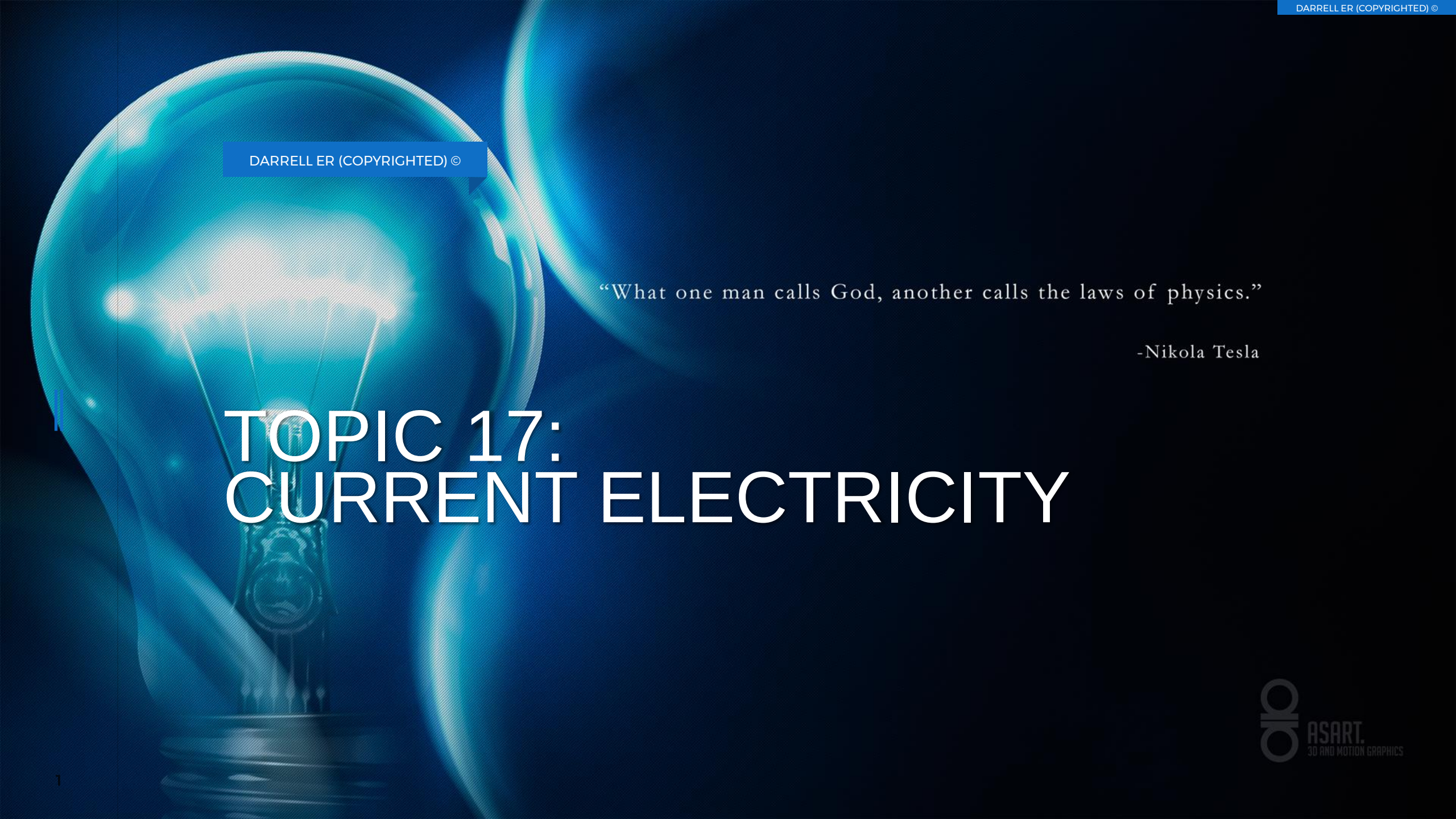


DARRELL ER (COPYRIGHTED) ©

"What one man calls God, another calls the laws of physics."

-Nikola Tesla

TOPIC 17: CURRENT ELECTRICITY

THE ABOUT

CHAPTER ANALYSIS

TIME

- Intangible concepts that are hard to grasp
- 3 **major key** concepts
- Current, Voltage, Resistance

