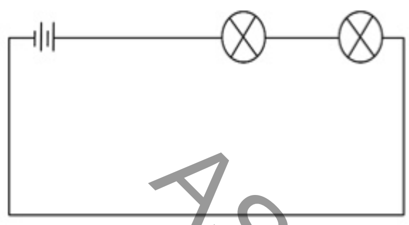
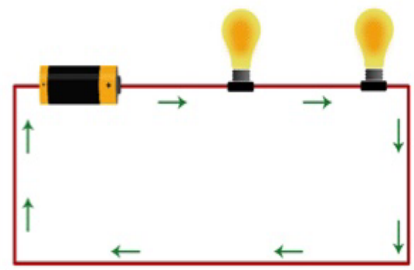
Series and Parallel Circuit

- **Series circuits** – in a series circuit, all components are connected in line with each other.





Rules and facts about series circuits

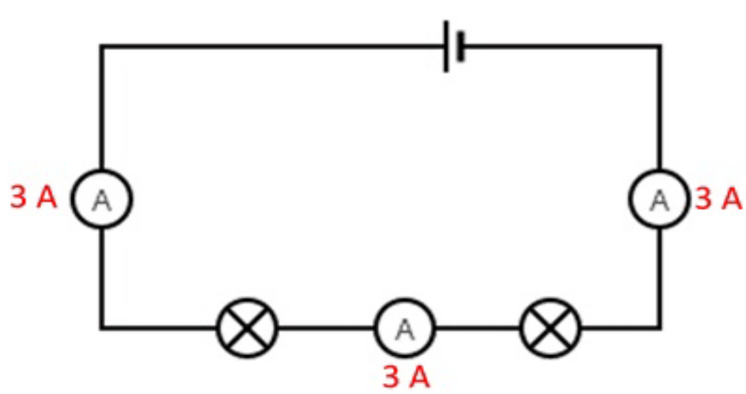
1. **Current in Series :**

Current is the same in all parts of the circuit. Current measure in Amperes (A).

$$I_1 = I_2 = I_3$$

We can calculate the current by dividing the total voltage of the battery or cell by the total resistance in the circuit.

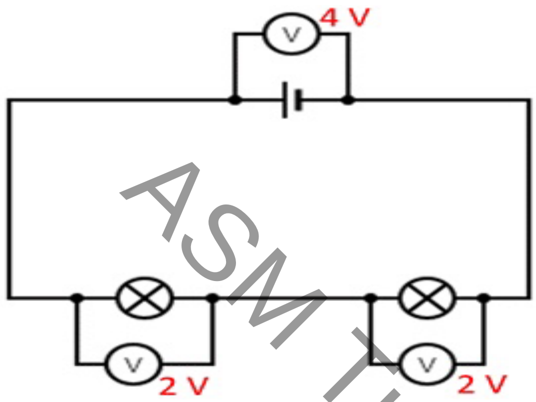
$$I = V / R$$



2. Potential Difference in series:

a. Total Potential difference is shared amongst components. The total voltage from the battery / cell is **shared** between the components

b. Cell voltages sum together. If there are two cells or batteries, then the voltage from both **add up** together to give the **total** circuit voltage.



$$V_s = V_1 + V_2$$

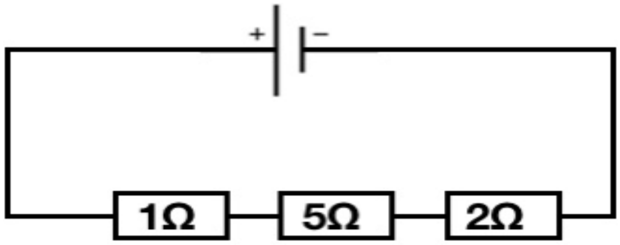
if the battery or cell provides 4V of energy, and there are two lamps (with equal resistance), each lamp will get 2.V.

