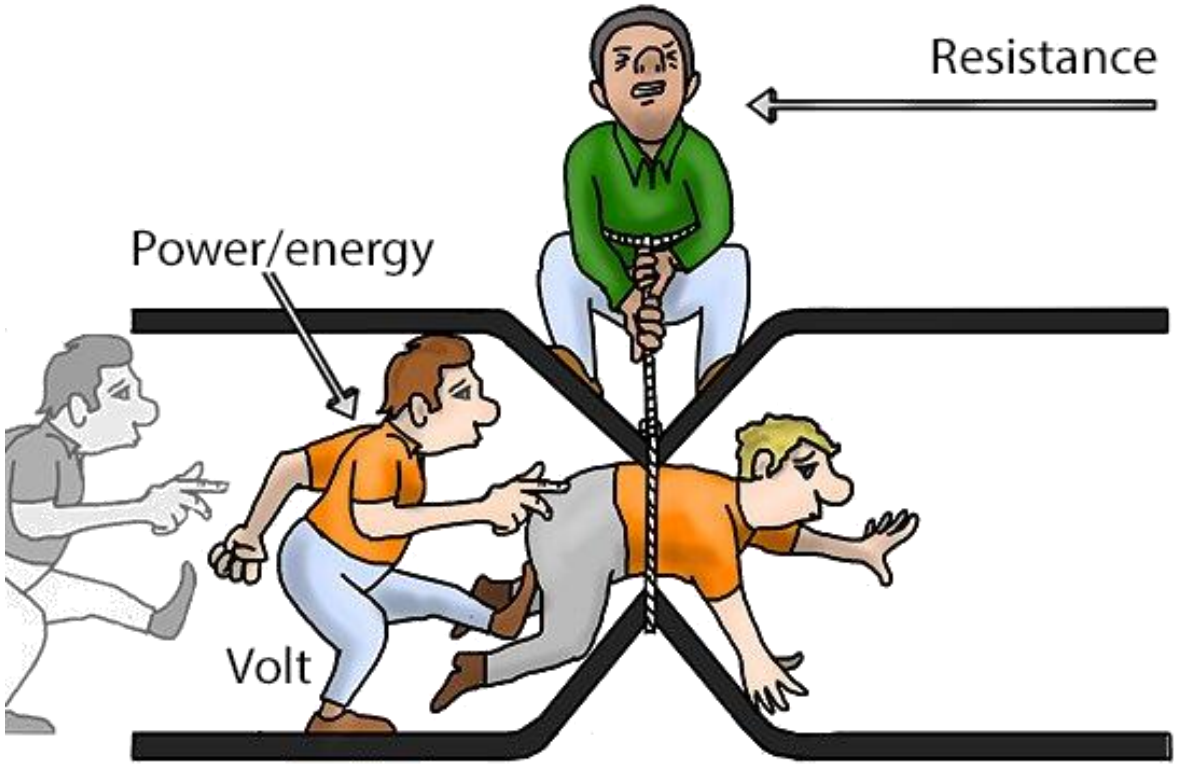
Physics – Grade 10



Unit One

Electricity

Chapter 4 – Resistors

Prepared & Presented by: Mr. Mohamad Seif

OBJECTIVES

1. Define resistor and resistance
2. Direct measurement of resistance

What is resistor?

Resistor is an electrical component that creates resistance in the flow of electric current.

A resistor is designed to transform electric energy to heat energy.

Electric Heater

Electric Stove

Irons

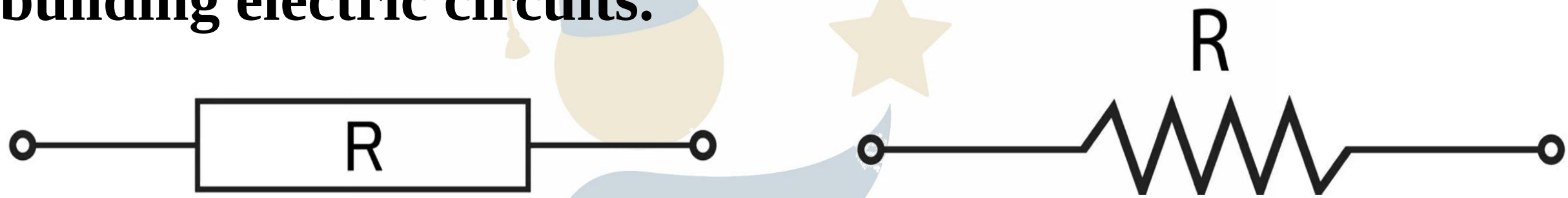
What is resistor?

A resistor is used to protect the electric devices by opposes the electric current (I).

The opposition of the electric current in the resistor leads to the liberation of heat (thermal energy

What is resistor?

The resistor have two symbols can be used in building electric circuits.

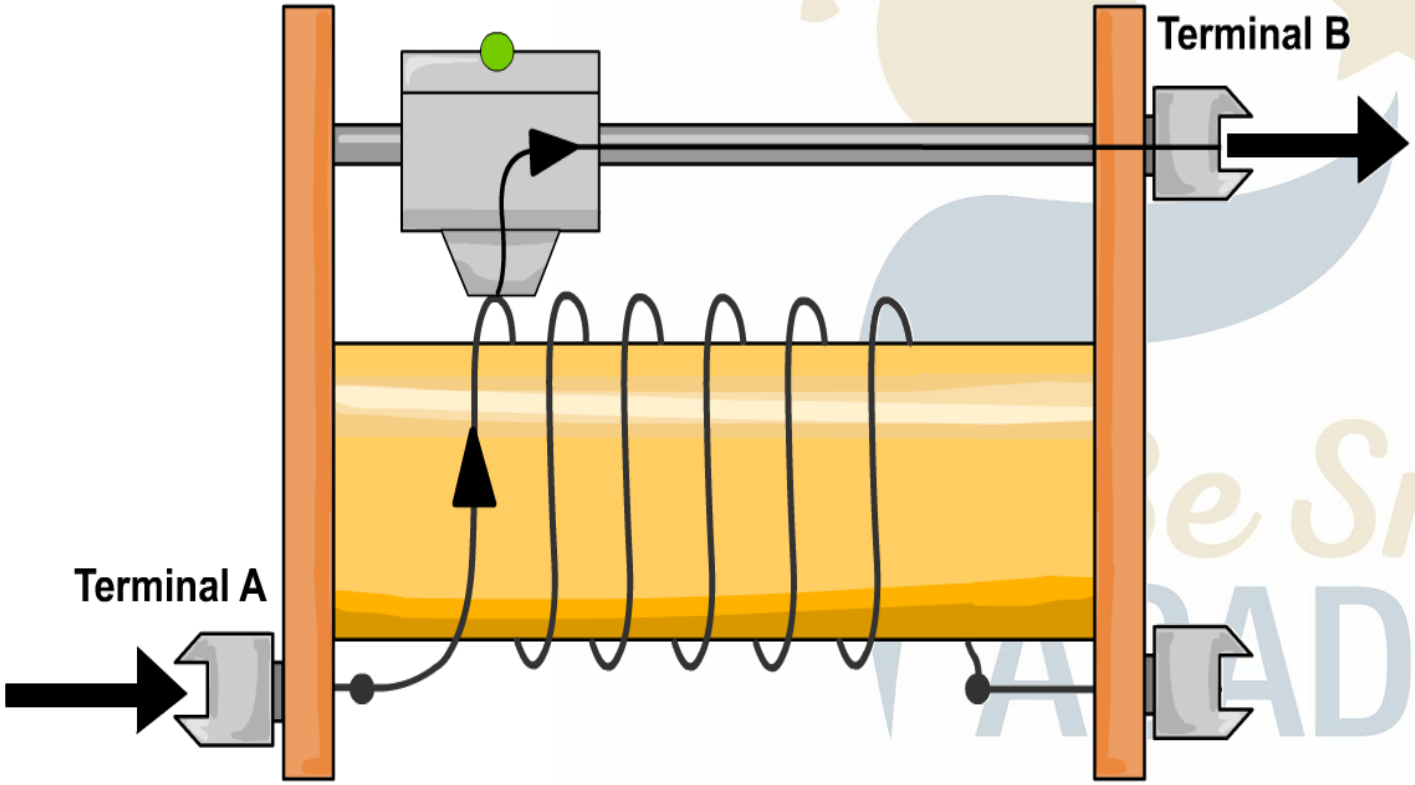


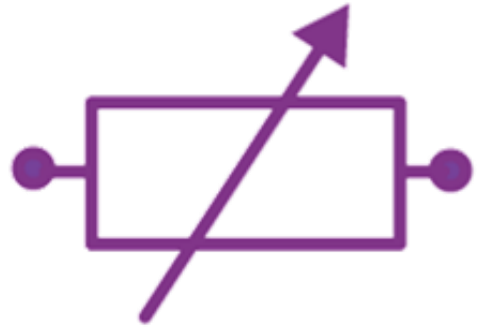
A resistor is characterized by a physical property called the resistance.

The resistance is denoted by R, and it is measured in Ohms [Ω]

What is resistor?

A **rheostat** (R_h) is a resistor of adjustable resistance used to adjust the value of the current or voltage.



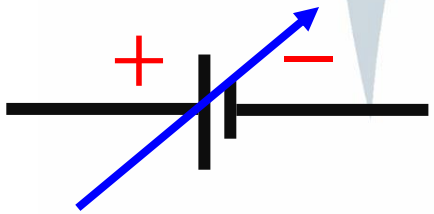


What is resistor?

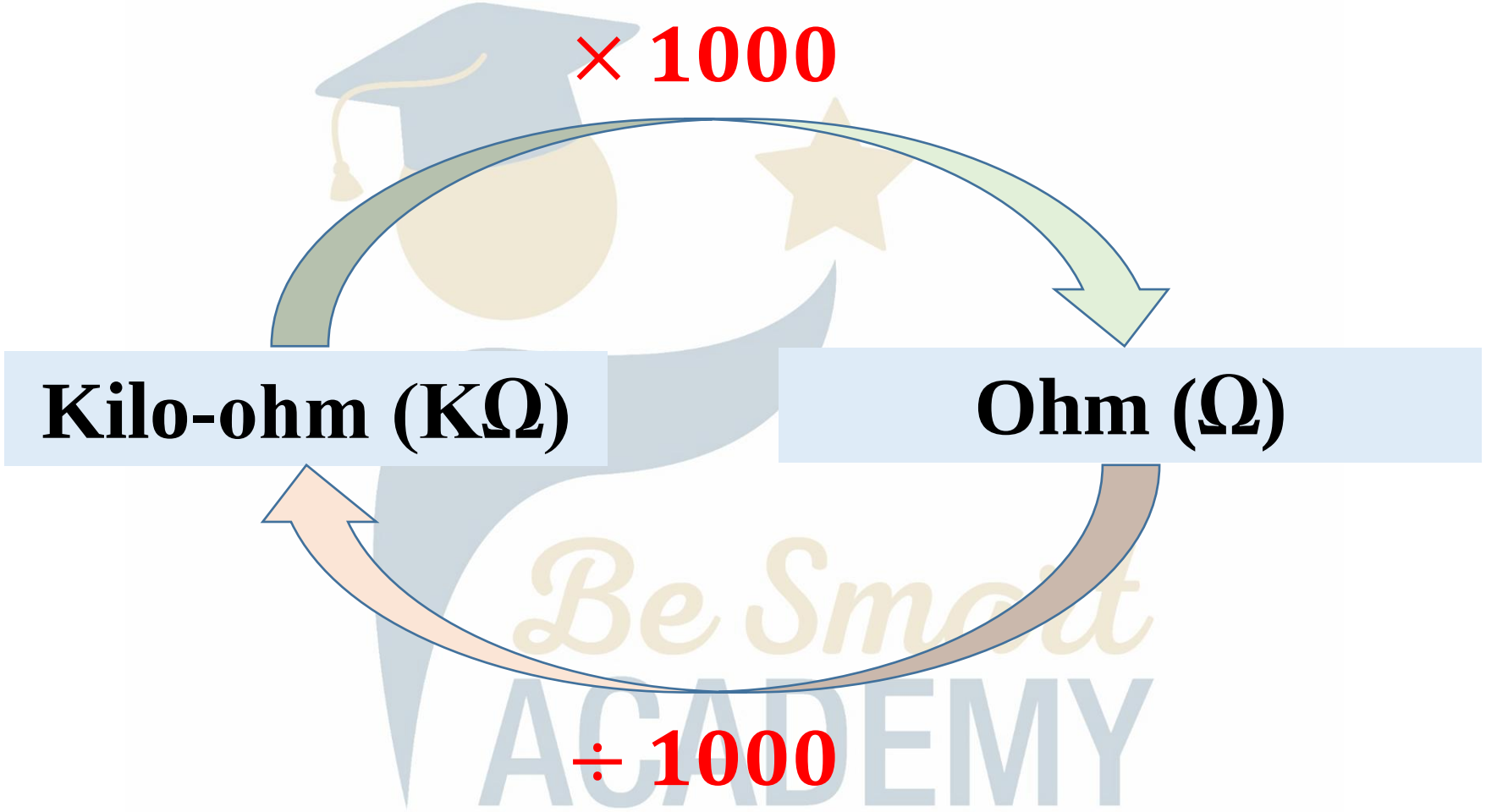
DC power supply:

DC power supply is an adjustable battery whose voltage can be changed between zero to a certain maximum value.

