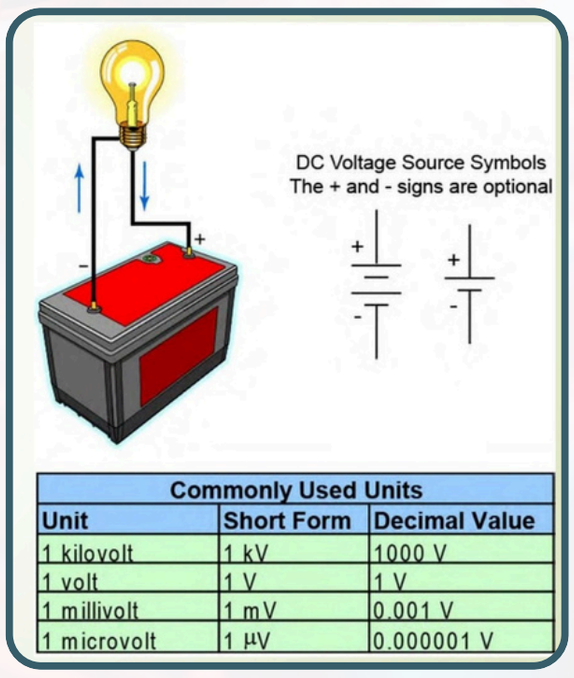


Commonly Used Units		
Unit	Short Form	Decimal Value
1 kiloampere	1 kA	1000 A
1 ampere	1 A	1 A
1 milliampere	1 mA	0.001 A
1 microampere	1 µA	0.000001 A

Voltage

- The force that causes current to flow through a conductor is called a difference in potential, electromotive force (emf), or voltage.

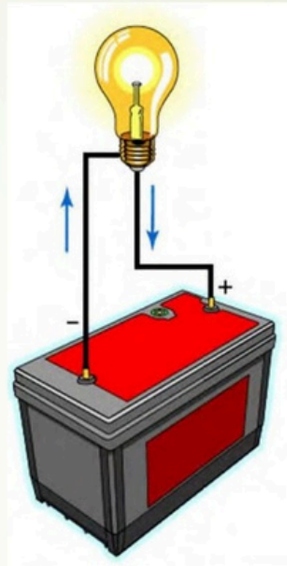
- Voltage is designated by the letter "E" or the letter "V." The unit of measurement for voltage is volts which is also designated by the letter "V."



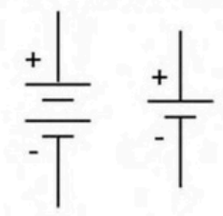
Commonly Used Units		
Unit	Short Form	Decimal Value
1 kilovolt	1 kV	1000 V
1 volt	1 V	1 V
1 millivolt	1 mV	0.001 V
1 microvolt	1 µV	0.000001 V

Voltage

- All voltage sources share the characteristic of an excess of electrons at one terminal and a shortage at the other terminal.
- This results in a difference of potential between the two terminals.
- For a DC voltage source, the polarity of the terminals does not change, so the resulting current constantly flows in the same direction.
- The terminals of an AC voltage source periodically change polarity, causing the current flow direction to change with each switch in polarity.



DC Voltage Source Symbols
The + and - signs are optional



Commonly Used Units		
Unit	Short Form	Decimal Value
1 kilovolt	1 kV	1000 V
1 volt	1 V	1 V
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1 microvolt	1 μV	0.000001 V

