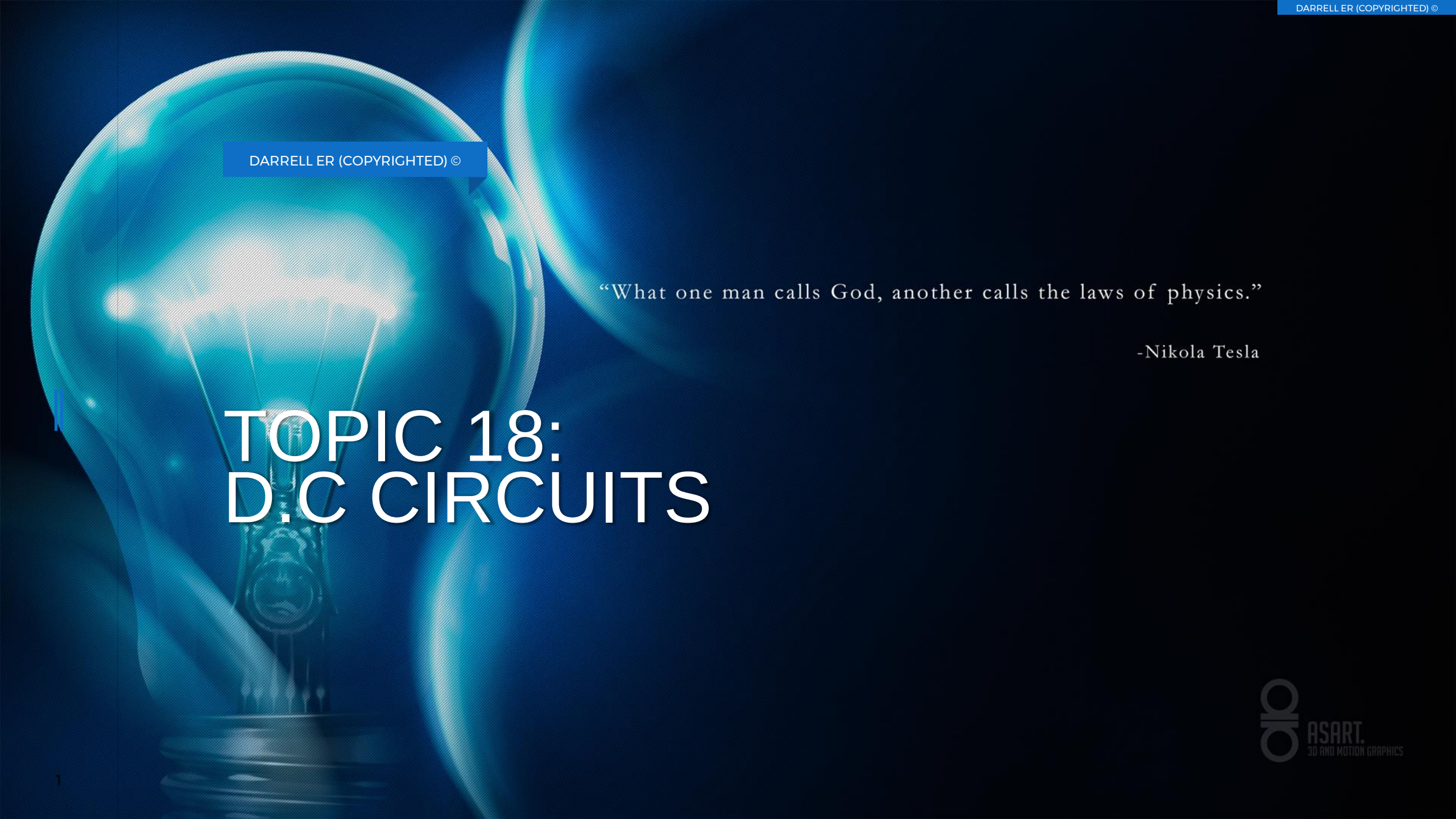

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"What one man calls God, another calls the laws of physics."