EXAM

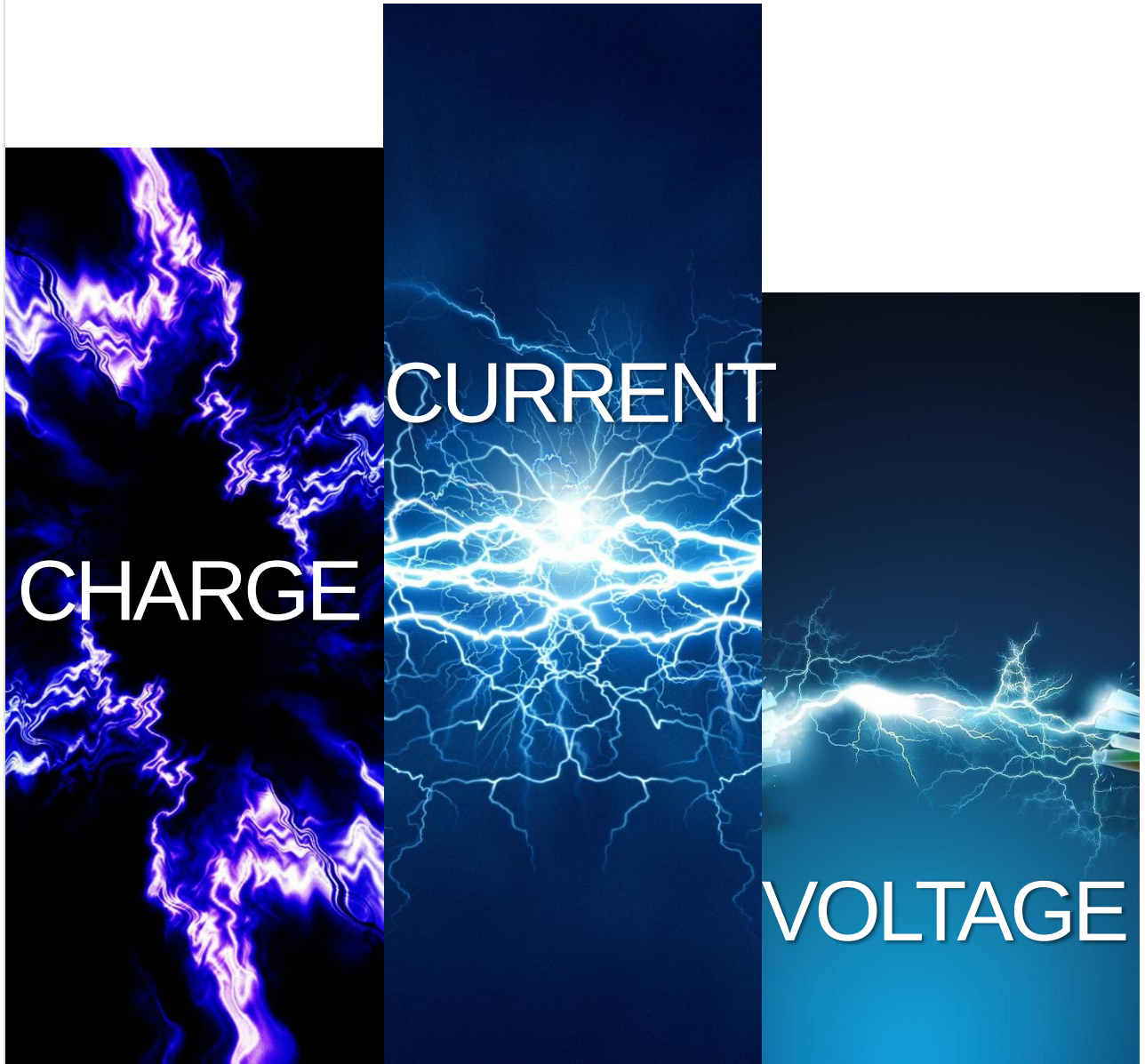
- Will **always be tested**
- **Foundation chapter** for DC Circuits & Practical Electricity

WEIGHTAGE

- Heavy-Medium overall weightage
- Constitute to around **5.5%** of marks for past 5 year papers

KEY CONCEPT

CURRENT
CHARGE / TIME
CONVENTIONAL CURRENT & ELECTRON FLOW



visualising electricity

The biggest obstacle for most students is not being able to visualise electricity.

Unlike other physics topics, electricity is invisible and hard to grasp with our imagination.

Hence, I will be using a **visualisation approach** to help students truly understand this chapter.

VISUALISATION

PIKACHU RACE

This is a story about a pikachu participating in a race.

He has to run one full lap around the circuit.