3. Resistance in series :

a. Total resistance is the sum of the resistances of all components. Current needs to be the same everywhere, so the **higher** the **resistance** of an individual component, the **greater** its **share** of the **voltage** (so that current, which is voltage / resistance, stays equal). Therefore if you add an extra lamp to a series circuit, the total resistance increases and hence the current decreases.

b. **Resistance**, R, in ohms, **Ω**

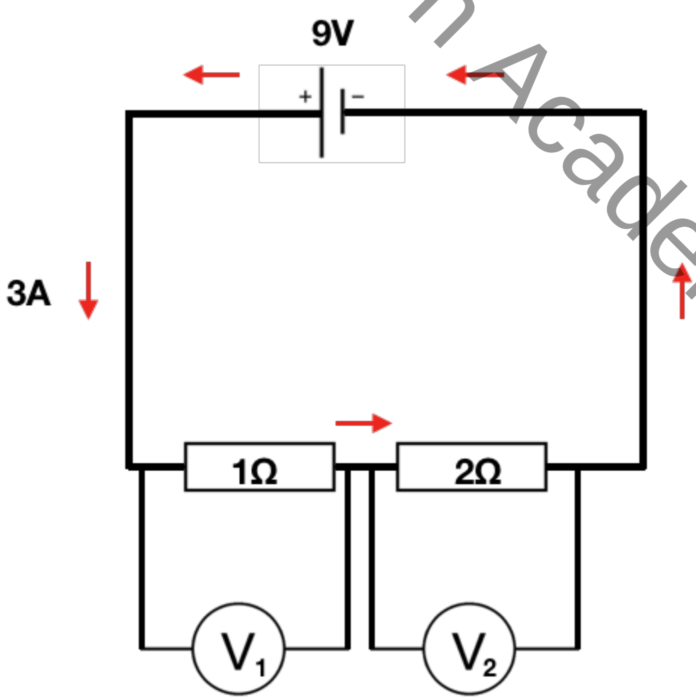
$$R_{total} = R_1 + R_2$$



Total resistance = R1+R2+R3. = 1+5+2 = 8 Ω

4. **A break in one component ruins the whole circuit.** There is only **one route** for **charge**, so if one lamp in a series circuit is broken, all lamps will stop working. Christmas lights are often sometimes in series circuits, because each bulb only needs a small voltage, so it is better to share the voltage in series. However, this means that if one light breaks then they all break.

If a cell provides **9V** to a circuit then those 9V must be shared between the other components. In the circuit below we have **two resistors**, one with a resistance of **1Ω**, the other with a resistance of **2Ω**. As the charges move around the circuit, they transfer energy to the resistors and the resistors warm up. The current in the circuit is **3A**.



- We can even calculate how the 9V of potential difference is shared between the resistors because we know Ohm's law, **V=IxR**.

- In this circuit, the current is 3A and this is the **same everywhere in the circuit**. This means that the potential difference across the first resistor (measured by a voltmeter) is,

$$V_1 = I \times R_1 = 3 \times 1 = 3V$$

- The potential difference across the second resistor is also give by Ohm's law, but now the resistance is larger so the potential difference is also going to be larger,

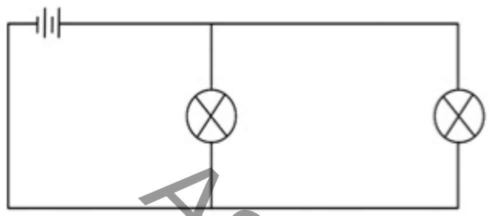
$$V_2 = I \times R_2 = 3 \times 2 = 6V$$

- So we can see that the potential difference supplied by the cell (9V) has been shared between the two resistors, with 3V going to the first resistor and 6V going to the second.

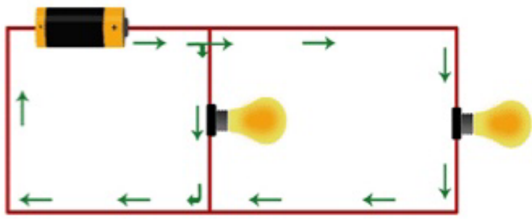
Components with larger resistance take a larger share of the potential difference.

Parallel Circuit

- **The voltage is the same for all components.**
- In **parallel** circuits, every single component gets the **full**, **maximum** voltage. Therefore bulbs in parallel will have the same brightness (assuming equal resistance). This means more components may be added in parallel without needing extra voltage.