-Nikola Tesla

TOPIC 18: D.C CIRCUITS

THE ABOUT

CHAPTER ANALYSIS

TIME

- Build up from Current Electricity
- 3 **major key** concepts
- Series Circuit, Parallel Circuit, Potential Divider

EXAM

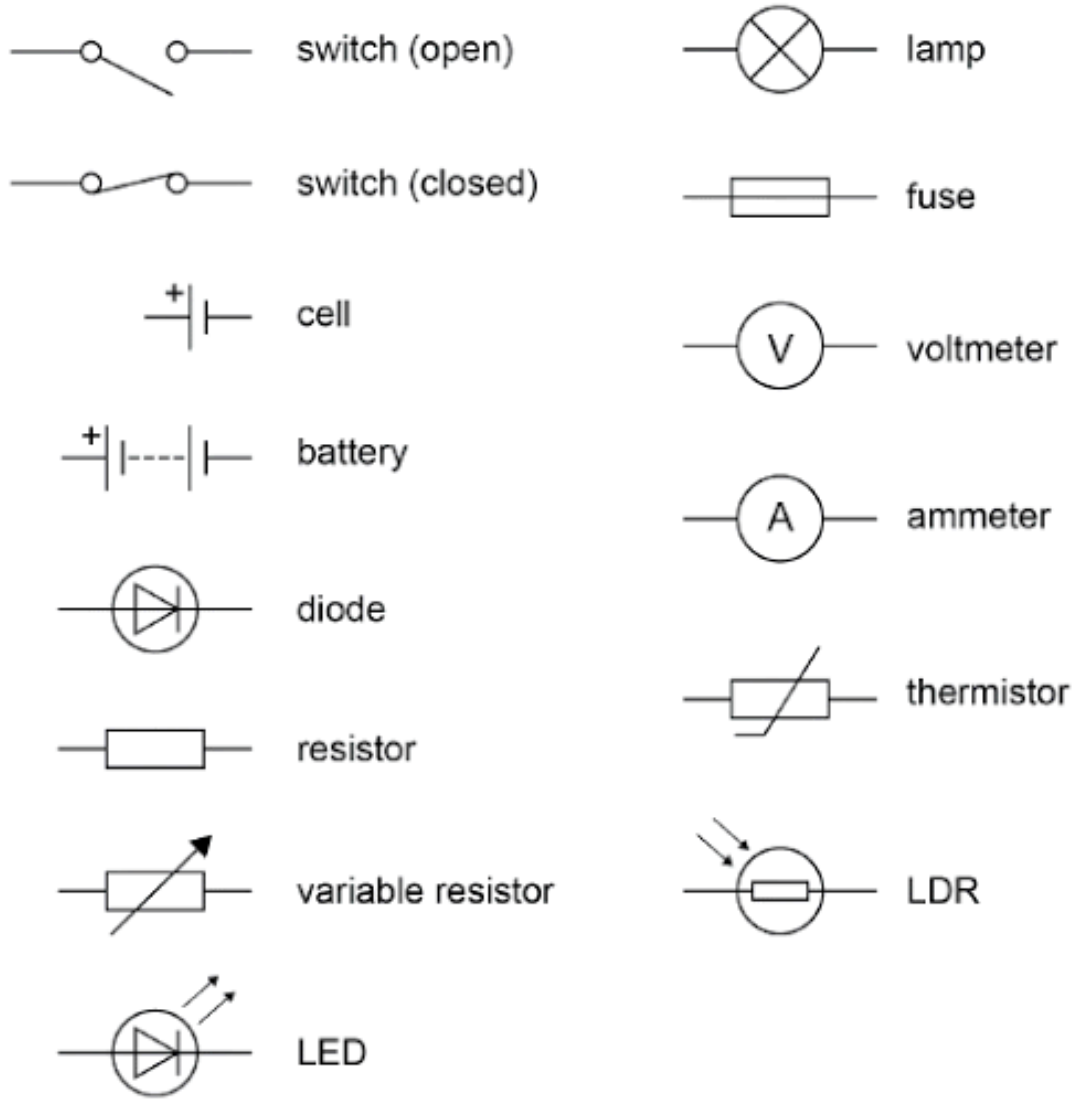
- Really need to practice to master the topic
- **Important** to get foundation right from Current Electricity