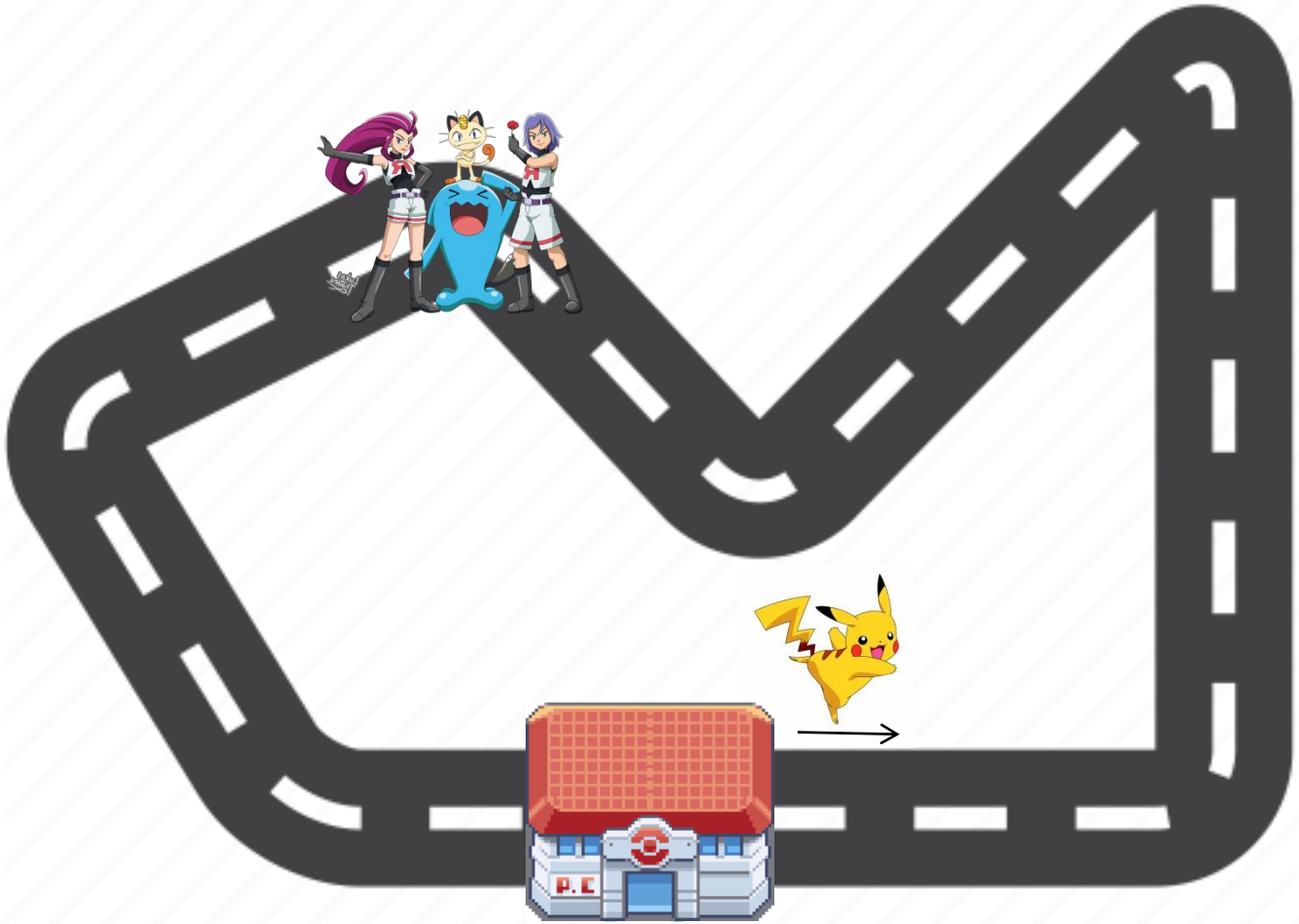
He starts off at the Pokemon center with full health.

However, along the way, he come across Team Rocket.

Although Team Rocket offered some resistance, Pikachu was still able to defeat them as usual. He uses all his energy and thunderbolt the shit out of them.

Now he is out of energy but with nothing left in his way, he makes his way safely back to the Pokemon center and replenishes his energy back to full health.

Pikachu is ready to go again!



VISUALISATION

COMPLETE CIRCUIT

This is how electricity works!

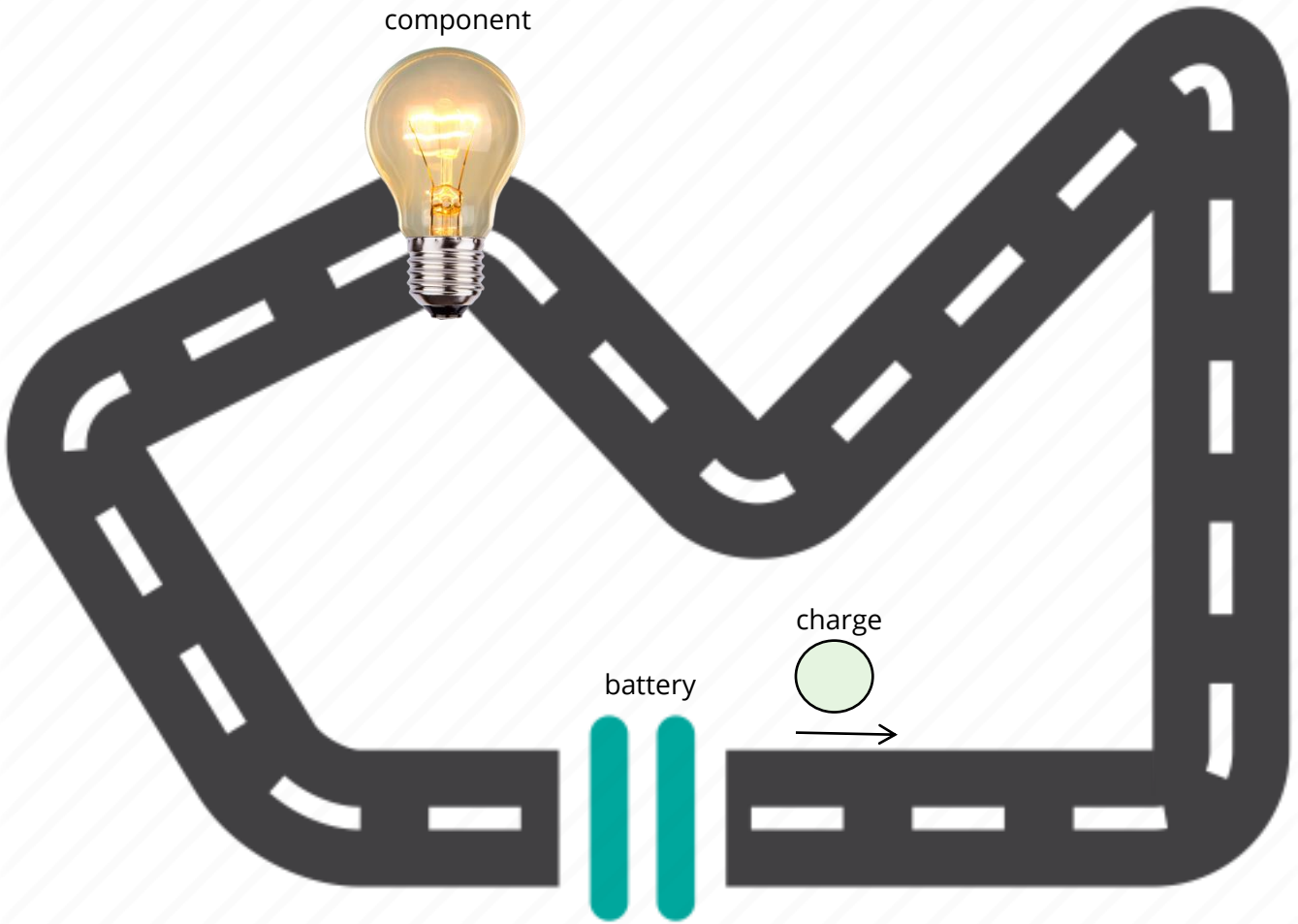
Pikachu is the **charge**, a particle capable of carrying electrical energy, that moves around the circuit.