The symbol of DC power supply is:



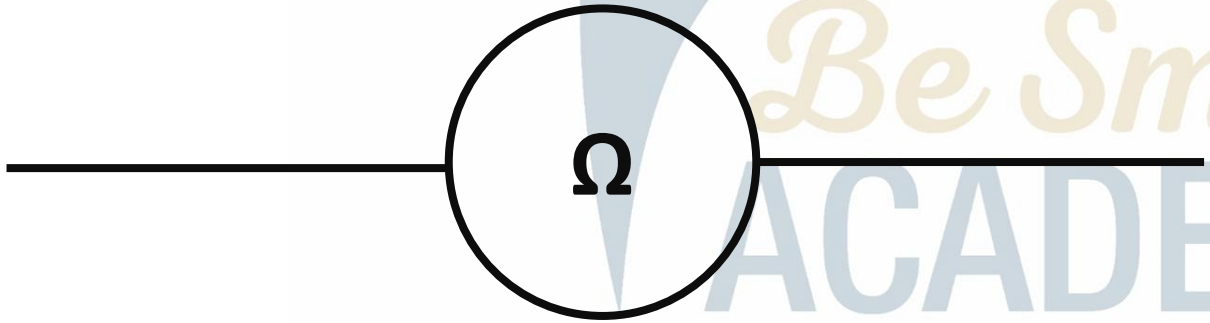
What is resistor?



Direct Measurement of Resistance

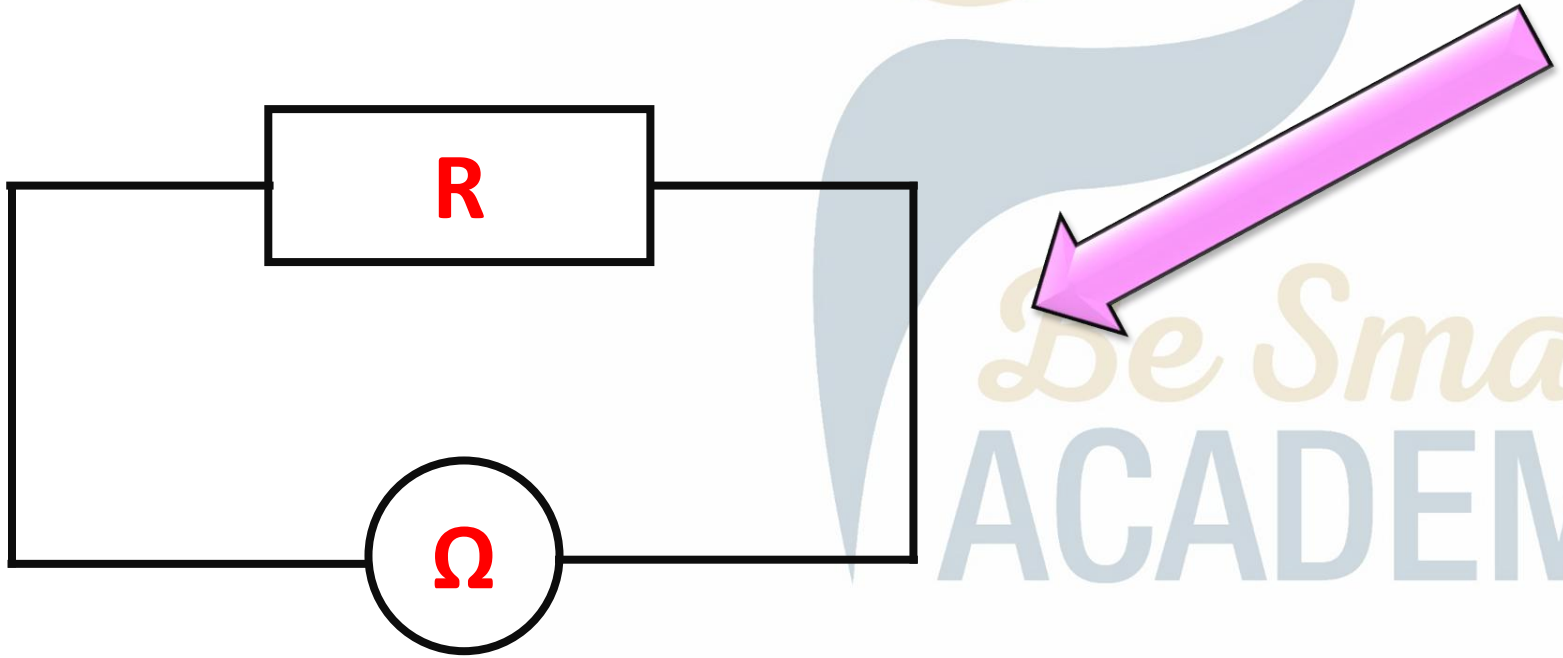
The resistance of a resistor can be directly measured by an instrument called "Ohmmeter", or a multi-meter functioning as ohmmeter

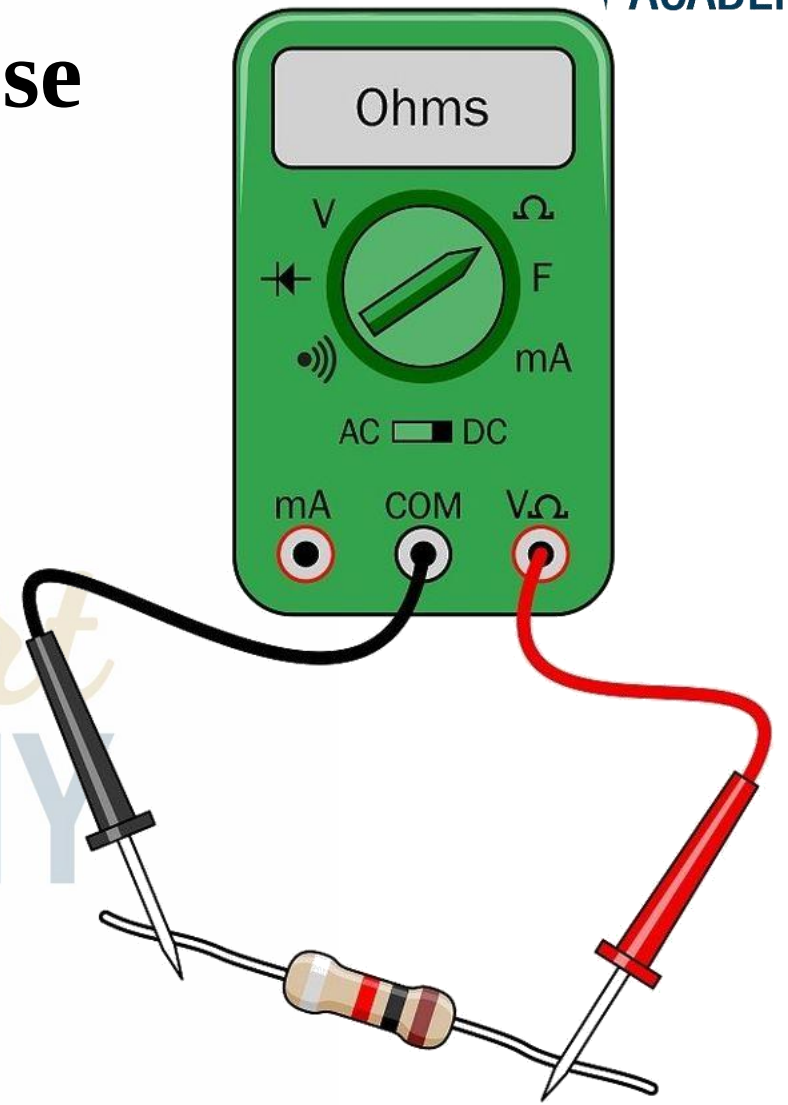
The symbol of ohmmeter:



Direct Measurement of Resistance

The Ohmmeter is connected in parallel across the resistor in any order, because the poles are identical.





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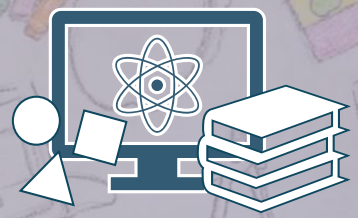
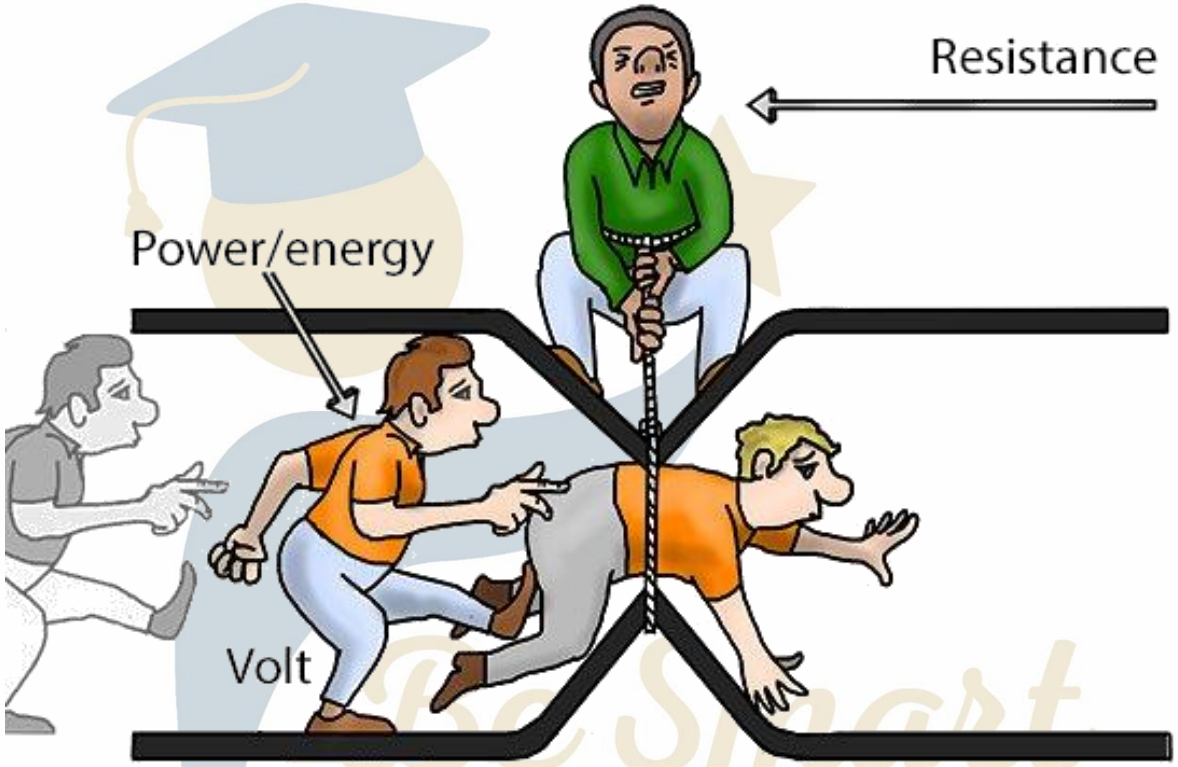


Physics – Grade 10



Unit One

Electricity

Chapter 4 – Resistors

Prepared & Presented by: Mr. Mohamad Seif

OBJECTIVES

3 Apply ohm's law

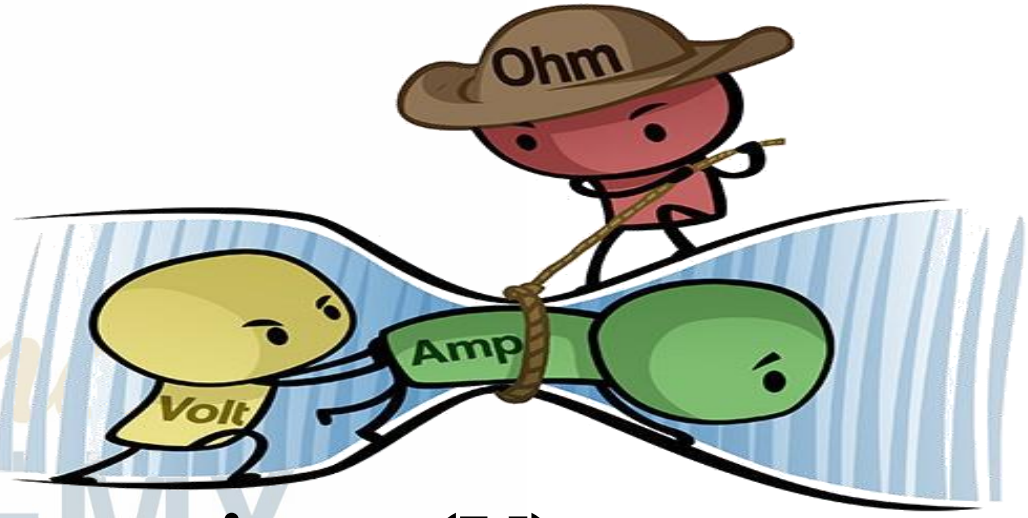
4 To draw the current-voltage characteristic of resistor

Ohm's law

Statement of ohm's law:

The electric current (I) flowing through a resistor is proportional to the voltage (V) applied across its ends.

