Year 11 Resistance

Week 9

Circuits

1) Current

Current will only flow through a component if there is a voltage across that component. Unit: ampere, A.

2) Voltage is the driving force that pushes the current round. Kind of like "electrical pressure". Unit: volt, V.

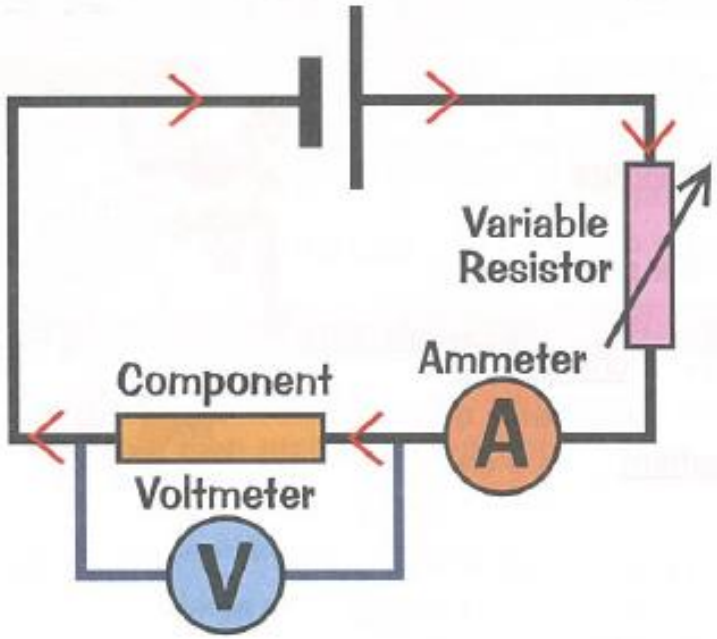
3) Resistance is anything in the circuit which slows the flow down. Unit: ohm, Ω.

4) There's a balance: the voltage is trying to push the current round the circuit, and the resistance is opposing it — the relative sizes of the voltage and resistance decide how big the current will be:

The Balance

If you increase the voltage — then more current will flow.
If you increase the resistance — then less current will flow
(or more voltage will be needed to keep the same current flowing).

The Standard Test Circuit



The Ammeter

Measures the current (in amps) flowing through the component.

Must be placed in series

Can be put anywhere in series in the main circuit, but never in parallel like the voltmeter.

The Voltmeter

Measures the voltage (in volts) across the component.

Must be placed in parallel

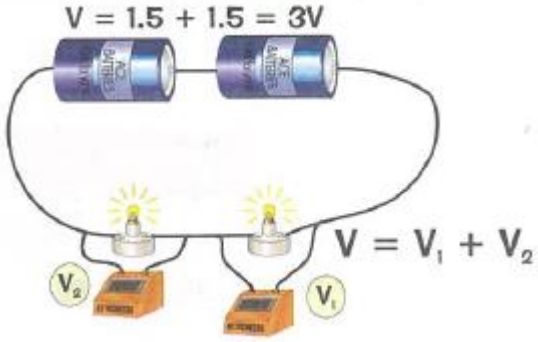
Series Circuit

In series circuits, the different components are connected in a line, end to end, between the +ve and –ve of the power supply (except for voltmeters, which are always connected in parallel, but they don't count as part of the circuit).

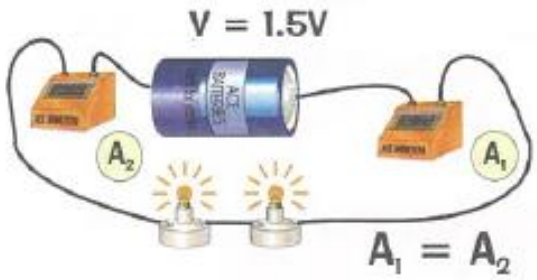
If you remove or disconnect one component, the circuit is broken and they all stop.