WEIGHTAGE

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

KEY CONCEPT

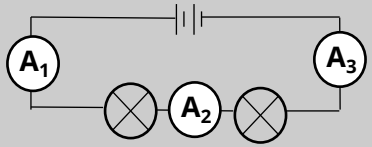
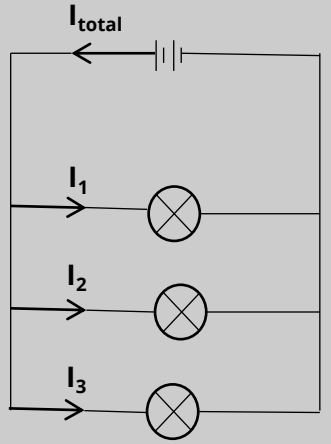
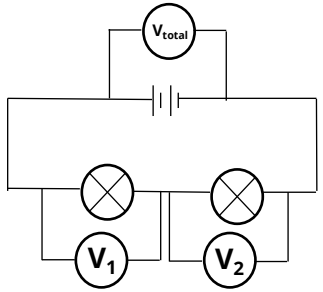
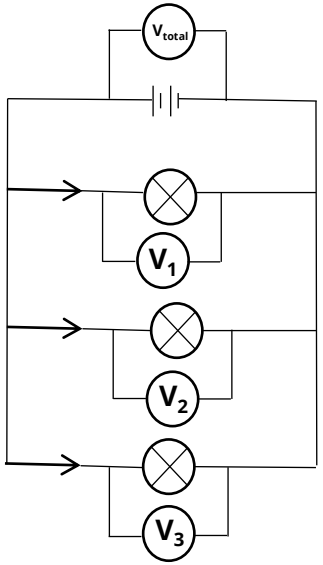
CIRCUIT DIAGRAM
SERIES CIRCUIT
PARALLEL CIRCUIT



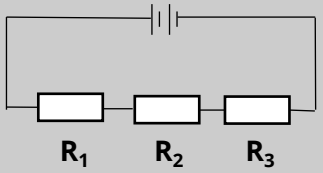
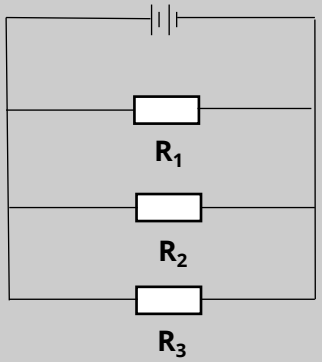
CIRCUIT DIAGRAMS

Familiarise yourself with the different components and their symbols!