Pokemon center is the **source (battery),** where the charge replenishes its electrical energy after going one round around the complete circuit.

In the battery, chemical potential energy is converted to electrical energy which is supplied to the charge.

Team Rocket is the **component (light bulb).** In order to overcome it, the charge has to use its electrical energy. After the charge hands over the required electrical energy, it is then allowed to pass through.

In the light bulb, electricity energy received from the charge is converted to light and heat energy.



VISUALISATION

CURRENT

SO WHAT IS CURRENT?

Current is defined as the **rate of flow of electrical charges**.

In order words, the amount of charges flowing in the circuit per second.

VISUALISATION

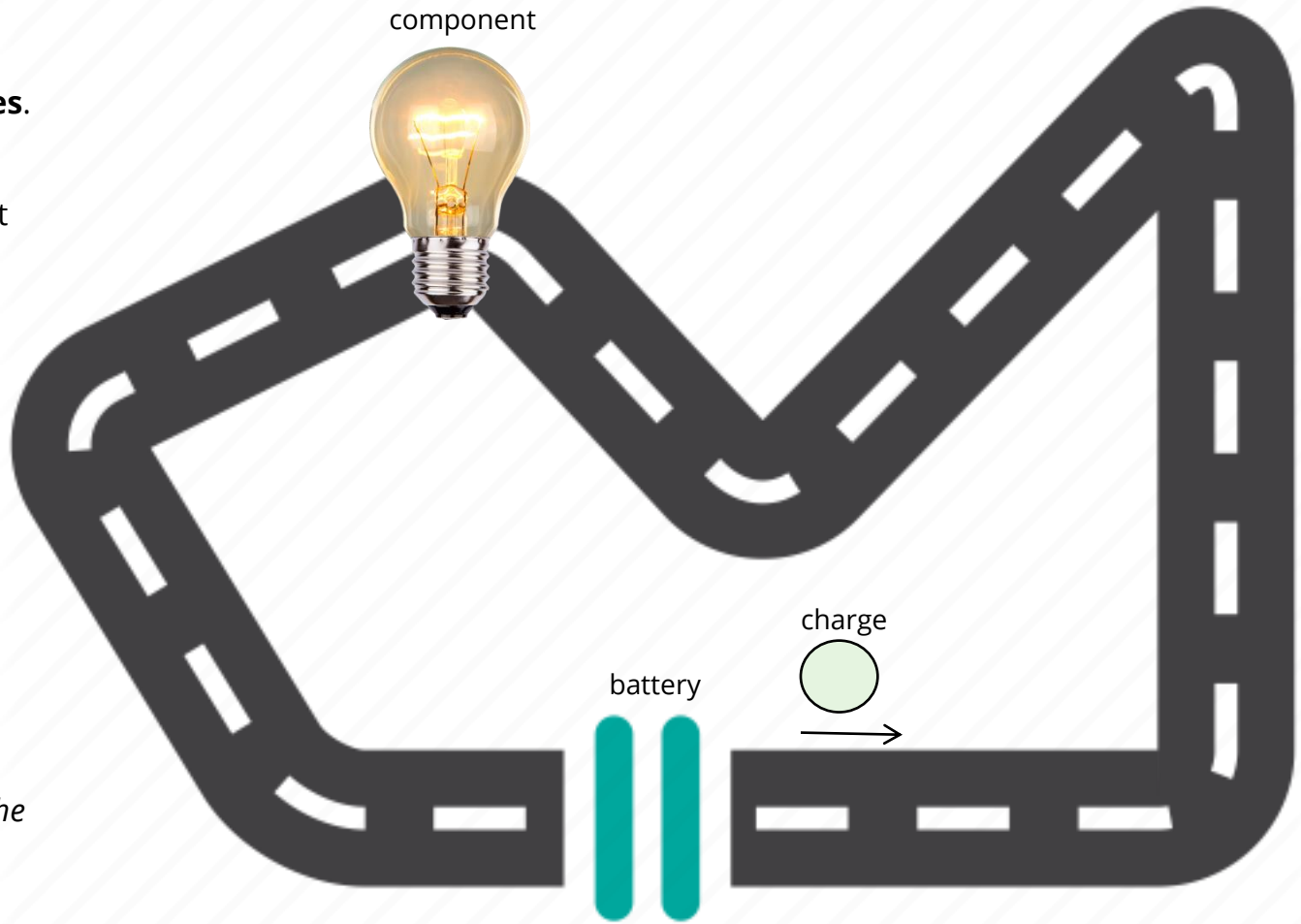
The whole process of pikachu going around the circuit is really quick, in milliseconds.