Potential Difference is Shared:

$$V = V_1 + V_2 + V_3$$



Current is the Same Everywhere:



In series circuits the same current flows through all parts of the circuit, i.e:

$$A_1 = A_2$$

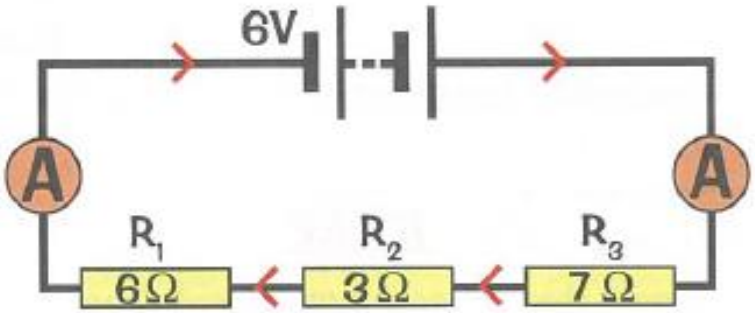
The size of the current is determined by the total P.D. of the cells and the total resistance of the circuit: i.e. $I = V/R$

Series circuit continued

Resistance Adds Up:

In series circuits the total resistance is just the sum of all the resistances:

$$R = R_1 + R_2 + R_3$$



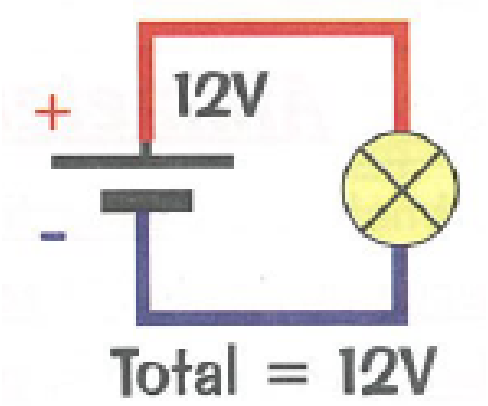
Total resistance = 6 + 3 + 7 = 16Ω

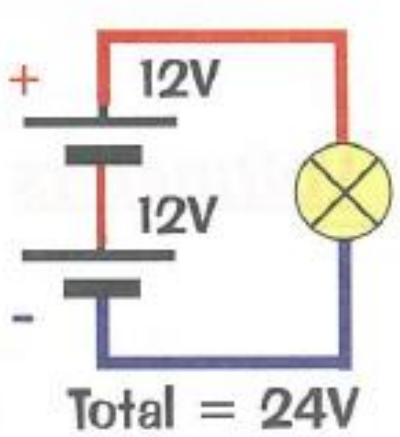
The bigger the resistance of a component, the bigger its share of the total P.D.

Cell Voltages Add Up:

There is a bigger potential difference when more cells are in series, provided the cells are all connected the same way.

For example when two batteries of voltage 1.5 V are connected in series they supply 3 V between them.





Parallel Circuits

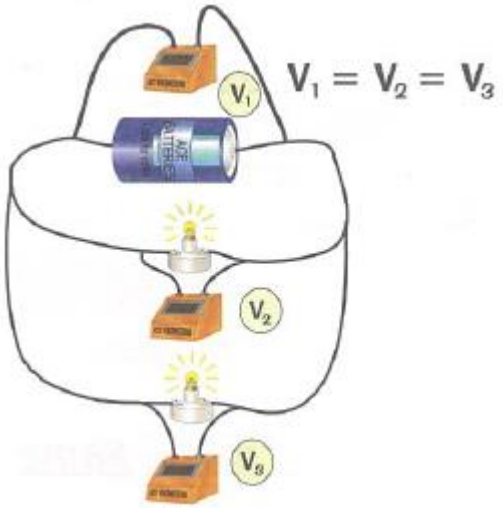
Independence and Isolation

In parallel circuits, each component is separately connected to the +ve and –ve of the supply.