SUMMARY TABLE

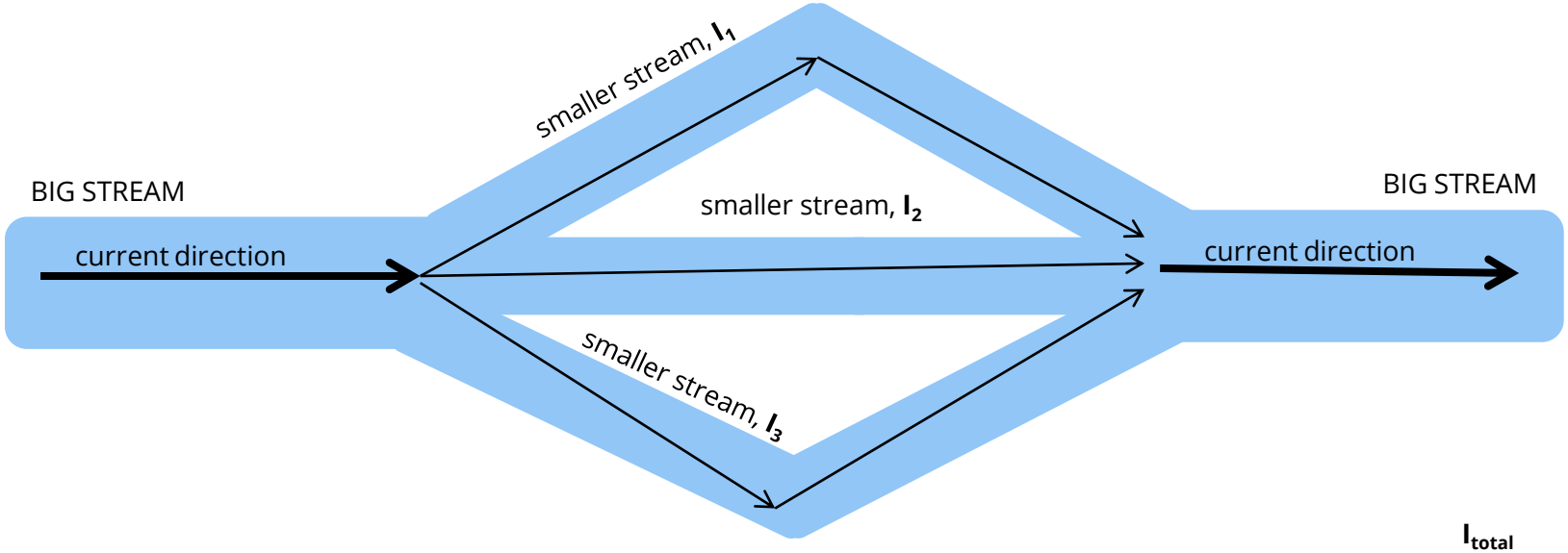
	Series	Parallel
Current	Current is the same throughout circuit. $I_1 = I_2 = I_3$ 	Total current is sum of current in each separate branch. $I_{total} = I_1 + I_2 + I_3$ 
Potential Difference	Total P.D is sum of P.D across each component. $V_{total} = V_1 + V_2$ 	Potential difference is the same across each branch. $V_{total} = V_1 = V_2 = V_3$ 

SUMMARY TABLE

	Series	Parallel
Resistance	Total effective resistance is sum of individual resistance. $R_{total} = R_1 + R_2 + R_3$ 	Total effective resistance is sum of reciprocal of resistance in each branch. $1 / R_{total} = 1/R_1 + 1/R_2 + 1/R_3$ 

VISUALISATION

A RIVER



How electricity works in a circuit is similar to a river.

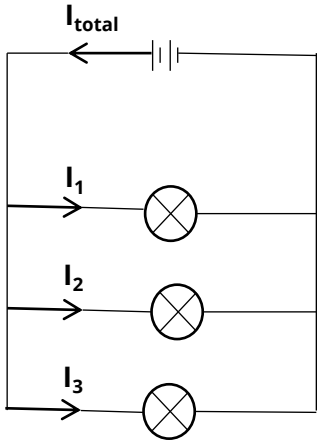
Current flows in a river and at times, it can split into smaller streams.

When it does, the volume of water is reduced in each smaller stream.

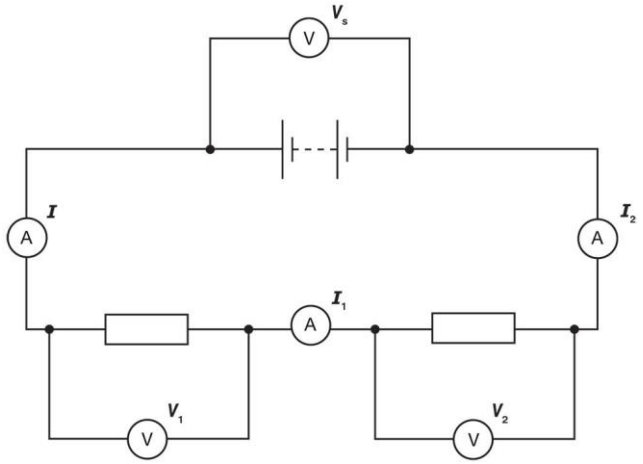
A parallel circuit works in the same way!