Resistance

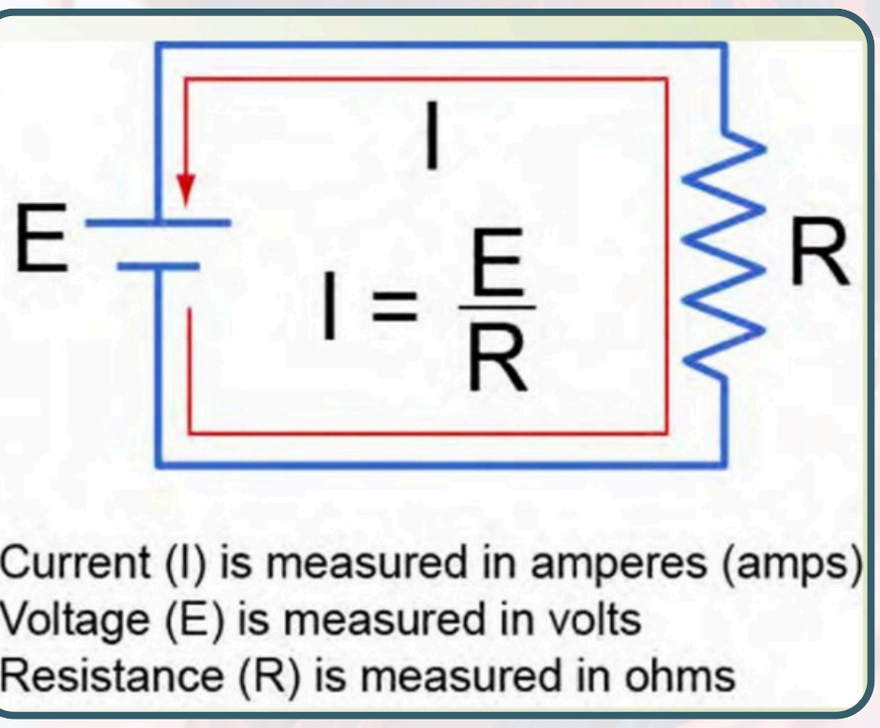
- A third factor that plays a role in an electrical circuit is resistance. Resistance is the property of a circuit, component, or material that opposes current flow.
- All material resists the flow of electrical current to some extent.
- Resistance is designated by the symbol "R." The unit of measurement for resistance is the ohm, symbolized by the Greek letter omega Ω.

Resistor

Resistor Symbol

Commonly Used Units		
Unit	Short Form	Decimal Value
1 Megaohm	1 MΩ	1,000,000 Ω
1 kiloohm	1 kΩ	1000 Ω
1 ohm	1 Ω	1 Ω

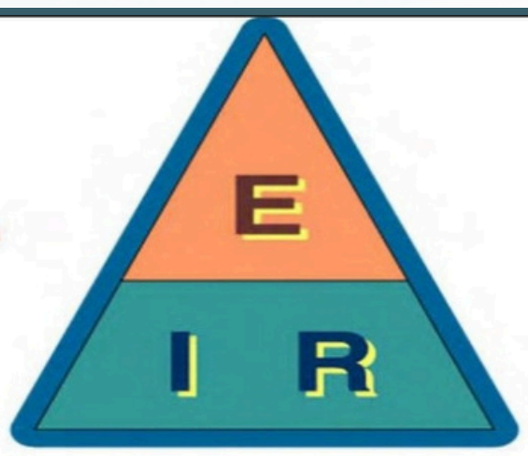
Ohm's Law



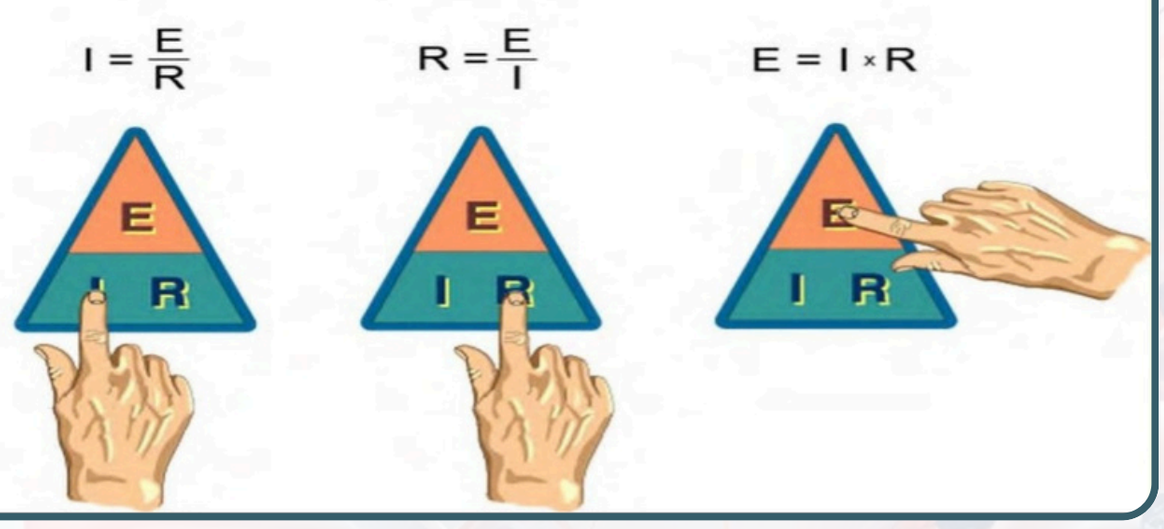
Current (I) is measured in amperes (amps)
Voltage (E) is measured in volts
Resistance (R) is measured in ohms