$$V = R \times I$$



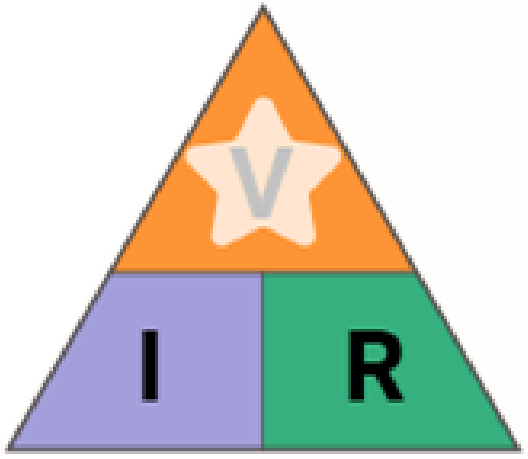
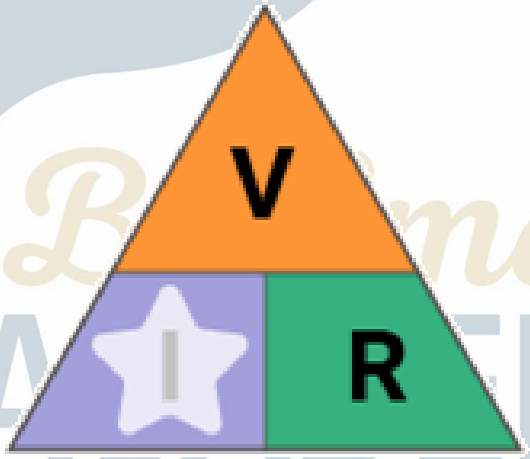
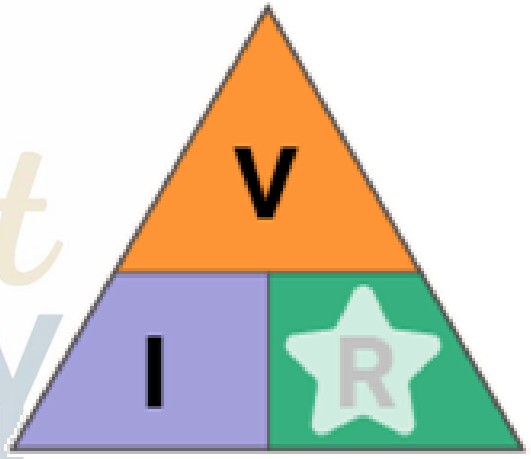
V: Voltage across the terminals of the resistor (V)

I: Current across the terminals of the resistor (A).

R: Resistance of the resistor (Ω)

Ohm’s law

Ohm’s Law Triangle

To Find Voltage	To Find Current	To Find Resistance
		
$V=IR$	$I=\frac{V}{R}$	$R=\frac{V}{I}$

Ohm's law

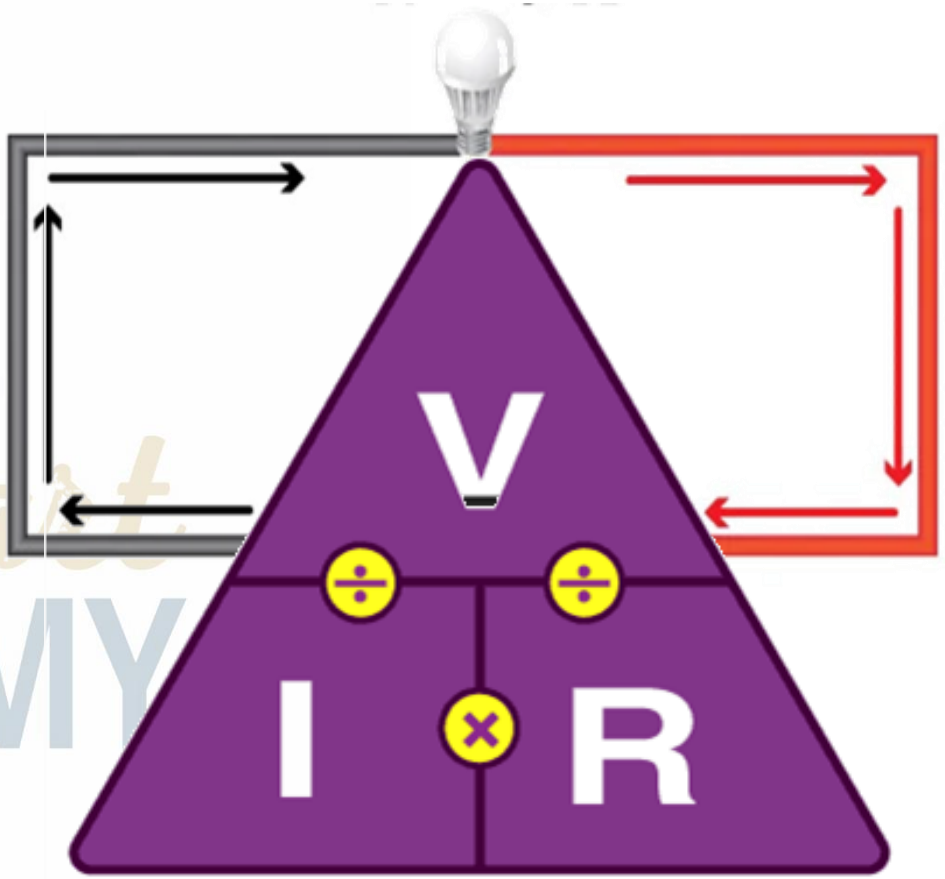
Application 1:

A resistor of resistance $R = 6\Omega$ is connected to a battery delivers a voltage $V = 12V$.

Determine the current in the circuit

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

$$I = \frac{12}{6} = 2A$$



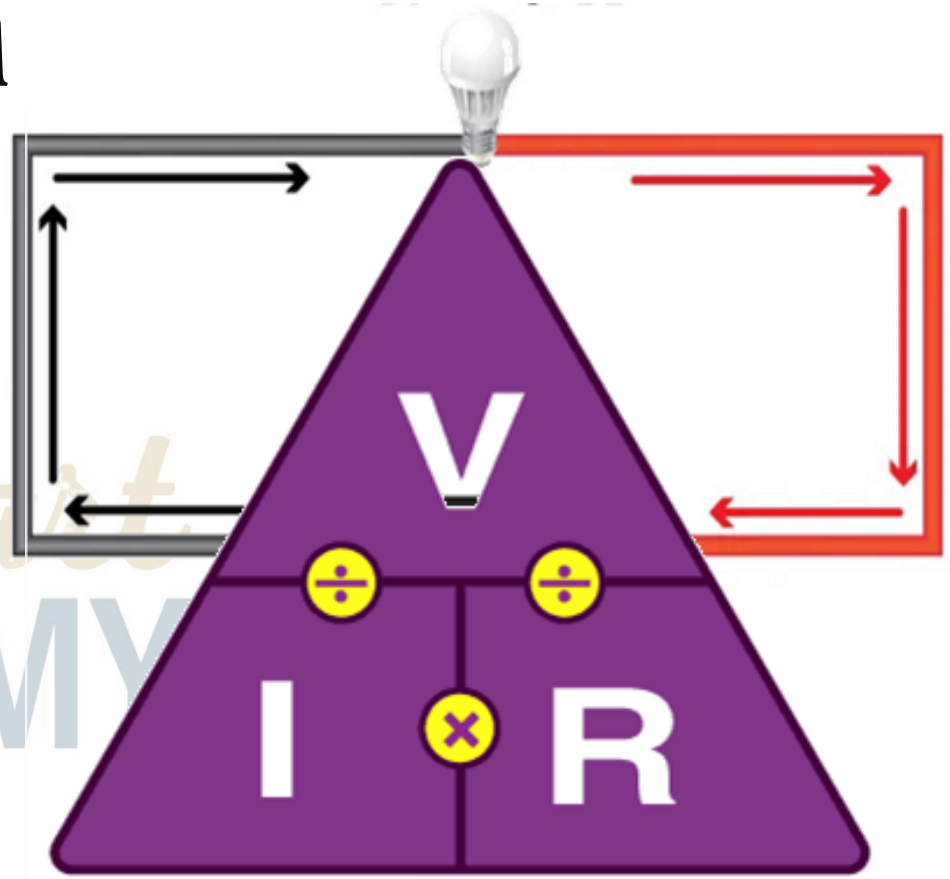
Application 2:

A resistor of resistance R is connected to a battery delivers a voltage $V = 24V$ and a current $I = 6A$

Determine the resistance of the resistor

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

$$R = \frac{24}{6} = 4\Omega$$



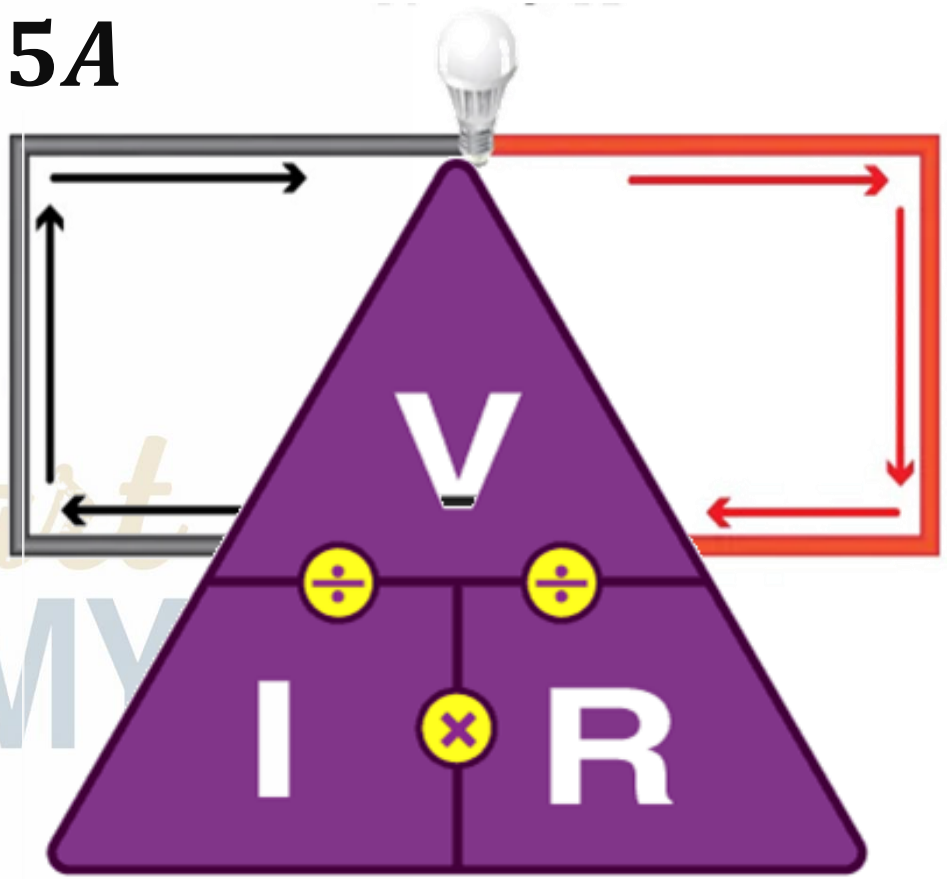
Application 3:

A resistor of resistance $R = 8\Omega$ is connected to a battery delivers a voltage V and a current $I = 5A$

Determine the voltage V in the circuit

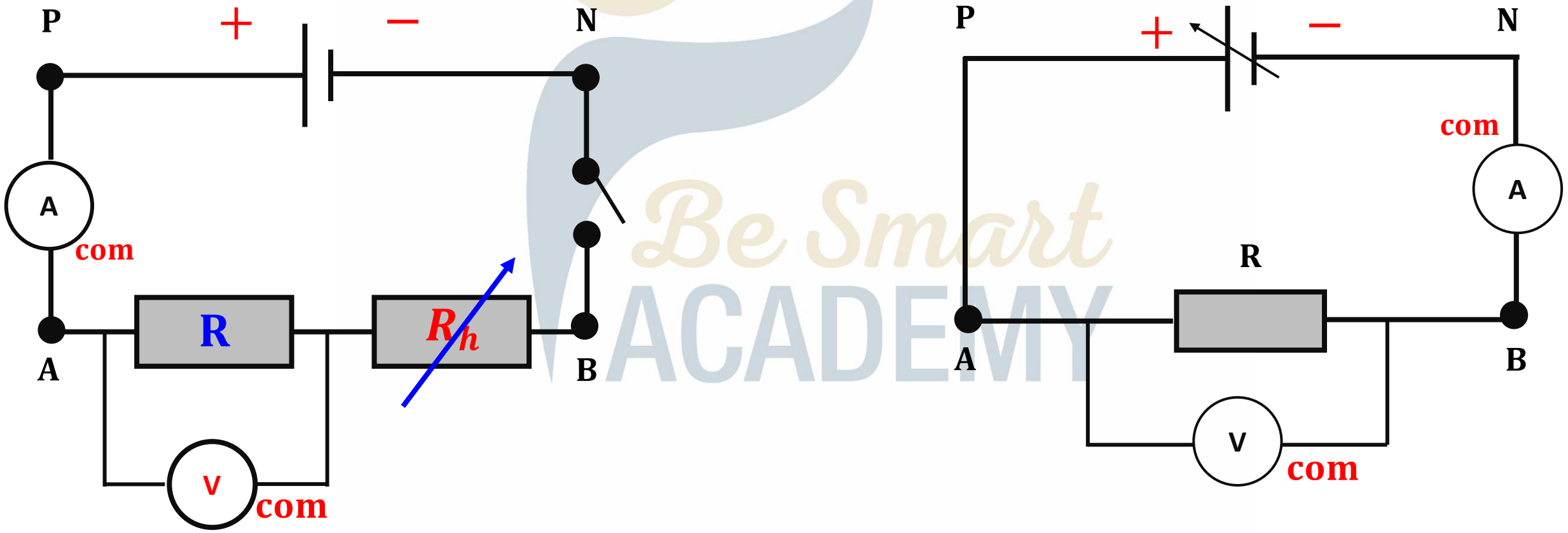
$$V = R \times I$$

$$V = 8 \times 5 = 40V$$



Verify Ohm's law experimentally

One of these circuits allows us to draw the characteristic current-voltage of the resistor in order to verify Ohm's law

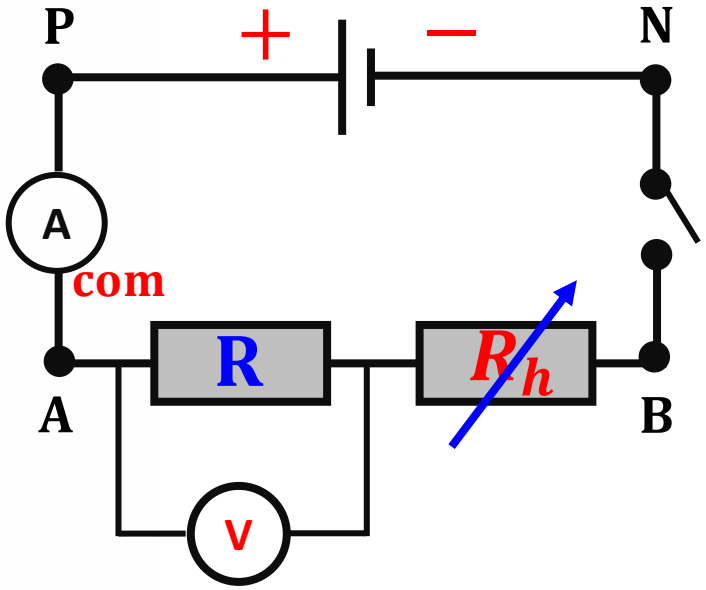


Verify Ohm's law experimentally

When the switch is opened, the voltmeter and the ammeter indicate zero.