Current will split into smaller volume as it enters each individual branch of the circuit.

$$I_{total} = I_1 + I_2 + I_3$$



SERIES CIRCUIT

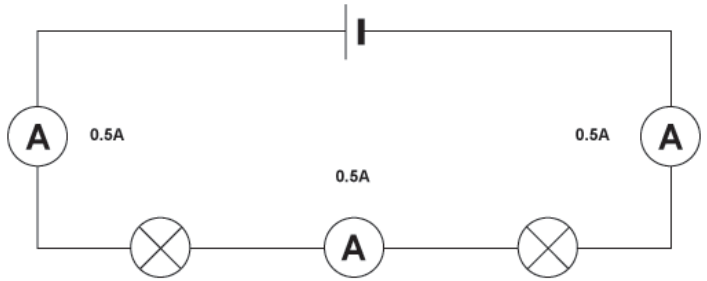


A **disadvantage** is that when one light bulb were to fuse, the entire circuit will no longer work.

SERIES CIRCUIT

Current is the same throughout circuit.

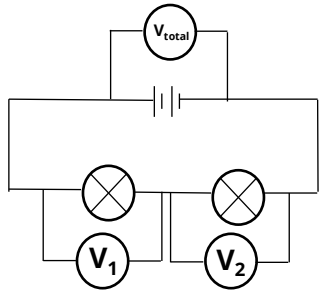
$$I_1 = I_2 = I_3$$



(There is only 1 big stream for the river)

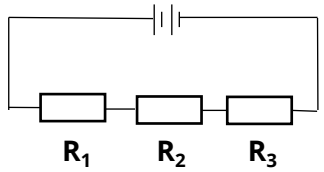
Total potential difference is **sum of P.D** across each **component**, as the current has to pass through all the resistors.

$$V_{total} = V_1 + V_2$$

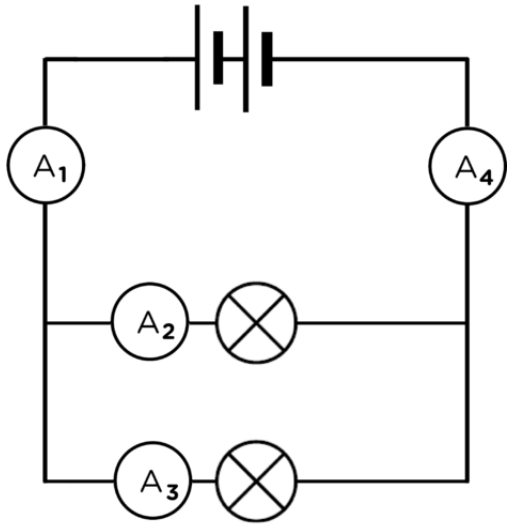


Total effective resistance is **sum** of **individual resistance**, as current has to pass through all the resistors.

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



PARALLEL CIRCUIT

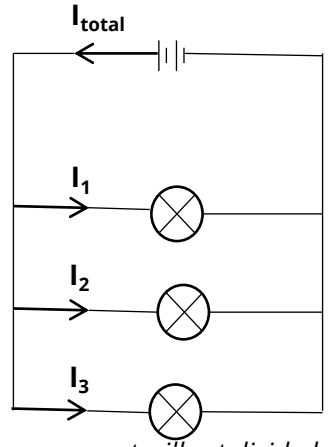


An **advantage** is that when one light bulb were to fuse the other parallel branches will still work.

PARALLEL CIRCUIT

Total current is sum of current in each separate branch.

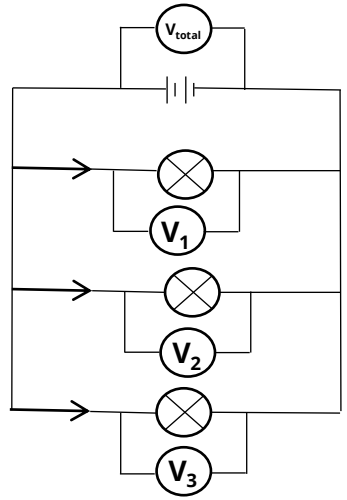
$I_{total} = I_1 + I_2 + I_3$



(River splits into smaller streams, current will get divided as well)

Potential difference is the same across each branch.