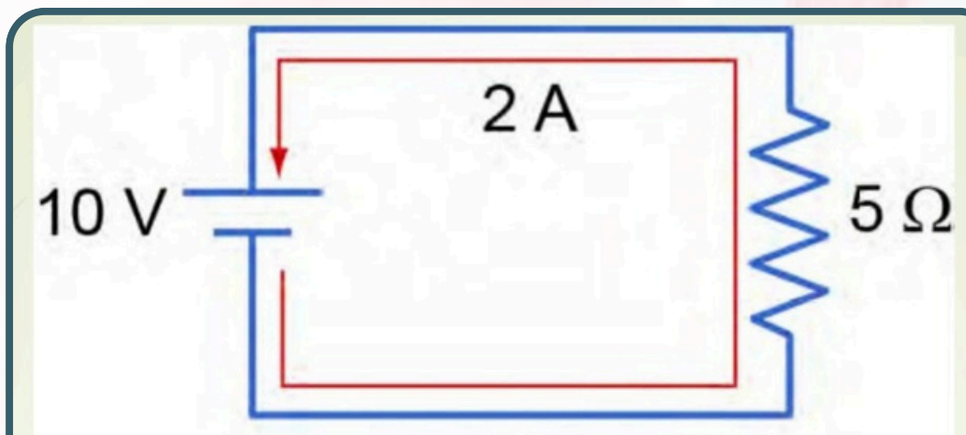
- A simple electric circuit consists of a voltage source, some type of load, and conductors to allow electrons to flow between the voltage source and the load.
- Ohm's law defines the relationship between current, voltage, and resistance and shows that current varies directly with voltage and inversely with resistance.

Point your finger on a letter to show the Ohm's law formula for that value



$I = \frac{E}{R}$ $R = \frac{E}{I}$ $E = I \times R$





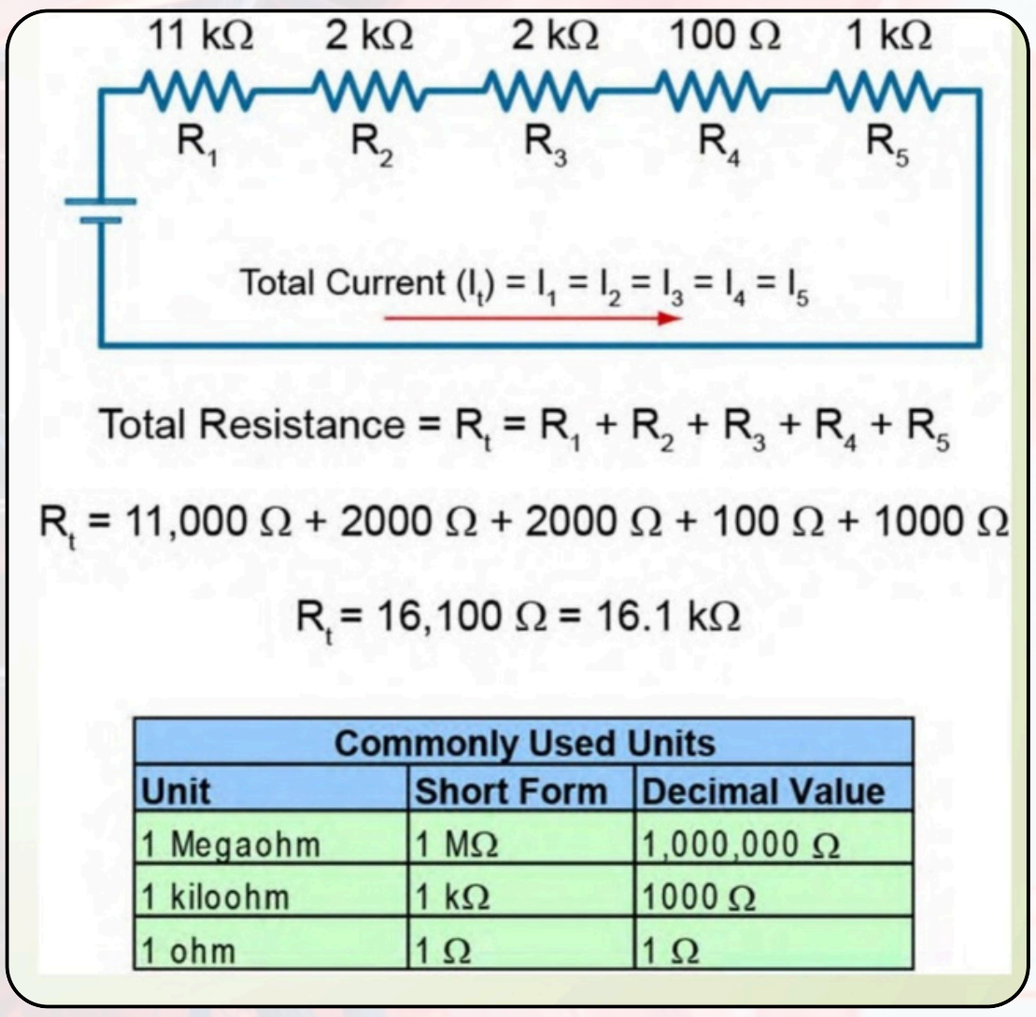
$$I = \frac{E}{R} = \frac{10\ V}{5\ \Omega} = 2\ A$$