Furthermore, multiple pikachus can be released to go around the circuit at the same time.

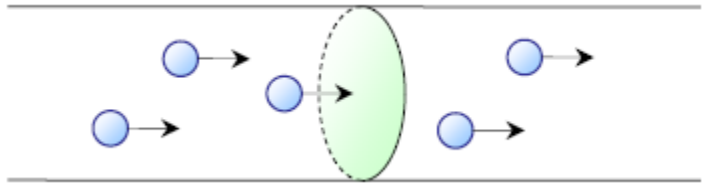
Current measures the number of pikachus going around the circuit every second!

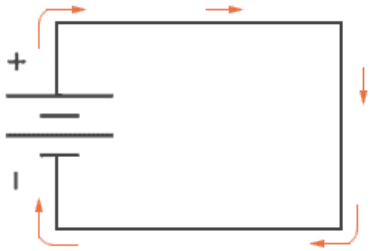
*Another analogy is **ERP**. The amount of cars passing through the ERP per second, is the rate of flow of cars.*

Current is the rate of flow of charges!



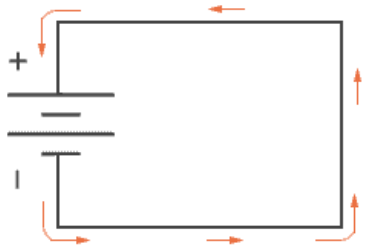
CURRENT





Convectional Current

Conventional current flows from positive to negative terminal.



Electron Flow

Electron flow is from negative to positive terminal.

DEFINITION

Current is defined as the **rate of flow of electrical charges**.

Unit: **Ampere (A)**

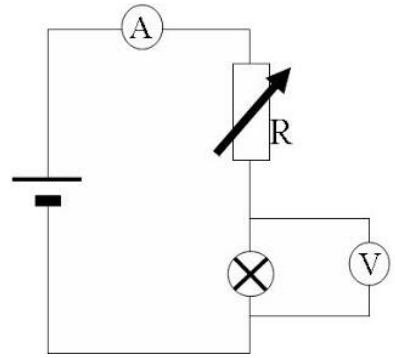
Formula:

$$\text{Current} = \frac{\text{Charge}}{\text{Time}}$$

Current is measured with an **ammeter** (which has very low internal resistance). The low resistance is to ensure that the ammeter does not affect the current flow.

It must be **connected in series** so that electric current flow through the ammeter, via the positive terminal and leave via the negative terminal.

(It's like a ERP, cars must go through it!)



KEY CONCEPT

VOLTAGE
ELECTROMOTIVE FORCE
POTENTIAL DIFFERENCE

VISUALISATION

A COMPLETE CIRCUIT

Electromotive Force

The amount of electrical energy the battery provides to each charge **depends on the amount of components** in the circuit.

So if there are 3 light bulbs, the battery must provide **sufficient energy** to the charge to go past all the components and be able to **complete a full circuit**.

This is also known as electromotive force, referring to how **much energy the source provides** to each charge.

Potential Difference

Before the charge enters the component, it will possess a certain amount of electrical energy. After it passes through it, it will have a lesser amount of energy.

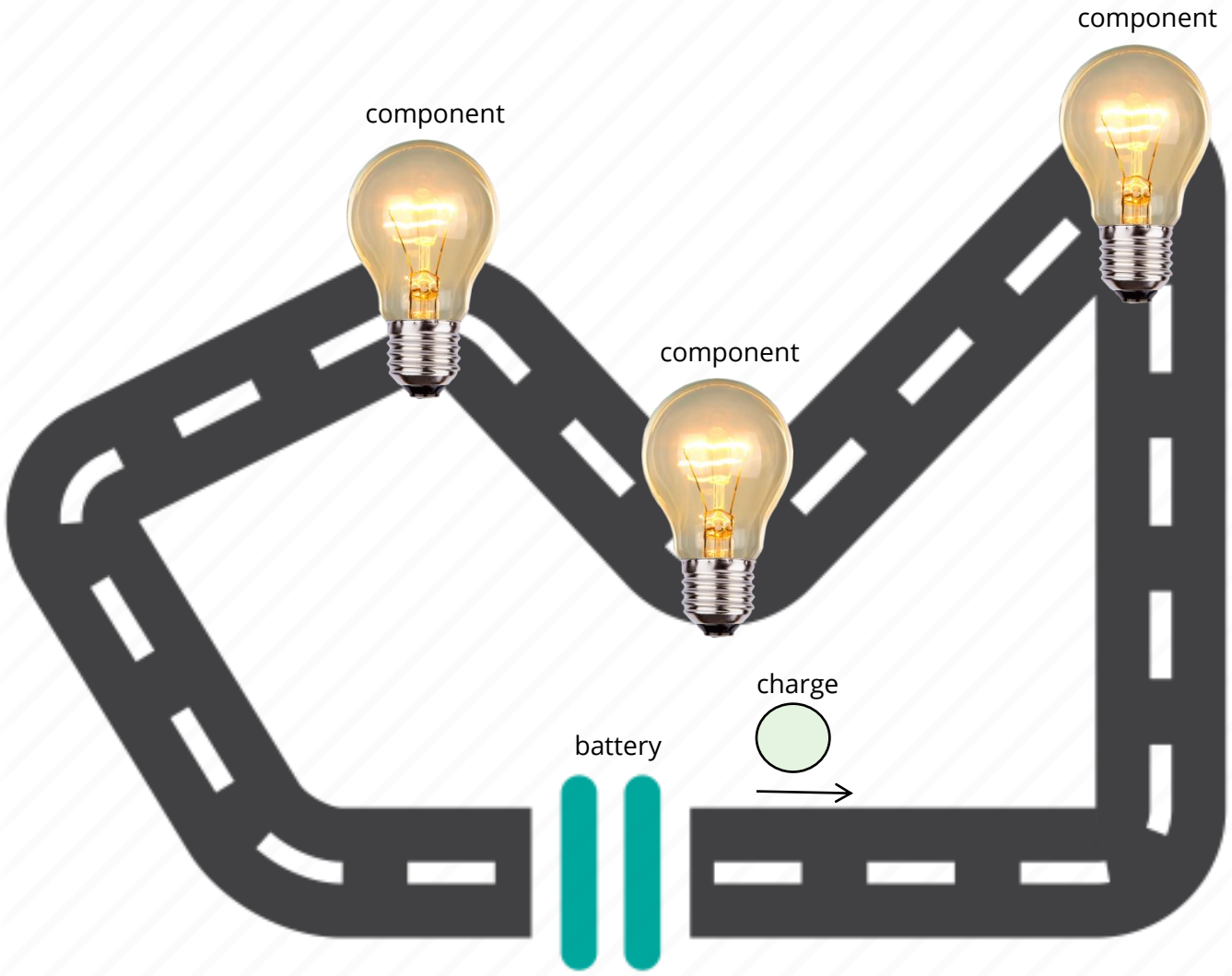
The **difference between before and after** is known as potential difference, referring to how much **electrical energy is consumed** per charge by the component.