$V = V_1 = V_2 = V_3$

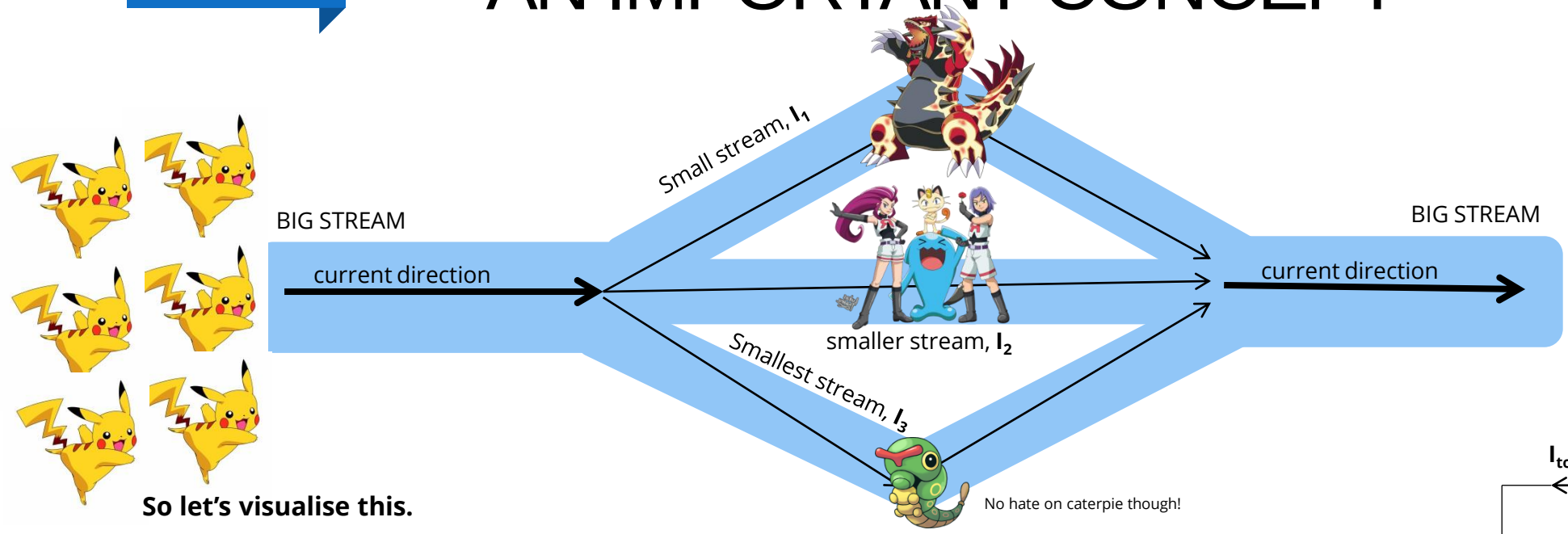


Total effective resistance is sum of reciprocal of resistance in each branch.

$$1 / R_{total} = 1/R_1 + 1/R_2 + 1/R_3$$

VISUALISATION

AN IMPORTANT CONCEPT



So let's visualise this.

This group of pikachu are the charges flowing in the river (current).

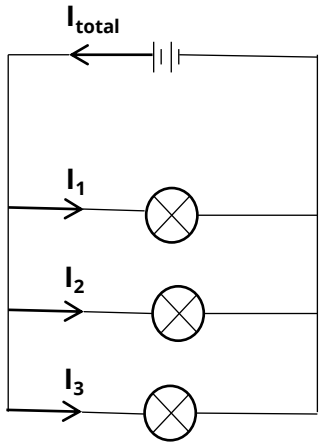
They have *3 options*, which path do you reckon they will take?

Like most lazy humans, its will be the ***path of least resistance!***

Most pikachus will go down stream I_3.
Some will go to stream I_2.
Only a few will go to stream I_1.

As current is the rate of flow of charges and charges tend to take the path of least resistance,

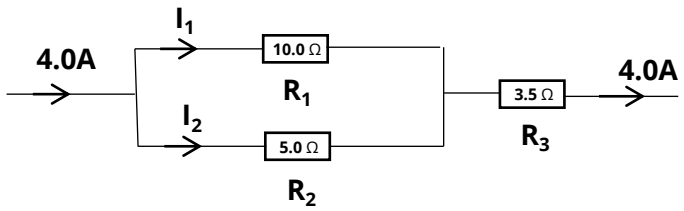
Current will split differently into each stream based on the amount of resistance in that branch.