Parallel Circuit



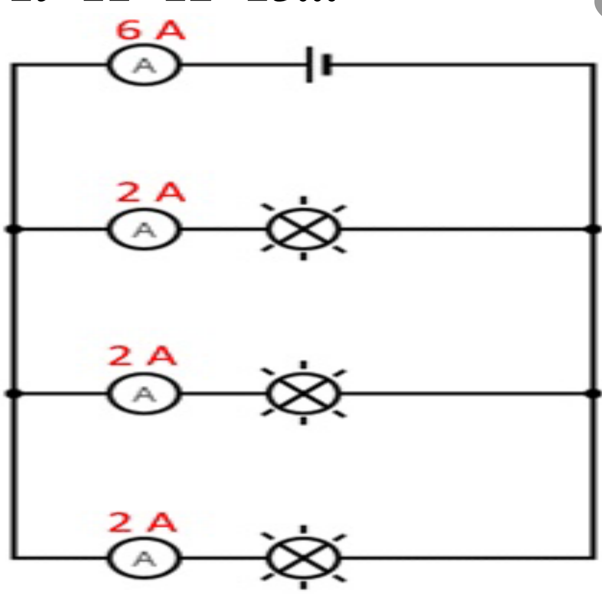
Parallel Circuit

Rules and facts about parallel circuit

1. **Current in parallel circuit:**

The current is split between the branches of the circuit. The sum of the currents of all branches is equal to the total current that flows from the cell / battery. In other words, the **total** current through the whole circuit is the **sum** of the currents through the separate components.

$$I_t = I_1 + I_2 + I_3 \ldots$$



2. **Resistance in parallel circuits:**

Total resistance is worked out using the reciprocal of the resistances of each branch. If there are 3 branches to the circuit (R1 – R3), then 1 / Total Resistance = 1 / R1 + 1 / R2 + 1 / R3. This means that the total resistance of two resistors is less than the resistance of the smallest individual resistor.

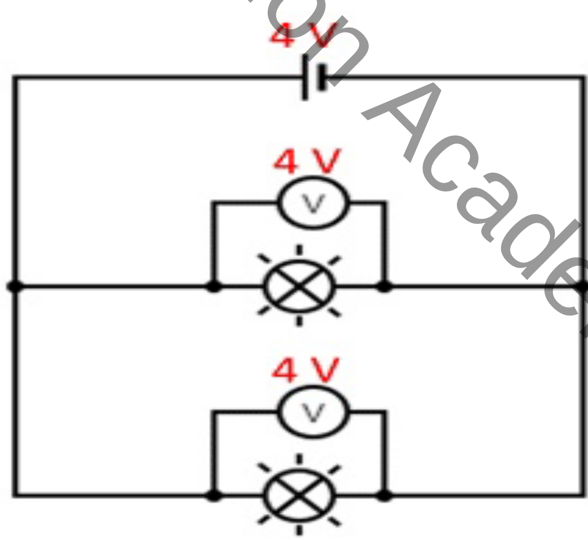
$$1/\text{Total Resistance} = 1/\text{Resistance}_1 + 1/\text{Resistance}_2 + 1/\text{Resistance}_3$$

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

3. **Potential difference in parallel circuit:**

In parallel circuit all components get equal and full potential difference. It Means pd is same across all the component

$$V_t = V_1 = V_2 = V_3$$



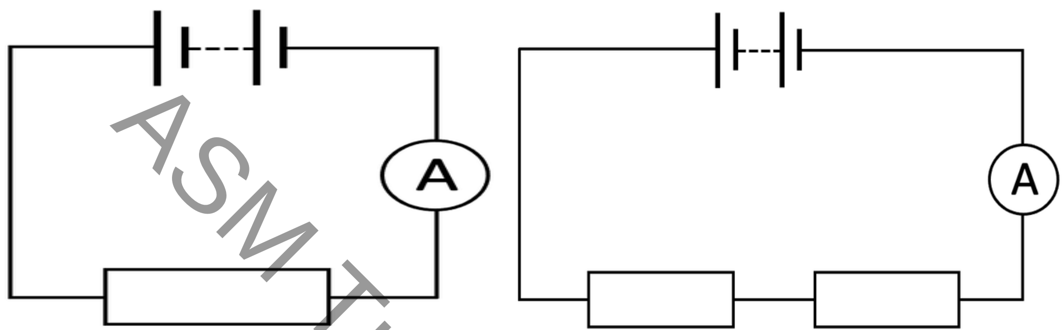
4. **A break in one component does not ruin the whole circuit.** There is **more than one route for charge**, so if one lamp in a parallel circuit is broken, only the lamps in the broken branch are affected. Lighting in houses is often connected in parallel because it means that we can control different branches of the circuit (representing different rooms) using different switches.