$$R = \frac{E}{I} = \frac{10\ V}{2\ A} = 5\ \Omega$$

$$E = I \times R = 2\ A \times 5\ \Omega = 10\ V$$

Series Circuit Resistance

- **A series circuit is formed when any number of resistors are connected end-to-end so that there is only one path for current to flow.**



Total Resistance = $R_t = R_1 + R_2 + R_3 + R_4 + R_5$

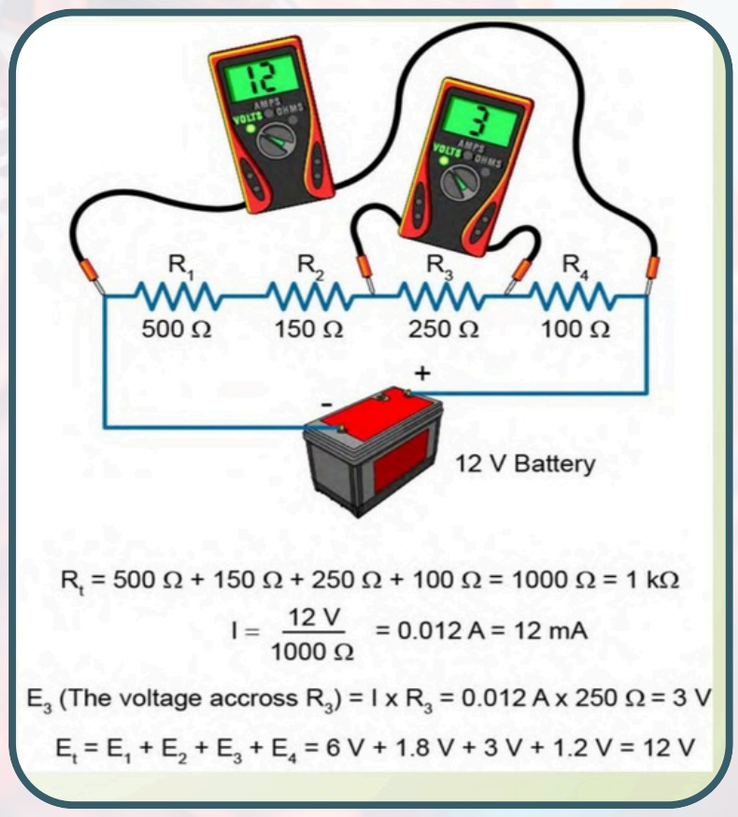
$R_t = 11{,}000\ \Omega + 2000\ \Omega + 2000\ \Omega + 100\ \Omega + 1000\ \Omega$

$R_t = 16{,}100\ \Omega = 16.1\ k\Omega$

Commonly Used Units		
Unit	Short Form	Decimal Value
1 Megaohm	1 MΩ	1,000,000 Ω
1 kiloohm	1 kΩ	1000 Ω
1 ohm	1 Ω	1 Ω

Series Circuit Voltage and Current

- The current in a series circuit can be determined using Ohm's law.
- First, total the resistance, and then divide the source voltage by the total resistance.
- This current flows through each resistor in the circuit.
- The voltage measured across each resistor can be calculated using Ohm's law.
- The voltage across a resistor is often referred to as a voltage drop. The sum of the voltage drops across each resistor is equal to the source voltage.