$I_1 = I_2 = I_3$ only when the reistance in each branch happens to be the same!

PRACTICE QUESTION

How would the current split in this situation?



RECALL

Current will split into different branches in parallel circuit.

$$I_{total} = I_1 + I_2 + I_3$$

Due to path of resistance,

Current will split differently into each stream based on the amount of resistance in that branch.

HOW DO WE SOLVE THE QUESTION?

Recall that voltage across each parallel branch is constant, so since V = RI,

$$I_1R_1 = I_2R_2$$

$$I_1 \times 10.0\ \Omega = I_2 \times 5.0\ \Omega$$

$$2\ (I_1) = I_2$$

I_2 is twice the value of I_1.

$$I_{total} = I_1 + I_2$$

$$4.0\ A = I_1 + 2\ (I_1)$$

$$I_1 = 4.0\ A / 3$$

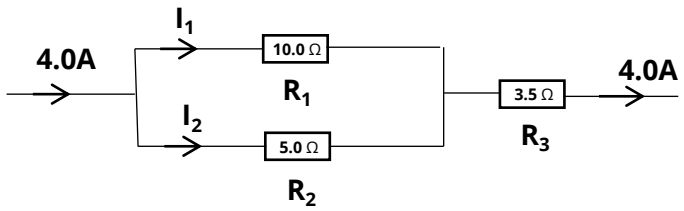
$$I_1 = 1.3\ A$$

$$I_2 = 4.0\ A - 1.3A = 2.7A$$

PARALLEL IN SERIES

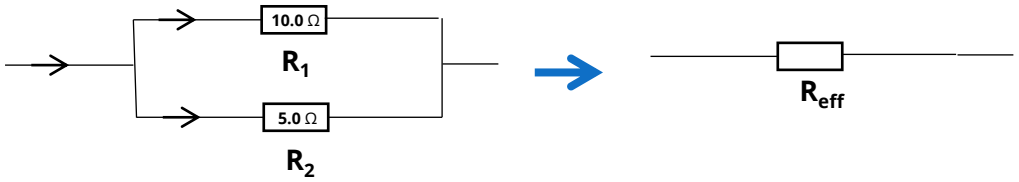
Using the same question, let's explore the resistance.

This is a case of a **parallel in a series circuit.**



HOW DO WE SOLVE FOR THE EFFECTIVE RESISTANCE?

(Combined R_1 & R_2 to simplify the circuit)

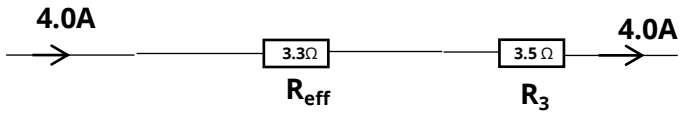


$1/ R_{eff} = 1 / R_1 + 1 / R_2$

$1 / R_{eff} = 1 / 10.0 + 1 / 5.0$

$R_{eff} = 3.3\ \mathbf{\Omega}$

(Since R_{eff} & R_3 are now technically in series)

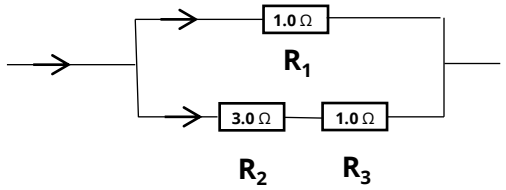


$R_{total} = 3.3\Omega + 3.5\Omega = 6.8\Omega$

HENCE, MAKE THE PARALLEL INTO A SINGLE RESISTOR BEFORE CALCULATING TOTAL RESISTANCE.

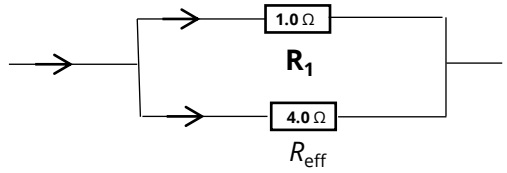
SERIES IN PARALLEL

There is also series in parallel **circuit.**



HOW DO WE SOLVE FOR THE EFFECTIVE RESISTANCE?