Practical:Investigate adding resistors series or parallel

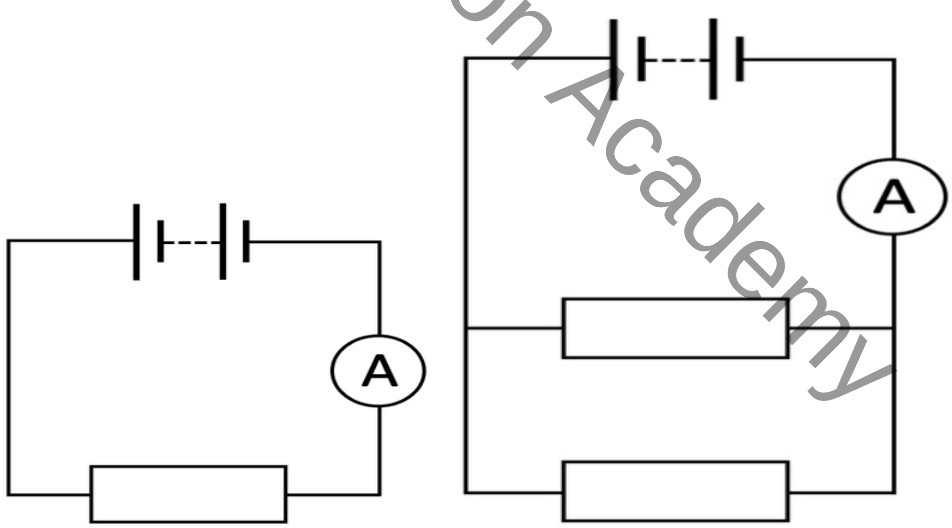
Method

1. Set up the circuit as shown in figure turn the power supply on and close the switch.

Setup for series circuit



Setup for parallel circuit



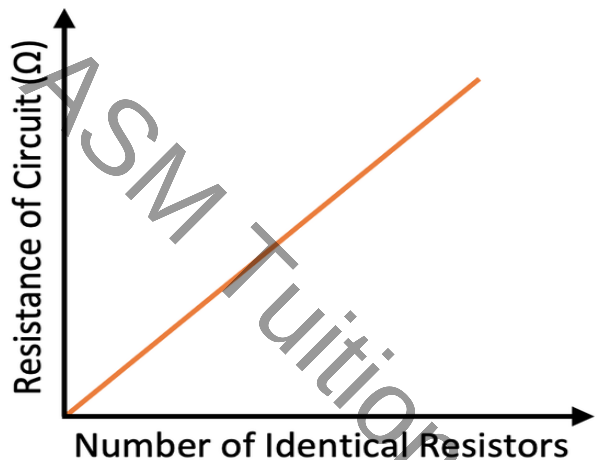
2. Record the voltmeter and ammeter readings and calculate the resistance of the resistor using R = V/I, where R is resistance, V is potential difference and I is current.
3. Change the resistor and repeat step two to find the resistance of a second resistor.
4. Arrange the two resistors in series as shown in figure 2 and close the switch.
5. Record the voltmeter and ammeter readings once again and determine the total resistance of both resistors in series using **R = V/I.**
6. Arrange the two resistors in parallel as shown in figure 3 and close the switch.

7. Record the voltmeter and ammeter readings once again and calculate the total resistance of both resistors in parallel.

Result:

In series circuit: adding resistor in series increases the total resistance and decrease the current through the circuit.

The more resistor added = larger the resistance



In parallel circuit: when we add resistor in parallel total current through The circuit increases and resistance decreases

The more resistor added = smaller the resistance