After closing the switch:

- **Adjust the cursor of the rheostat at a resistance zero, the ammeter and the voltmeter reads zero.**

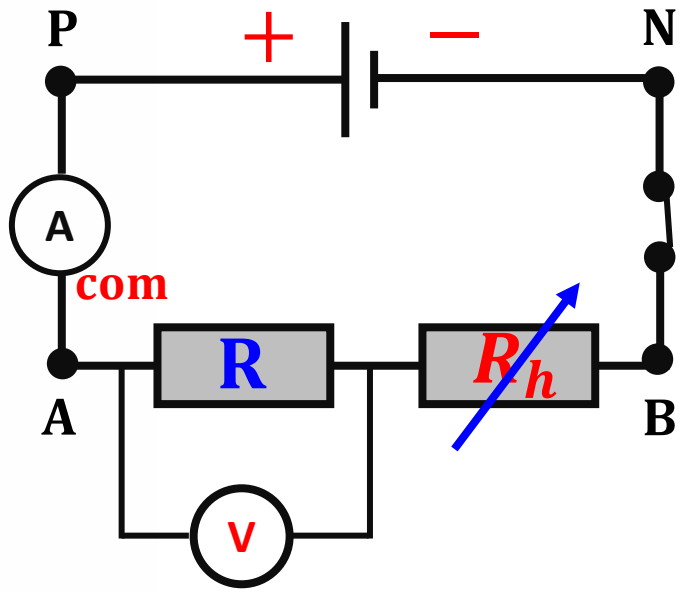


- **Increase the resistance of the rheostat to a certain value and record the new values of I and V.**
- **Repeat this step few times.**

Verify Ohm's law experimentally

The values of the current and the voltage are recorded in the following table

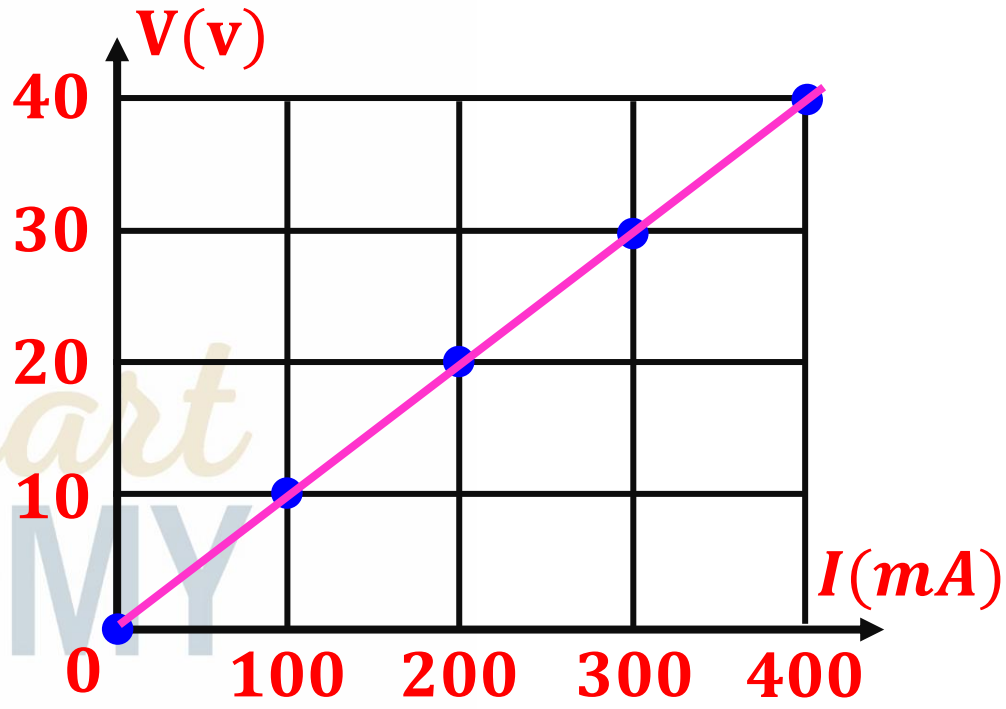
I(mA)	0	100	200	300	400
V(v)	0	10	20	30	40



Verify Ohm's law experimentally

I(mA)	0	100	200	300	400
V(v)	0	10	20	30	40

- This graph is called the characteristics current-voltage of the resistor.
- The curve is a straight line passing through the origin.



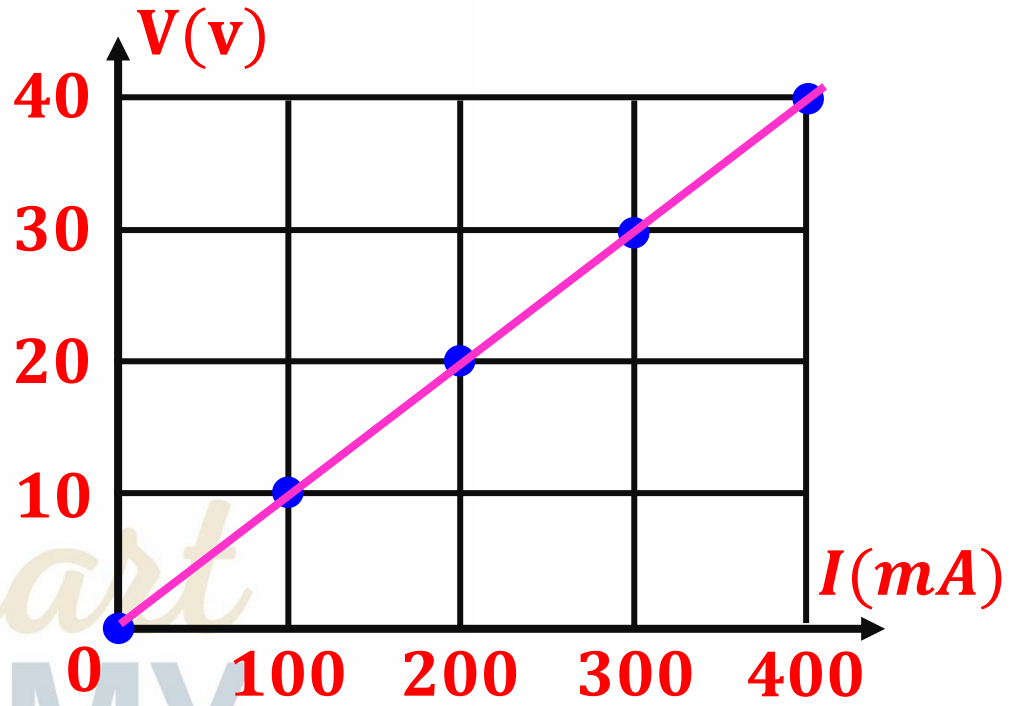
Verify Ohm's law experimentally

The resistance (R) of the resistor is equal to the slope of the straight line:

$$\text{slope} = R = \frac{U_2 - U_1}{I_2 - I_1}$$

$$\text{slope} = R = \frac{40 - 0}{(400 - 0) \times 10^{-3}}$$

$$\text{slope} = R = 100\Omega$$



Verify Ohm's law experimentally

Application 4:

A resistor of resistance R is connected across a DC power supply. We connect a voltmeter and an Ammeter to measure the voltage and the current.

The table below shows the voltage V and the current I across the resistor.

V(v)	0	1	2	3	4
I(mA)	0	2	4	6	8

Verify Ohm's law experimentally

1. Draw a schematic diagram of the circuit showing all components
2. Plot on the graph paper the characteristic current – voltage using the scale:

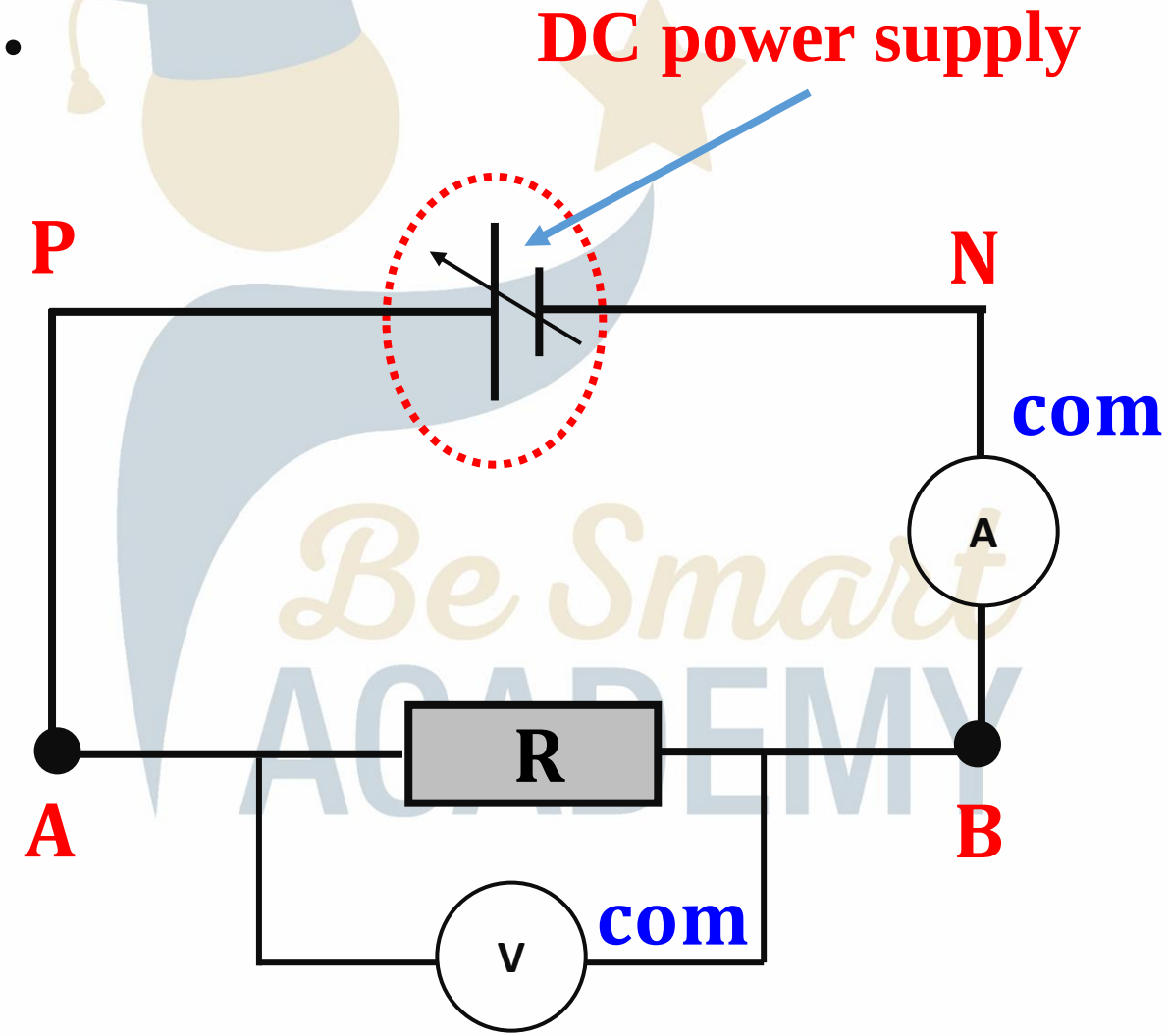
$$x - axis: 1cm \rightarrow 2mA$$

$$y - axis: 1cm \rightarrow 1V$$

3. Does the graph verify ohm's law? Justify.
4. Find graphically, the current when the voltage $V = 3.5V$.
5. Calculate R the resistance of the resistor.