(Combined $R_{3.0}$ & $R_{1.0}$ to simplify the circuit)



R_{eff} = 3.0 **Ω + 1.0 Ω = 4.0 Ω**

(Since R_{eff} & R_3 are now technically in parallel)

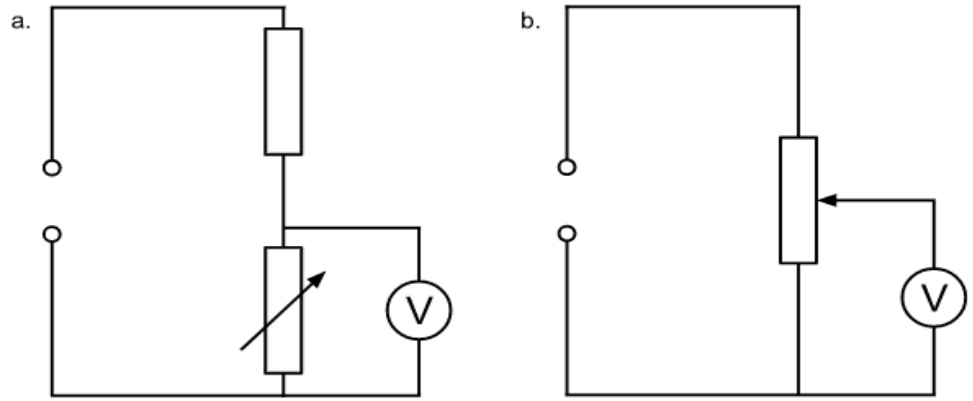
1/ R_{total} = 1 / $R_{1.0}$ + 1 / R_{eff}
1 / R_{total} = 1 / 1.0 + 1 / 4.0
R_{total} = 0.8 **Ω**

HENCE, MAKE THE SERIES INTO A SINGLE RESISTOR BEFORE CALCULATING TOTAL RESISTANCE.

KEY CONCEPT

POTENTIAL DIVIDER
THERMISTOR
LIGHT DEPENDENT RESISTOR (LDR)

POTENTIAL DIVIDER



We can vary the resistance using a *rheostat* and get a different voltage as a result.

We can also use transducers like thermistor and LDR to vary the resistance according to external factors like temperature or light.

POTENTIAL DIVIDER

It is a circuit with 2 resistors arranged in series.

The key idea is that the resistance of R_1 & R_2 are different so that will receive a different voltage.

General Formula:

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

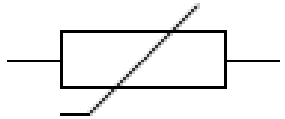
But since V =RI,

V is directly proportional to R,

$$\frac{V_1}{V_2} = \frac{R_1}{R_2}$$

THERMISTOR

THERMISTOR



THERMISTOR

A thermistor is a device that decreases in resistance as temperature increases.

At **low temperature, resistance is high and little current will flow through it.**

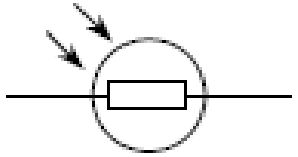
At **high temperature, resistance is low and more current can flow through it.**

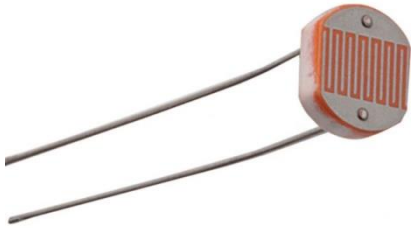
A thermistor can be used as a temperature sensor or in fire alarms.

When the temperature exceeds a set temperature in a fire alarm, the large current will trigger a relay circuit and be activated.

LIGHT DEPENDENT RESISTOR

LDR





LIGHT DEPENDENT RESISTOR (LDR)

A LDR is a device that decreases in resistance as light intensity increases.

At **low light, resistance is high and little current will flow through it.**

At **bright light, resistance is low and more current can flow through it.**

A LDR is used in digital cameras and is used to control the shutter speed.

When light intensity is low, the change in resistance in the LDR will be detected and the shutter takes longer to close to take in more light.

When light intensity is high, the change in resistance in the LDR will be detected and the shutter close much faster and limit the amount of light it takes in.

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