Both emf & P.D have the same formula,

emf = Work Done / Charge
P.D = Work Done / Charge

But I prefer to remember it as,

Voltage = Energy per Charge



ELECTROMOTIVE FORCE

Electromotive force is defined as the **work done by the source** in driving a **unit charge** round a **complete circuit.**

Units: V (Voltage)

Formula:

$$\text{Voltage} = \frac{\text{Energy}}{\text{Charge}} = \frac{\text{Work Done}}{\text{Charge}}$$

1V is when 1C has 1 J of electrical energy.

For eg: A battery with emf 3V, means it supplies 3J of electrical energy to each charge.

POTENTIAL DIFFERENCE

Potential difference is defined as the **work done** in driving a **unit charge through a component.**

Units: V (Voltage)

Formula:

$$\text{Voltage} = \frac{\text{Energy}}{\text{Charge}} = \frac{\text{Work Done}}{\text{Charge}}$$

1V is when 1C uses 1 J of electrical energy.

For eg: A light bulb with p.d 3V, means 3J of electrical energy is converted to light and heat energy when each charge passes through it.

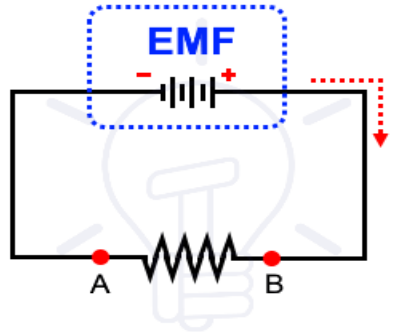
TAKE NOTE

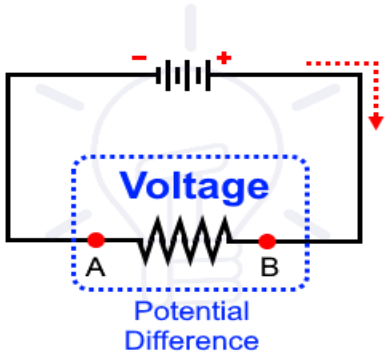
While both emf and p.d share the **same unit, V,** they are **not the same**.

Emf is always about the **source**, where other forms of energy is converted to electrical energy.

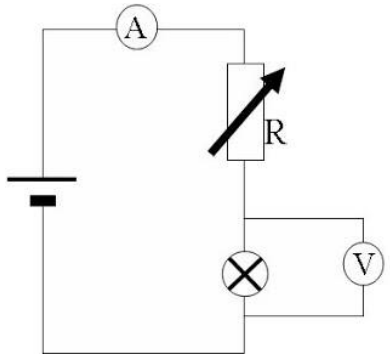
P.D is always about the **component**, where electrical energy is converted to other forms on energy.

The sum of all the **p.d across all the components** in the circuit is **equal** to the **sum of emf of all cells**, in a series circuit.





MEASURING VOLTAGE



MEASURING VOLTAGE

Potential difference is measured with a **voltmeter** (which has very high internal resistance).

It must be **connected in parallel,** with its high internal resistance, minimum current is directed away from the component.

This is to ensure that almost all of the current will flow through the component as intended.

KEY CONCEPT

RESISTANCE
RESITIVITY
OHM's LAW

VISUALISATION

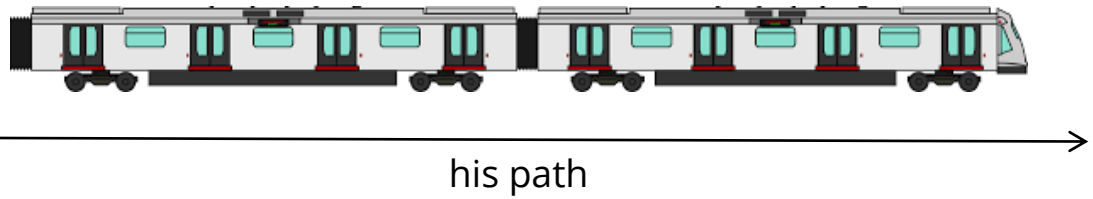
WHAT IS RESISTANCE?