$R_t = 500\ \Omega + 150\ \Omega + 250\ \Omega + 100\ \Omega = 1000\ \Omega = 1\ k\Omega$

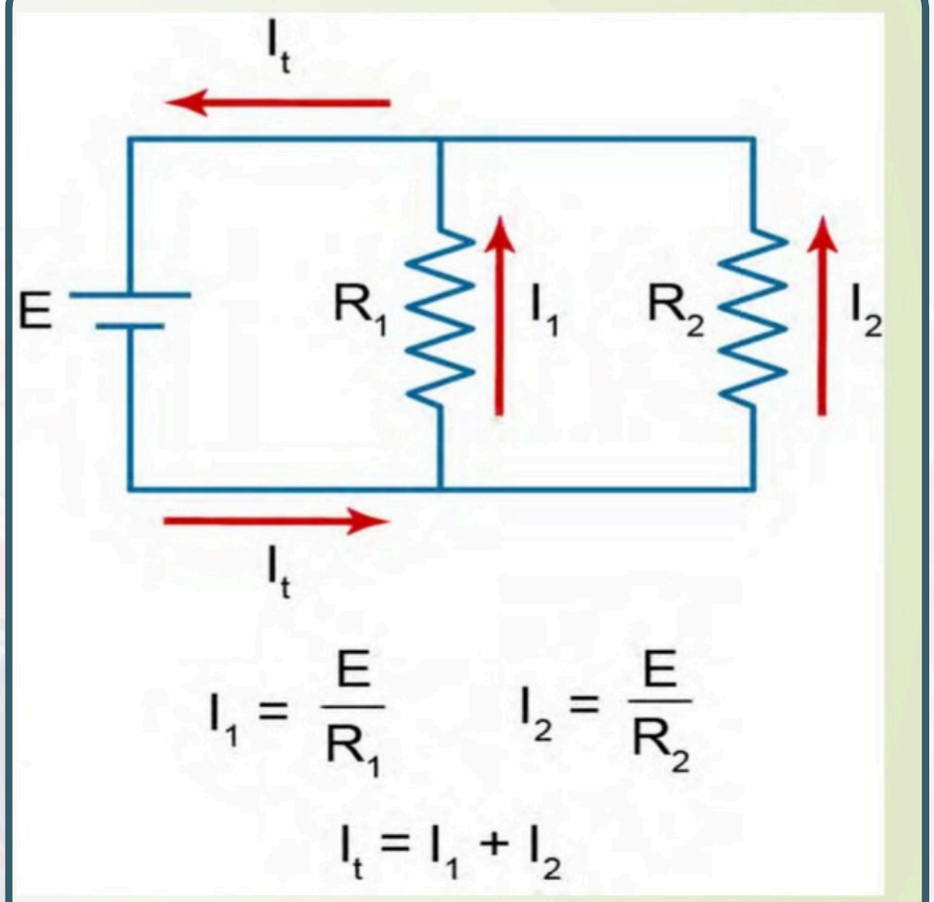
$I = \frac{12\ V}{1000\ \Omega} = 0.012\ A = 12\ mA$