Verify Ohm's law experimentally

1. Draw a schematic diagram of the circuit showing all components.

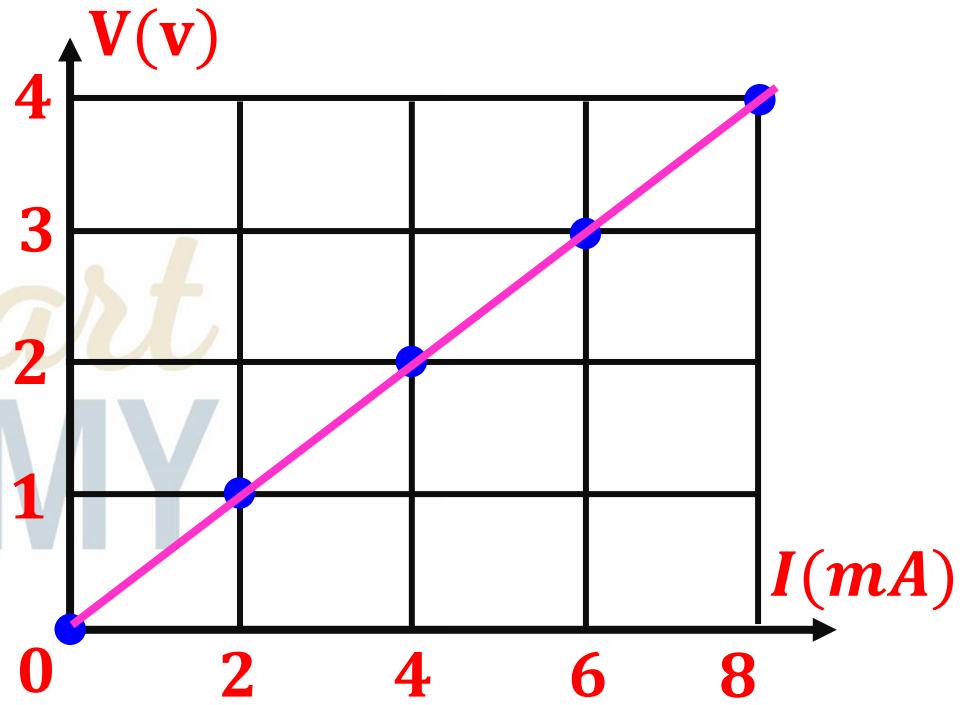


Verify Ohm's law experimentally

2. Plot on the graph paper the characteristic current – voltage using the scale: $x-axis: 1cm \rightarrow 2mA$

$y-axis: 1cm \rightarrow 1V$

V(v)	0	1	2	3	4
I(mA)	0	2	4	6	8



Verify Ohm's law experimentally

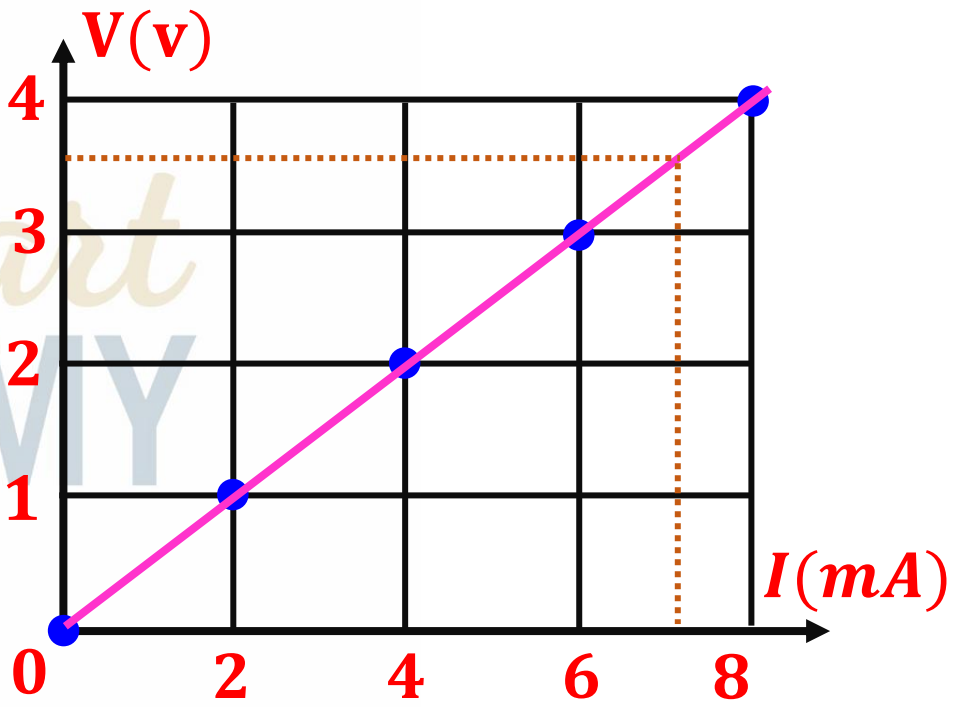
3. Does the graph verify ohm's law? Justify

Ohm's law was verified, because the graph is St. line passing through origin.

4. Find graphically, the current when the voltage $U = 3.5V$.

From the graph:

For the voltage $V = 3.5V$; the current $I = 7mA$



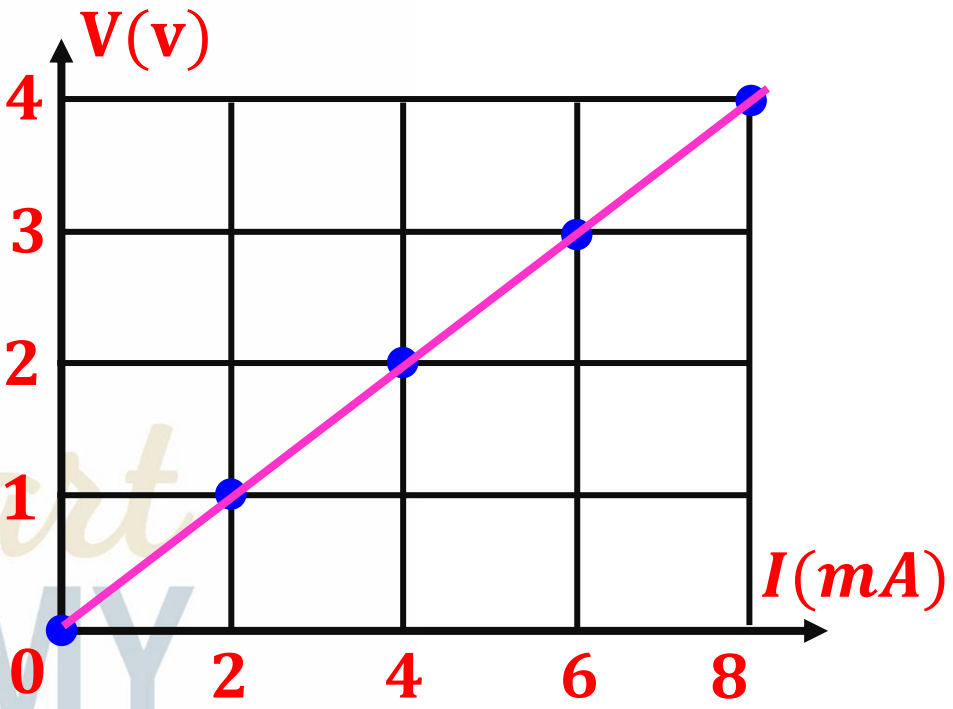
Verify Ohm's law experimentally

5. Calculate R the resistance of the resistor.

$$\text{slope} = \text{R} = \frac{V_2 - V_1}{\text{I}_2 - \text{I}_1}$$

$$\text{slope} = \text{R} = \frac{3V - 2V}{(6 - 4) \div 1000}$$

$$R = 500\Omega$$



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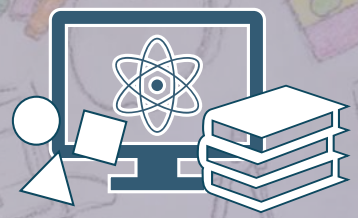
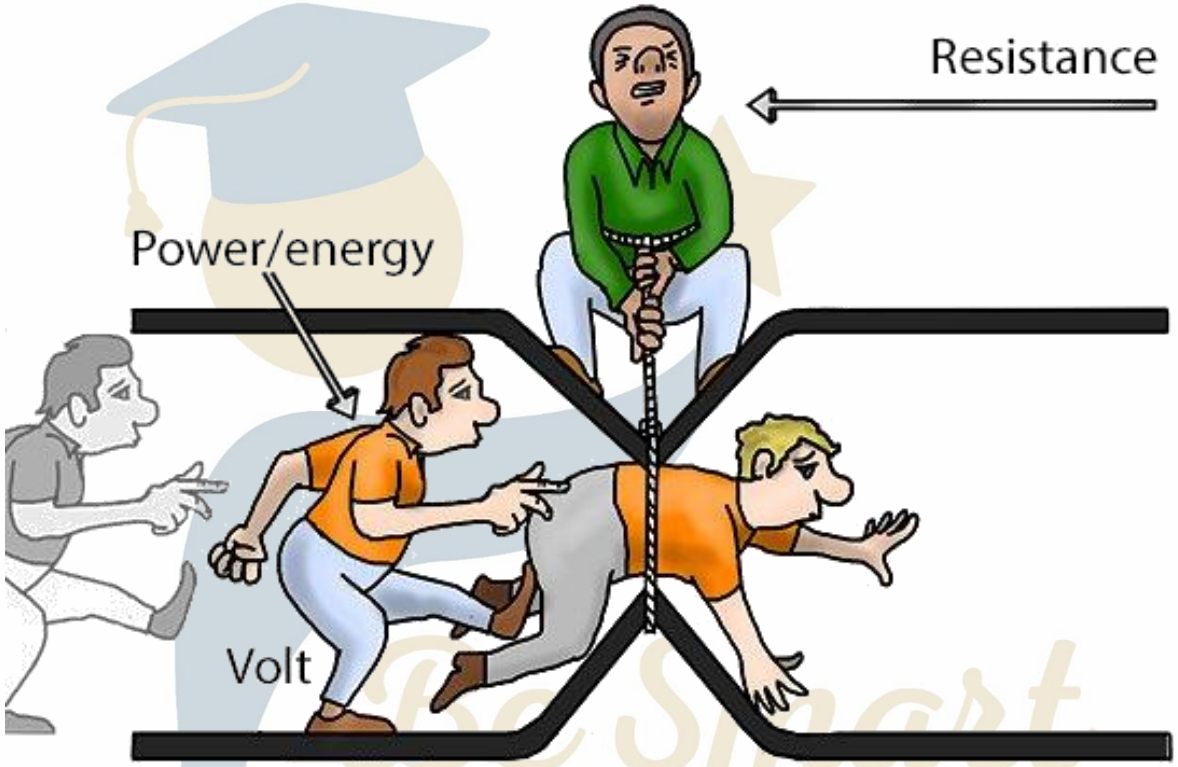


Physics – Grade 10



Unit One

Electricity

Chapter 4 – Resistors

Prepared & Presented by: Mr. Mohamad Seif

OBJECTIVES

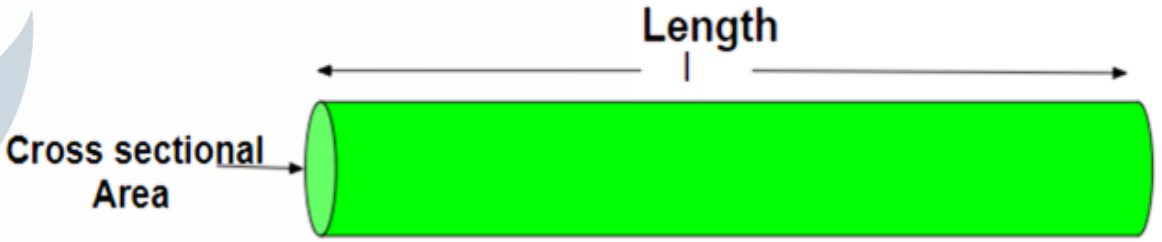
1. Determine resistance of a wire resistor
2. Determine the resistance of color-coding resistor

Resistance of a wire resistor

The resistance of a homogenous and cylindrical wire resistor depends on three factors: its length, cross sectional area and the nature of substance.

The expression of resistance is:

$$R = \frac{\rho \times L}{S}$$



R: resistance of the wire resistor in ohm [Ω]

ρ: resistivity of the substance in [Ω.m]

L: is the length of the wire in [m]

$S = \pi r^2$: cross-sectional area in [m^2], where r is the radius.

Resistance of a wire resistor

Application 5:

A cylindrical copper conductor has a diameter $D = 10cm$ and a length $L = 10Km$.

The resistivity of copper is $1.6 \times 10^{-8}\Omega.m$.

1) Determine the resistance of the copper wire.
2) Determine the resistance of the wire if its radius doubled.

Resistance of a wire resistor

$D = 10cm; L = 10Km; \rho = 1.6 \times 10^{-8} \Omega.m.$

1)Determine the resistance of the copper wire.

The area of the wire is $S = \pi r^2$

$$S = \pi \left[\frac{D}{2}\right]^2 \Rightarrow S = 3.14 \left[\frac{(10 \div 100)}{2}\right]^2 \Rightarrow S = 0.00785 m^2$$

$$R = \frac{\rho \times L}{S} = \frac{1.6 \times 10^{-8} \times (10 \times 1000)}{0.00785}$$

$$R = 0.02\Omega$$

Resistance of a wire resistor

$D = 10cm; L = 10Km; \rho = 1.6 \times 10^{-8} \Omega.m.$

2) Determine the resistance of the wire if its radius is doubled.