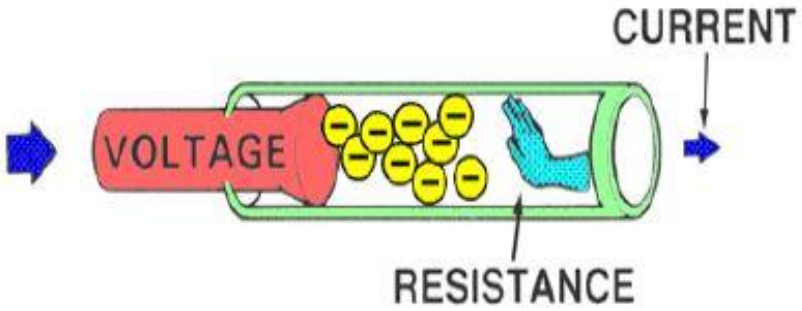
Gong Yoo has to fight his way through a crowded train to the control terminal at the front.

He has to make his way from one end of the train to another.

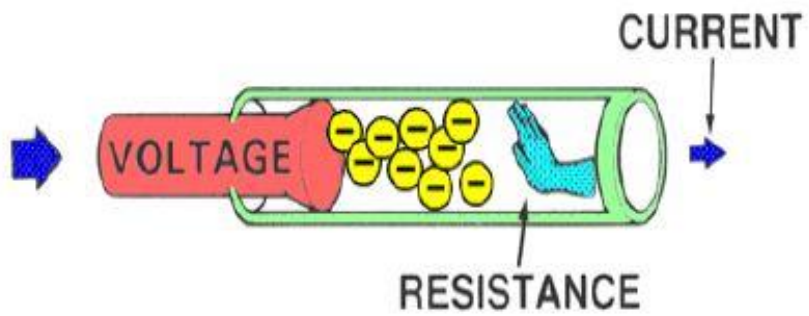
He have to expend a lot of energy to squeeze through the crowd but eventually he makes it through.

The **degree of difficulty** to squeeze through the crowded train is a visualisation of what resistance feels like.





RESISTANCE



DEFINITION

Resistance is defined as the ratio of potential difference to the current flowing through it.

Can also be understood as,

A measure of the degree to which an electrical component opposes the passage of an electric current.

Unit: **Ohm (Ω)**

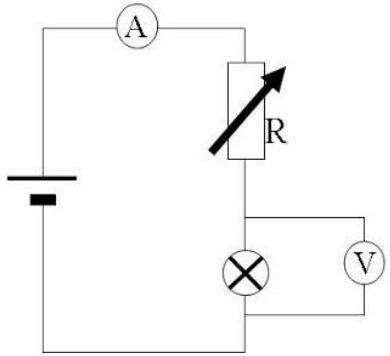
Formula:

R = V / I

V = RI
(victoria = RI)

where,
R = Resistance
Q = Potential Difference
I = Current

Resistance can be measured using by finding the currrent using an ammeter & the potential difference using a voltmeter.



VISUALISATION

Resistance can also be calculated as,

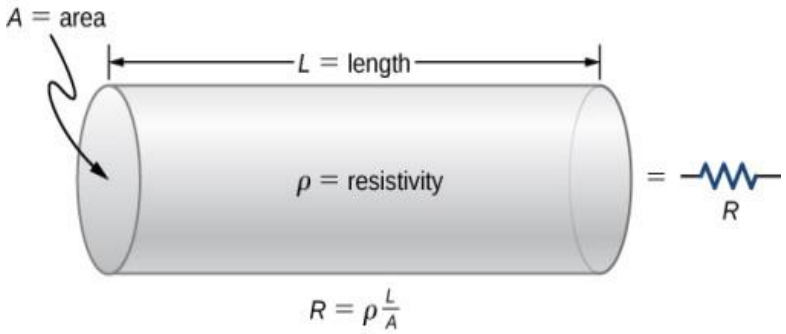
$$\text{Resistance} = \frac{\rho L}{A}$$

where,
R = Resistance
ρ = resistivity
L = length of wire
A = cross-sectional area of wire

The **longer a wire, the higher the resistance**.

The **smaller the cross-sectional area of a wire, the higher the resistance.**

Resistivity, ρ, depends on the **material** of the wire.

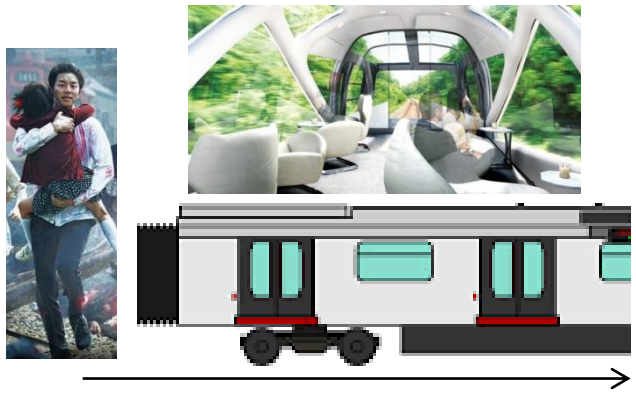


A simple way to visual this concept is:

<u>Scenario 1:</u>
Train is narrow in space and the train is 2 carriage in length! → journey is hard!