E_3 (The voltage accross R_3) = I x R_3 = 0.012 A x 250 Ω = 3 V

$E_t = E_1 + E_2 + E_3 + E_4 = 6\ V + 1.8\ V + 3\ V + 1.2\ V = 12\ V$

Parallel Circuits

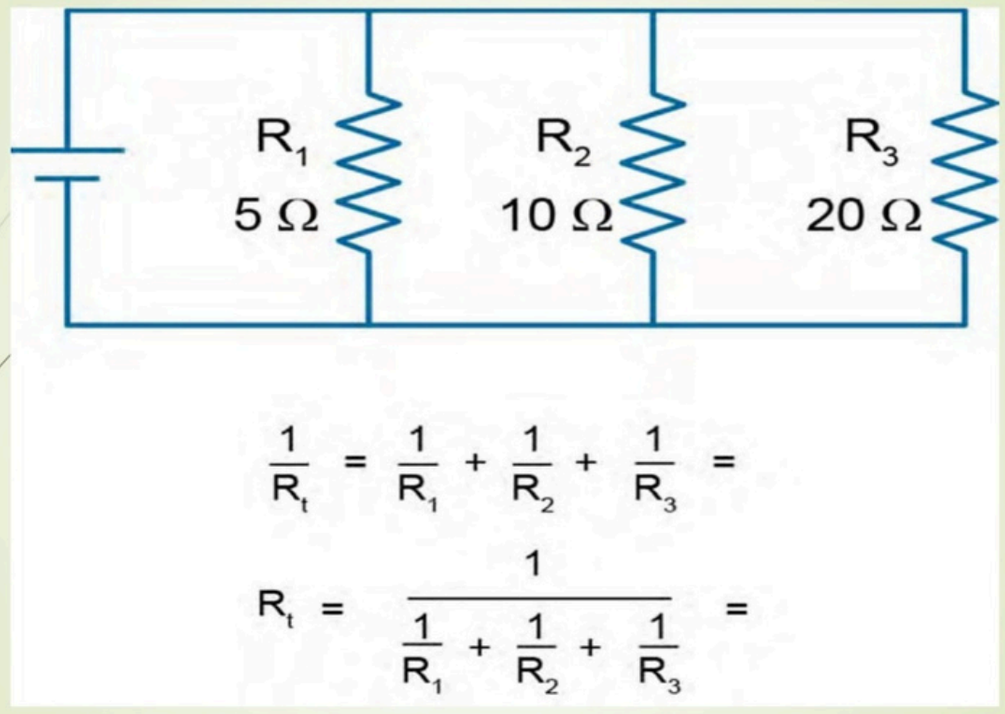
- A parallel circuit is formed when two or more resistances are placed in a circuit side-by-side so that current can flow through more than one path.
- There are two paths of current flow.
- One path is from the negative terminal of the battery through R1 returning to the positive terminal.
- The second path is from the negative terminal of the battery through R2 returning to the positive terminal of the battery.