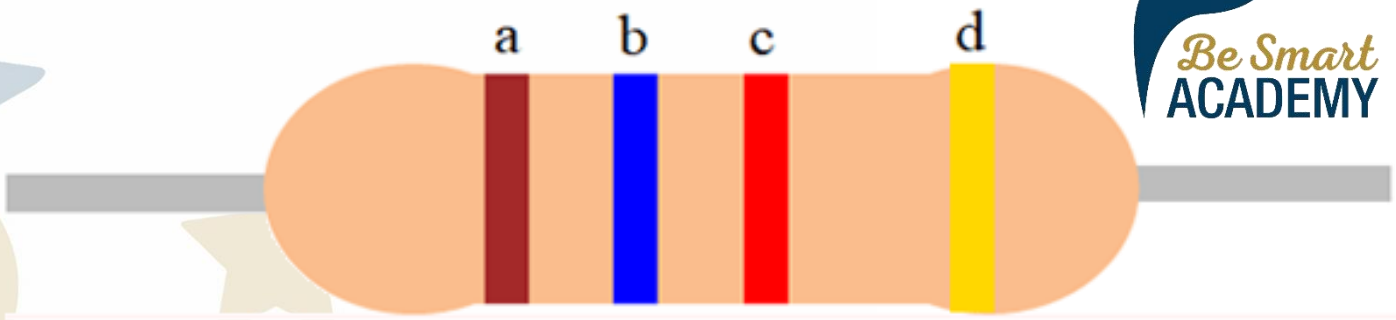
$r' = 2r \Rightarrow S' = \pi(r')^2 \Rightarrow S' = \pi(2r)^2 \Rightarrow S' = 4\pi r^2$

$R' = \frac{\rho \times L}{S'} \Rightarrow R' = \frac{\rho \times L}{4\pi r^2} \quad R' = \frac{R}{4} = \frac{0.02}{4}$

$R' = 0.005\Omega$

Color Coding Resistor

Color Coding Resistor is used in electronic circuits (radios, televisions, computers, ...).



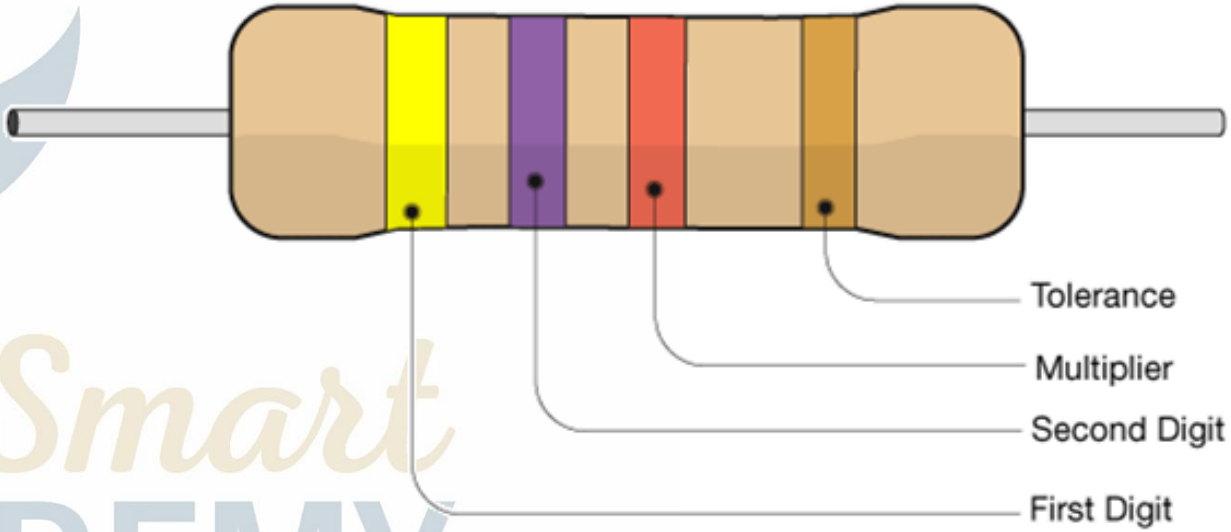
They are made of a thin layer of carbon powder covering an insulating rod.

The resistance of a Color-Coding Resistor is indicated according to **international code**

Color Coding Resistor

The Figure below, shows how to read color stripes on carbon resistors for R in ohms.

1st digit	2nd digit	Multiplier	Tolerance
0	0	x 1	
1	1	x 10	±1%
2	2	x 100	±2%
3	3	x 1K	
4	4	X 10K	
5	5	x 100K	
6	6	x 1M	
7	7		
8	8	x 0.1	±5%
9	9	x 0.01	±10%

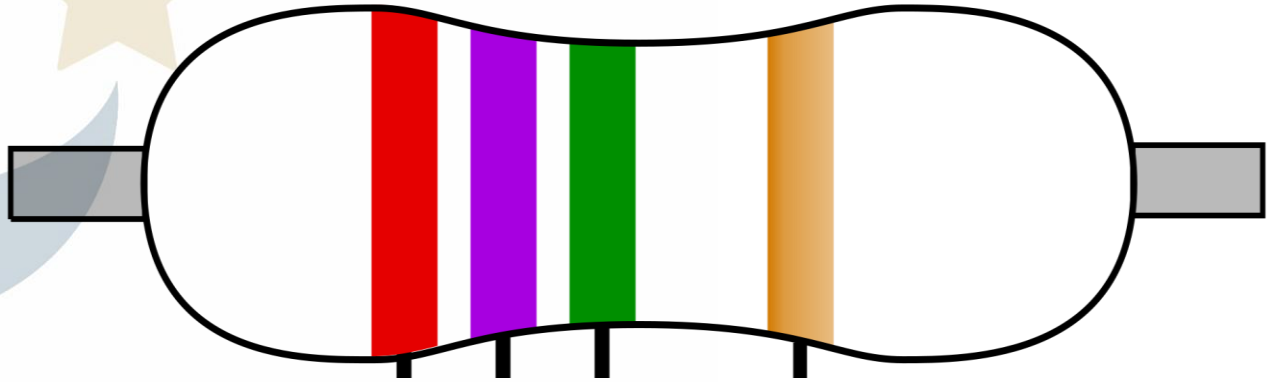


Color Coding Resistor

Application 6:

Calculate the resistance of the following color code resistor.

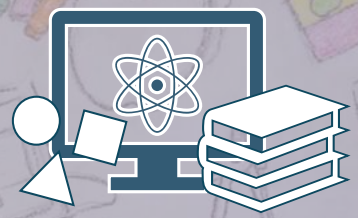
1st digit	2nd digit	Multiplier	Tolerance
0	0	x 1	
1	1	x 10	±1%
2	2	x 100	±2%
3	3	x 1K	
4	4	X 10K	
5	5	x 100K	
6	6	x 1M	
7	7		
8	8	x 0.1	±5%
9	9	x 0.01	±10%



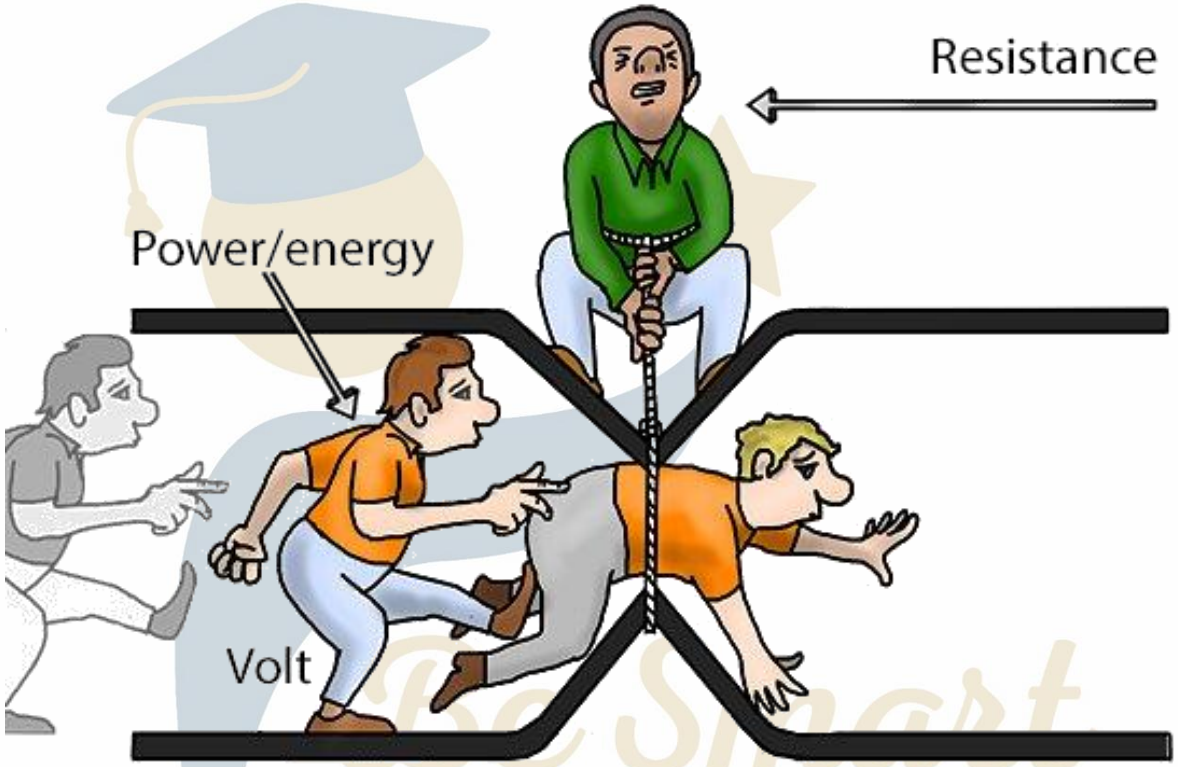
$$R = 27 \times 100k\Omega \mp 5\%$$

$$R = 27 \times 10^5\Omega \mp 5\%$$

The End



Physics – Grade 10



Unit One

Electricity

Chapter 4 – Resistors

Prepared & Presented by: Mr. Mohamad Seif

OBJECTIVES

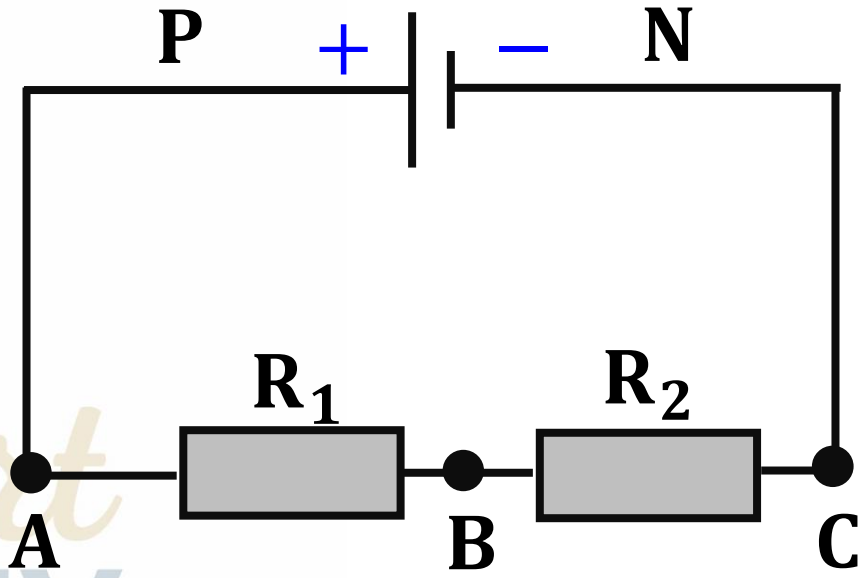
3 Grouping of resistors in series

4 Grouping of resistors in parallel

Grouping of resistors/ Grouping in Series

When many resistors are connected in series, the resistance of their equivalent resistor is:

$$R_{eq} = R_1 + R_2 + \cdots$$



$$V_{PN} = V_{AB} + V_{BC}$$

$$I = I_1 = I_2$$

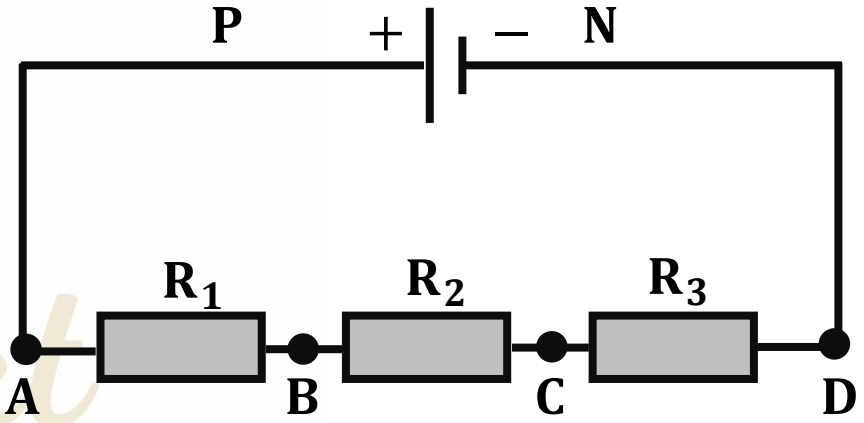
$$V = R \times I$$

Grouping of resistors/ Grouping in Series

Application 6:

Consider three resistors $R_1 = 10\Omega$, $R_2 = 6\Omega$ and $R_3 = 4\Omega$ connected in series as shown in the figure.