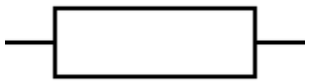
Conclusion: A long and thin wire has high resistance.

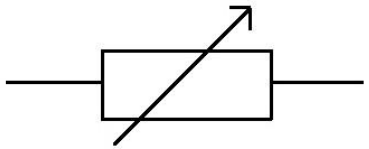
<u>Scenario 2:</u>
Train is spacious and the train is one carriage in length! → journey is easy!



Conclusion: A short and fat wire has low resistance.

RESISTORS





Fixed resistor

Variable resistor

DEFINITION

A **resistor** is a component in an electric circuit which provides a **known value of resistance.**

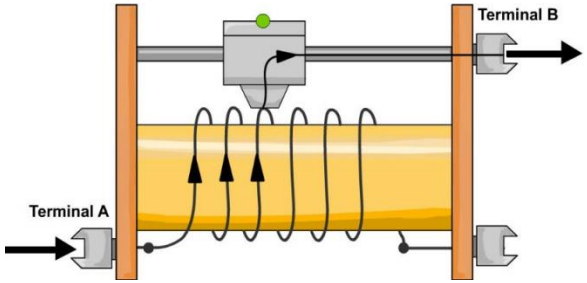
As,

$$V = RI$$

When resistance increases, current decreases.

Hence, resistors can **control or limit the size of a current** flowing in a circuit.

A **rheostat** varies its contact point and changes the length of the wire the current has to flow through.



As we learnt previously, the **longer the wire**, the **greater the resistance.**

OHM'S LAW

OHMIC CONDUCTORS

As p.d increases, current increases proportionally.

Resistance is **constant**. (represented as gradient)

NON-OHMIC CONDUCTORS

As p.d increases, current increases/decreases disproportionally.

Resistance **varies** as the p.d increases.

This may be due to a variety of reasons such as increased current leading to a heating effect, which can cause increased temperature and hence increased resistance (filament lamp).

For thermistors, an increase in temperature will lead to a decrease in resistance.

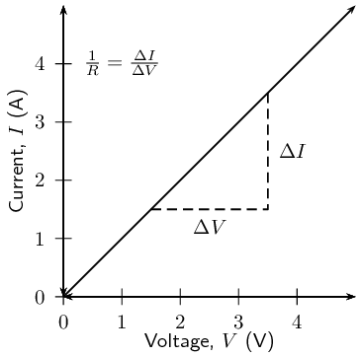
A diode only allow current flow in one direction.

DEFINITION

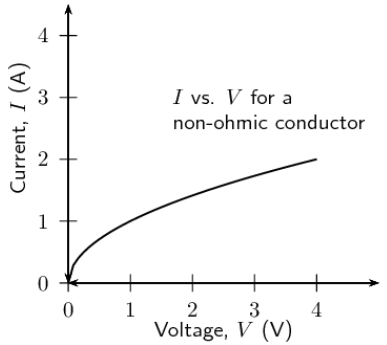
Ohm's law states that a **current** through a metallic conductor is **directly proportional** to the **potential difference** across the ends of the conductor, provided the temperature and other physical conditions remain constant.

A resistor that has constant resistance is called an **ohmic conductor.**

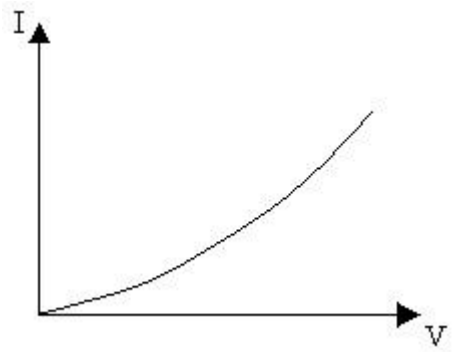
We can check whether a resistor is ohmic by observing the I-V graph.



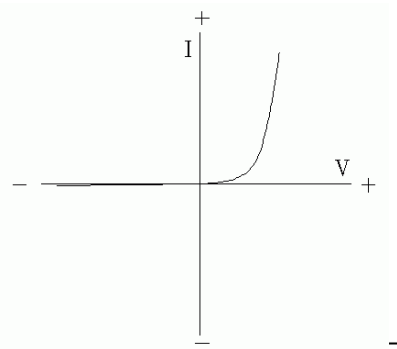
Ohmic conductor



Non-ohmic conductor (filament lamp)



Non-ohmic conductor (thermistor)



Non-ohmic conductor (semiconductor diode)

OVERMUGGED
By Tutors, For Students

For more notes & learning materials, visit: www.overmugged.com

IG handle: @overmugged

Join our telegram channel: @overmugged

‘O’ levels crash course program

Professionally designed crash course to help you get a **condensed revision** before your ‘O’ Levels!

The **4 hour session** focuses on going through **key concepts** and **identifying commonly tested questions!**

Our **specialist tutors** will also impart valuable **exam pointers and tips** to help you maximise your preparation and ace your upcoming national exam!

The crash courses will begin in **June 2021 and last till Oct 2021**.

Pre-register now on our website and secure your slots!

Need help?

Darrell Er
(Private tutor with **8 years** of experience)

8777 0921
(Whatsapp)

@DarrellEr
(telegram username)