$$I_1 = \frac{E}{R_1} \qquad I_2 = \frac{E}{R_2}$$

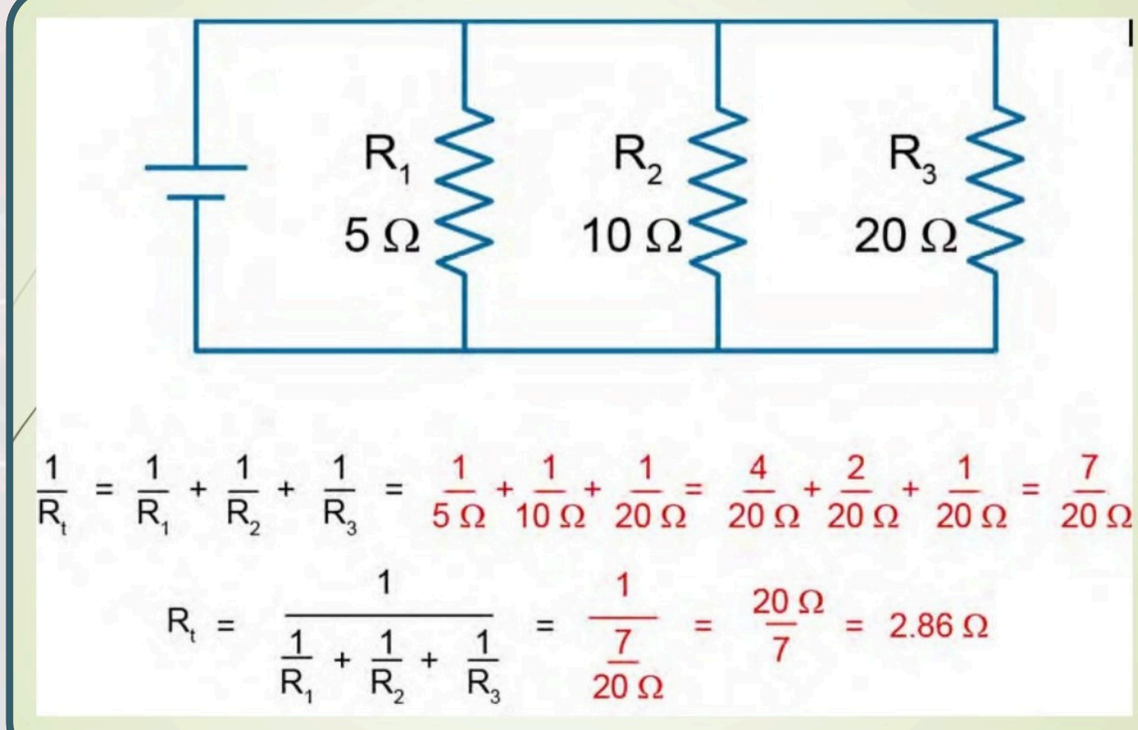
$$I_t = I_1 + I_2$$

Examples



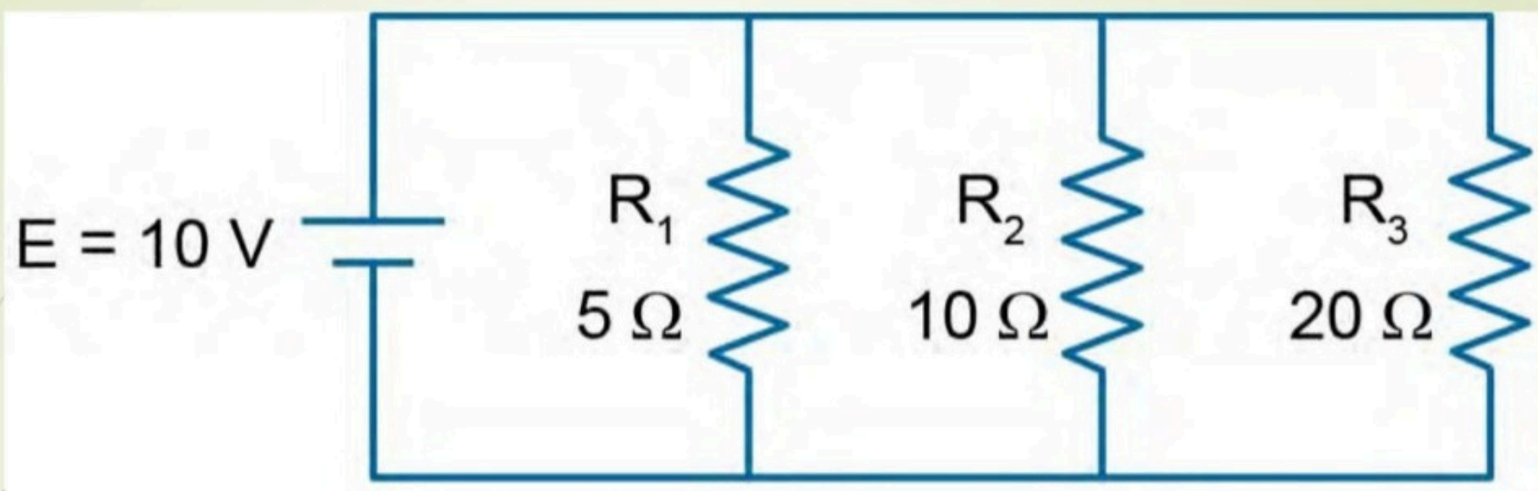
$$\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} =$$

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



$$\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{5\,\Omega} + \frac{1}{10\,\Omega} + \frac{1}{20\,\Omega} = \frac{4}{20\,\Omega} + \frac{2}{20\,\Omega} + \frac{1}{20\,\Omega} = \frac{7}{20\,\Omega}$$

$$R_t = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}} = \frac{1}{\frac{7}{20\,\Omega}} = \frac{20\,\Omega}{7} = 2.86\,\Omega$$



$$I_t = I_1 + I_2 + I_3 = \frac{E}{R_1} + \frac{E}{R_2} + \frac{E}{R_3} = \frac{10\,V}{5\,\Omega} + \frac{10\,V}{10\,\Omega} + \frac{10\,V}{20\,\Omega} = 2\,A + 1\,A + 0.5\,A = 3.5\,A$$

$$I_t = \frac{E}{R_t} = \frac{10\,V}{2.86\,\Omega} = 3.5\,A$$