1. Calculate the equivalent resistance.

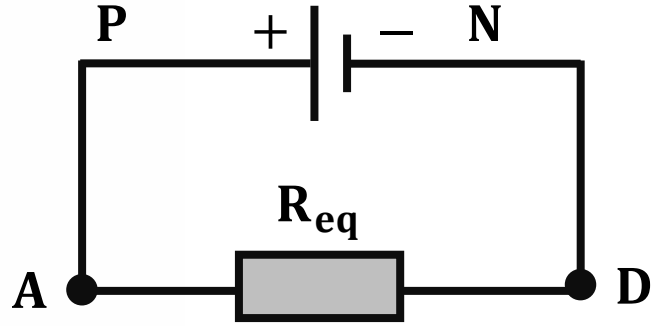


R_1, R_2 and R_3 are connected in series:

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

$$R_{eq} = 10\Omega + 6\Omega + 4\Omega$$

$$R_{eq} = 20\Omega$$



Grouping of resistors/ Grouping in Series

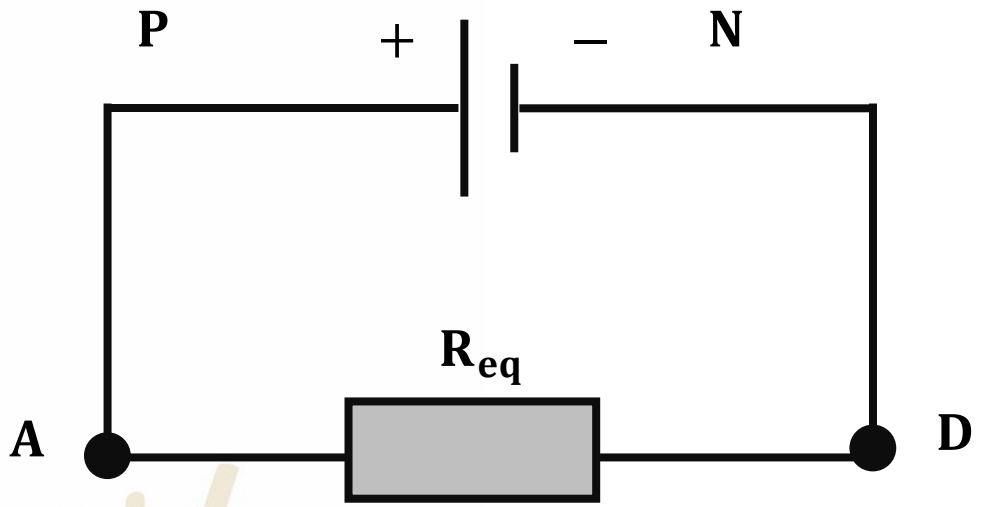
2. Calculate the main current knowing that $V_{PN} = 12V$.

Using ohm's law:

$$V_{PN} = R_{eq} \times I$$

$$I = \frac{V_{PN}}{R_{eq}} = \frac{12V}{20\Omega}$$

$$I = 0.6A$$

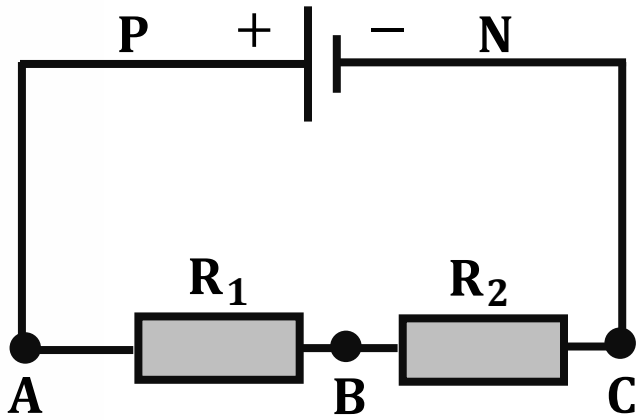


Grouping of resistors/ Grouping in Series

Application 7:

Consider an electric circuit contains: A dry cell of constant voltage $V_{PN} = 12V$ and of main current I.

Two resistors; $R_1 = 10\Omega$ and the voltage across it is $V_1 = 8.8V$ and R_2 as shown in the figure.

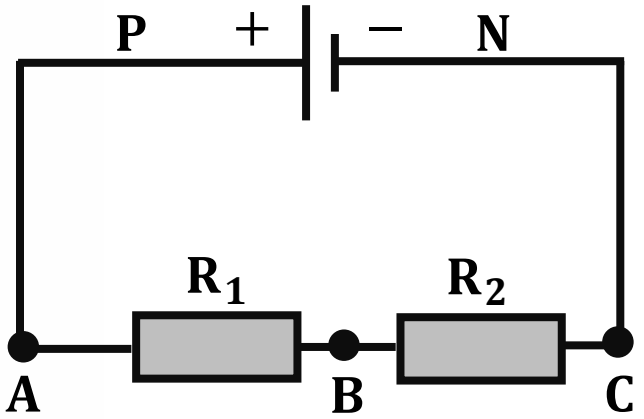


1. Determine the current I sent by dry cell.
2. Calculate the voltage V_2 across the resistor R_2.
3. Deduce the resistance of R_2.
4. Calculate the equivalent resistance R_{eq}.

Grouping of resistors/ Grouping in Series

$V_{PN} = 12V; R_1 = 10\Omega ; V_1 = 8.8V.$

1. Determine the current I sent by dry cell.



R_1 and R_2 are connected in series with the battery then:

$$I = I_1 = I_2$$

But; $V_1 = R_1 \times I_1$ ⇒ $8.8V = 10 \times I_1$

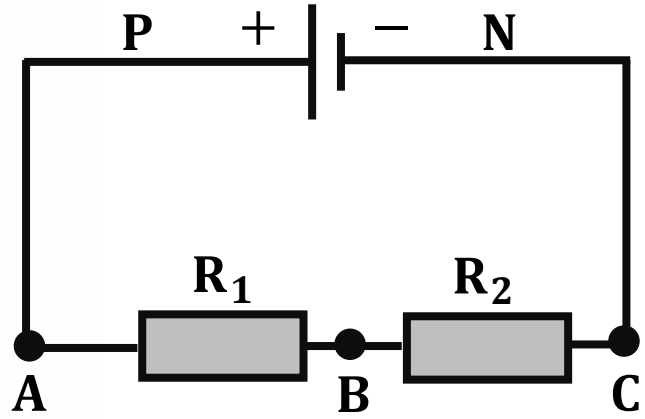
$$I_1 = \frac{8.8}{10} = 0.88A \Rightarrow I = I_1 = I_2 = 0.88A$$

Grouping of resistors/ Grouping in Series

$V_{PN} = 12V; R_1 = 10\Omega ; V_1 = 8.8V.$

2.Calculate the voltage V_2 across the resistor R_2.

R_1 and R_2 are connected in series, then we use law of addition of voltage:



$$V_{PN} = V_{PA} + V_{AB} + V_{BC} + V_{CN}$$

$$12 = 0 + 8.8 + V_2 + 0$$

$$12V - 8.8V = V_2$$

$$V_2 = 3.2V$$

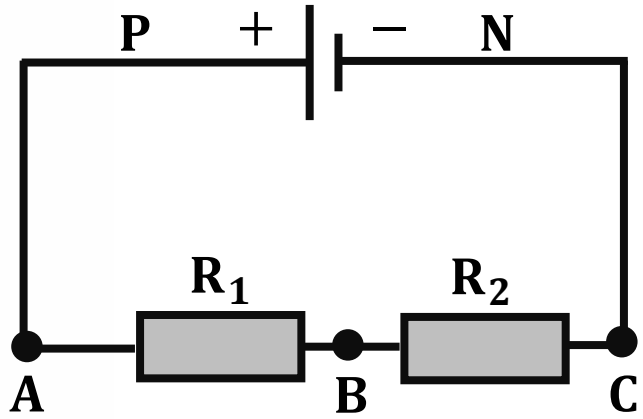
Grouping of resistors/ Grouping in Series

$V_{PN} = 12V; R_1 = 10\Omega ; V_1 = 8.8V.$

3. Deduce the resistance of R_2.

$V_2 = R_2 \times I_2$ ⇨ $3.2V = R_2 \times 0.88A$

$R_2 = \frac{3.2V}{0.88A}$ ⇨ $R_2 = 3.64\Omega$



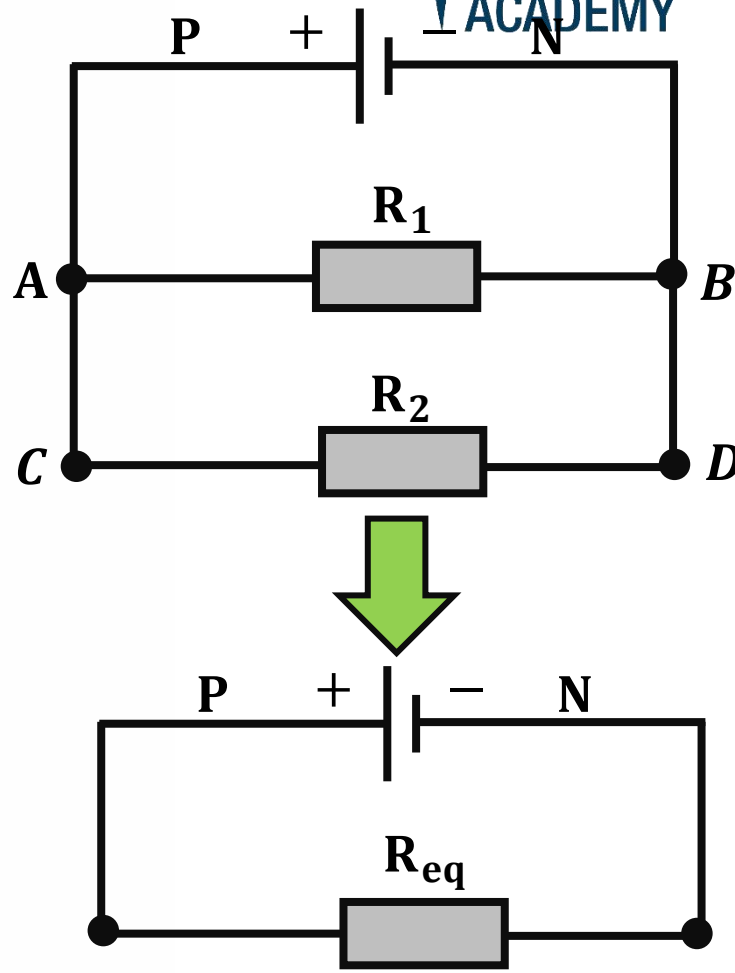
4. Calculate the equivalent resistance R_{eq}.

R_1 and R_2 are connected in series with the battery then:

$R_{eq} = R_1 + R_2$ ⇨ $R_{eq} = 10\Omega + 3.64\Omega$ ⇨ $R_{eq} = 13.64\Omega$

Grouping of resistors/ Grouping in parallel

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots$$



In case of only two resistors in parallel we can also use:

$$R_{eq} = \frac{R_1 \times R_2}{R_1 + R_2}$$

$V_{PN} = V_{AB} = V_{CD}$

$I = I_1 + I_2$

$V = R \times I$

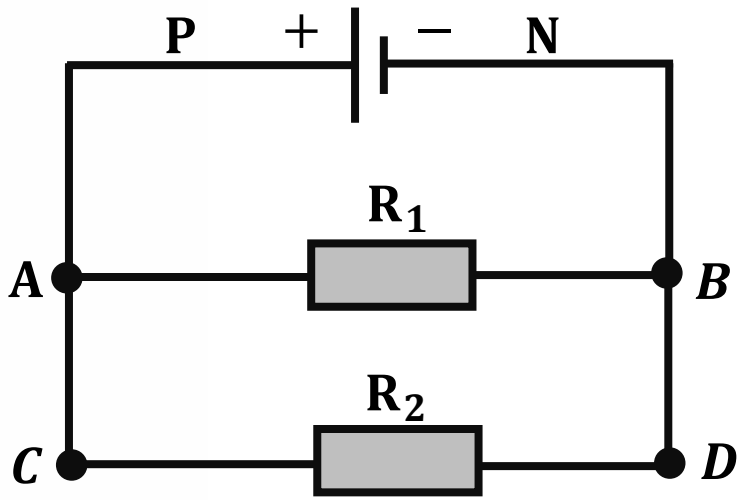
Grouping of resistors/ Grouping in parallel

Application 8:

Consider two resistors $R_1 = 5\Omega$ and $R_2 = 10\Omega$ are connected across a battery as shown in the figure.

Calculate the resistance of their equivalent resistor.

R_1 and R_2 are connected in parallel then:



$$R_{eq} = \frac{R_1 \times R_2}{R_1 + R_2} = \frac{5 \times 10}{5 + 10} = \frac{50}{15}$$

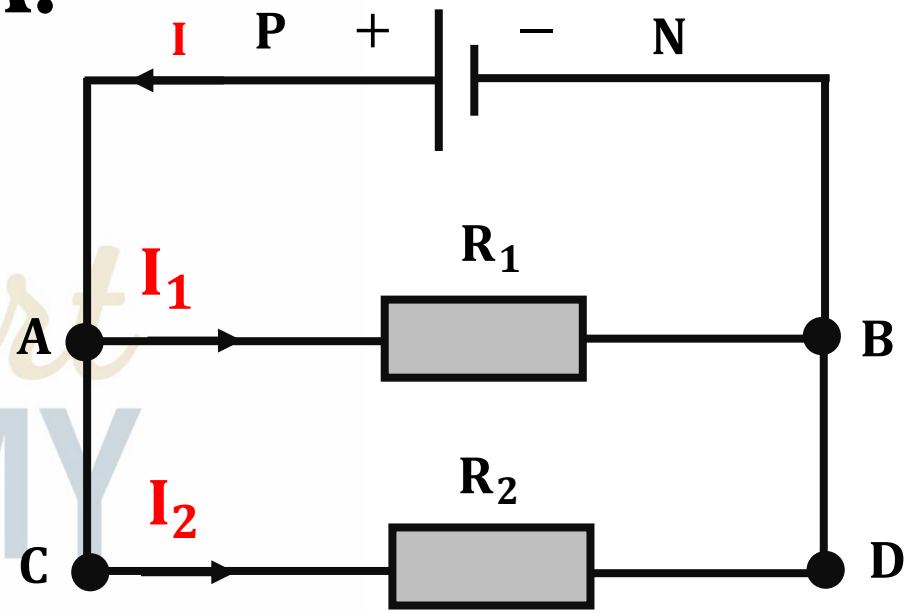
$$R_{eq} = 3.33\Omega$$

Grouping of resistors/ Grouping in parallel

Application 9:

Consider two resistors $R_1 = 20\Omega$ and R_2 are connected across a generator as shown in the figure. Given $V_{CD} = 5V$. The generator sends a current of $I = 1A$.

1) Determine the current passing through each resistor.
2) Calculate the equivalent resistance of the circuit.
3) Deduce the resistance R_2.



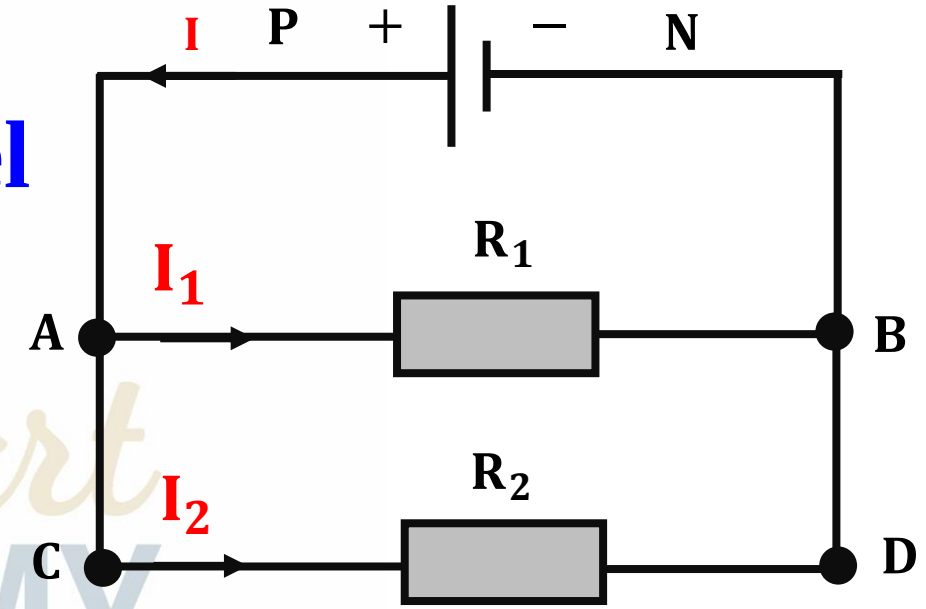
Grouping of resistors/ Grouping in parallel

$R_1 = 20\Omega; R_2 = ?; V_{CD} = 5V; I = 1A.$

1)Determine the current passing through each resistor.

$$V_{PN} = V_{AB} = V_{CD} = 5V$$

(law of uniqueness of voltage in parallel



$$V_{PN} = R_1 \times I_1$$

$$I_1 = \frac{V_{PN}}{R_1} = \frac{5}{20} = 0.25A$$

Using law of addition of current in parallel:

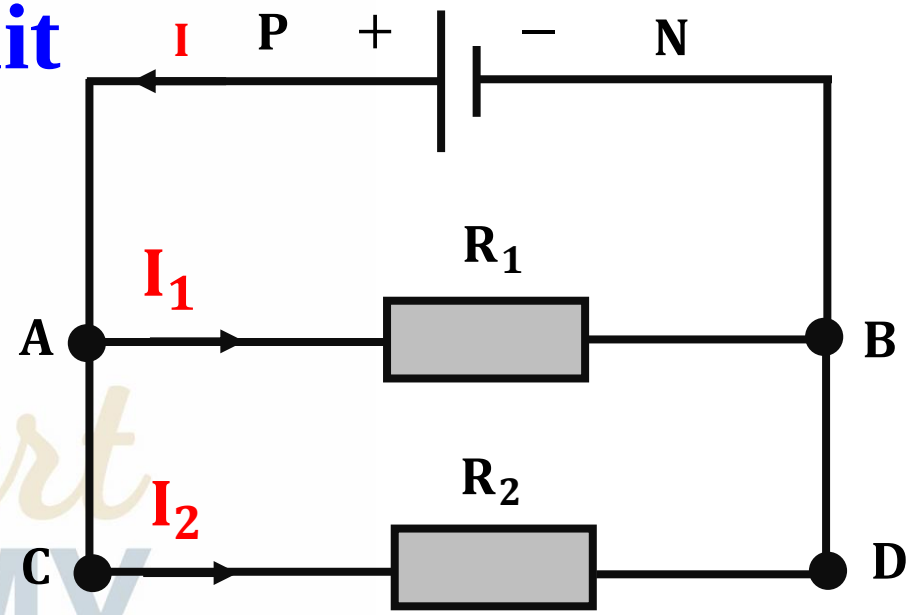
$I = I_1 + I_2$ ⇨ $I_2 = I - I_1 = 1 - 0.25$ ⇨ $I_2 = 0.75A$

Grouping of resistors/ Grouping in parallel

$R_1 = 20\Omega; R_2 = ?; V_{CD} = 5V; I = 1A.$

2)Calculate the equivalent resistance of the circuit.

Using ohm's law for the equivalent circuit



$$V_{PN} = R_{eq} \times I$$

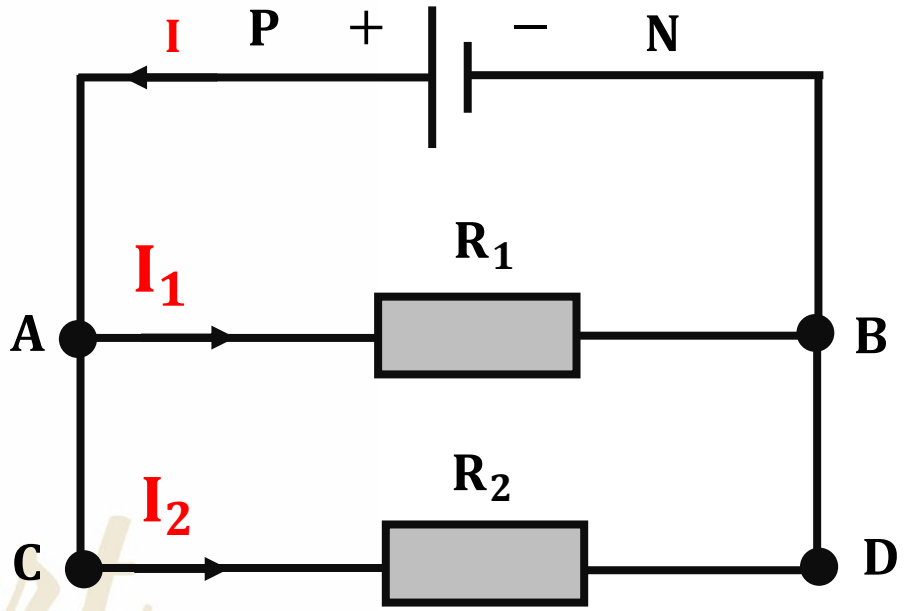
$$R_{eq} = \frac{V_{PN}}{I}$$

$$R_{eq} = \frac{5}{1} = 5\Omega$$

Grouping of resistors/ Grouping in parallel

$R_1 = 20\Omega$; $R_2 = ?$; $V_{CD} = 5V$; $I = 1A$.

3)Deduce the resistance R_2.

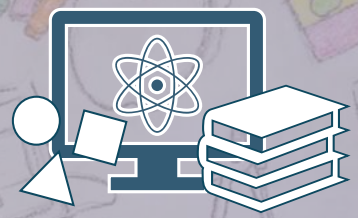


$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$$

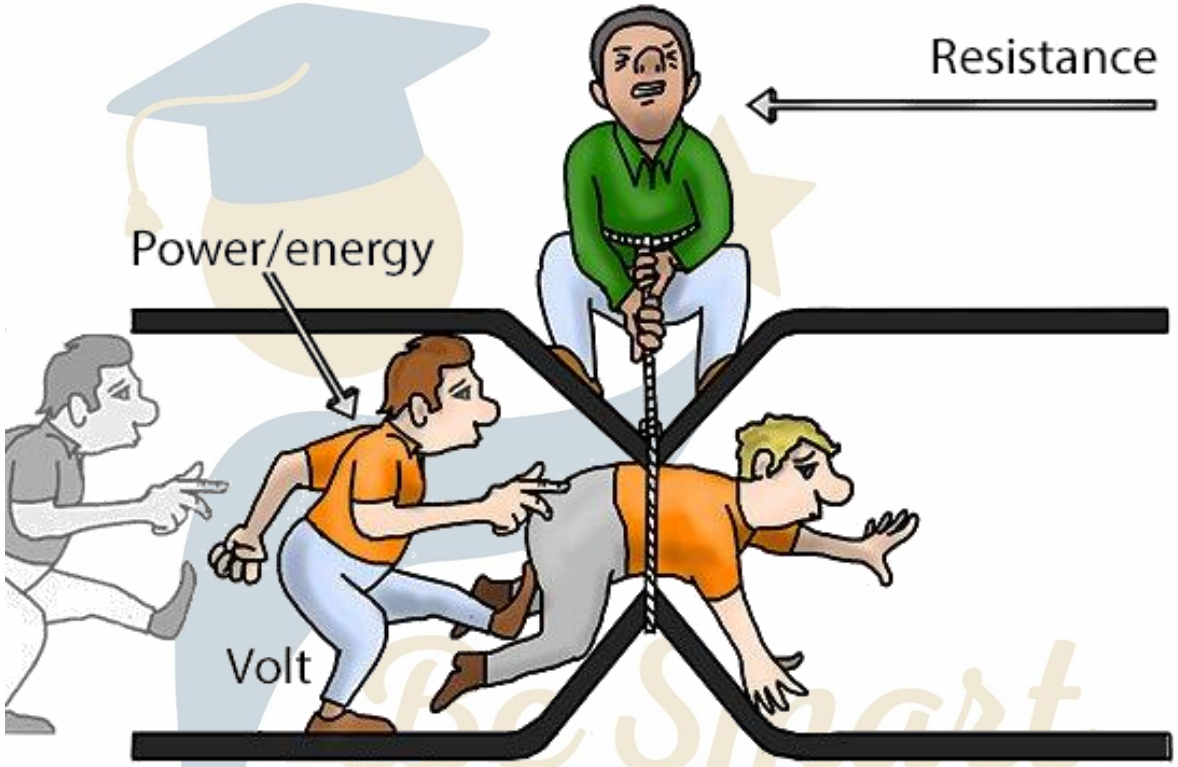
$$\frac{1}{5} = \frac{1}{20} + \frac{1}{R_2}$$

$$\frac{1}{5} - \frac{1}{20} = \frac{1}{R_2} \Rightarrow \frac{1}{R_2} = \frac{3}{20} \Rightarrow \frac{R_2}{1} = \frac{20}{3} \Rightarrow R = 6.667\Omega$$

The End



Physics – Grade 10



Unit One

Electricity

Chapter 4 – Resistors

Prepared & Presented by: Mr. Mohamad Seif

OBJECTIVES

1. Determine the Power of resistor
2. Determine the Energy of resistor

Power and Energy

- The electric power (P): is the rate of doing work, measured in **Watts (W).**
- The electric Power (P) consumed by an electric load (resistor, lamp, motor…), is equal to the product of voltage V across it by the current I it carries.

$$P = V \times I$$

Power and Energy

$$P = V \times I$$

The expression of power of a resistor

Using ohm's law: $V = RI$

$$P = (R \times I) \times I$$

$$P = R \times I^2$$

$$P = V \times \left(\frac{V}{R}\right)$$

$$P = \frac{V^2}{R}$$

Power and Energy

The electric energy (E) expressed in Joules (J), consumed by a load when traversed by a current I, under a potential difference V during a time t is given by:

$$E = P \times t$$

$$E = R \times I^2 \times t$$

Called Joule's law

Joule's law:

The heat developed by a resistor is proportional to the resistance R, the square of the current, and the time during which the current is maintained.

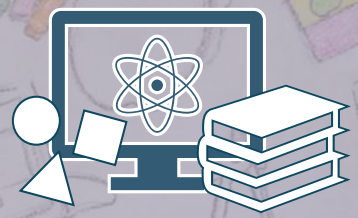
Power and Energy

Joule's effect: is the transformation (totally or partially) of electric energy into thermal energy (heat).

Joule's effect: represents the loss of energy (dissipated energy).

In a resistor the electric energy is completely transformed into thermal energy by joule's effect.

The End



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