P.D. is the Same Across All Components:

In parallel circuits all components get the full source P.D., so the voltage is the same across all components:

$$V_1 = V_2 = V_3$$



This means that identical bulbs connected in parallel will all be at the same brightness.

Parallel Circuits continued

Current is Shared Between Branches:

$A = A_1 + A_2$

In parallel circuits the total current flowing around the circuit is equal to the total of all the currents in the separate branches.

In a parallel circuit, there are junctions where the current either splits or rejoins. The total current going into a junction has to equal the total current leaving.

If two identical components are connected in parallel then the same current will flow through each component.

Parallel Resistance

The current through each component depends on its resistance.

The lower the resistance, the bigger the current that'll flow through it.

The total resistance of the circuit is

always less than that of the branch with the smallest resistance.

What is Ohm's Law:

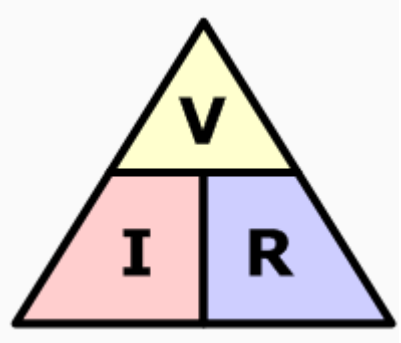
- Ohm's Law is made from 3 **mathematical equations** that shows the **relationship** between electric **voltage**, **current** and **resistance**.
- **V** is voltage measured in **volts**
- **I** is current measured in **amperes**
- **R** is resistance measured in **ohms**

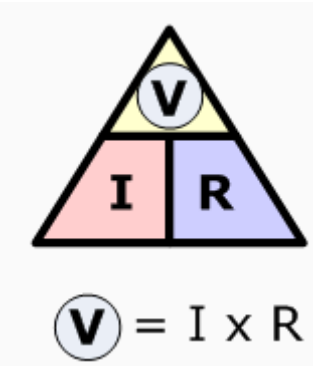
Ohms Law Relationship

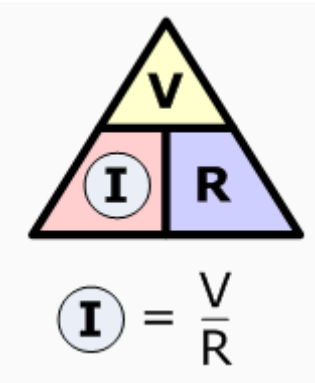
$$Current,(I) = \frac{Voltage,(V)}{Resistance,(R)} \; in \; Amperes,(A)$$

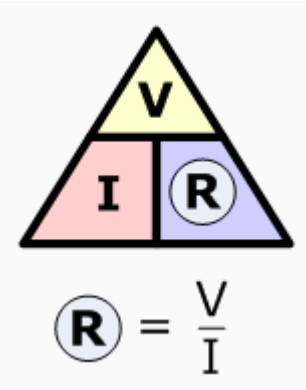
- By knowing any two values of the Voltage, Current or Resistance quantities we can use **Ohms Law** to find the third missing value.
- **To find Voltage (V)**
- [V = I x R] V (volts) = I (amps) x R (Ω)
- **To find Current (I)**
- [I = V ÷ R] I (amps) = V (volts) ÷ R (Ω)
- **To find Resistance (R)**
- [R = V ÷ I] R (Ω) = V (volts) ÷ I (amps)

Ohms Law Triangle







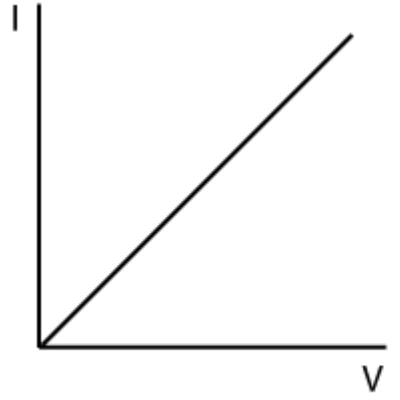


Ohmic and Non-ohmic

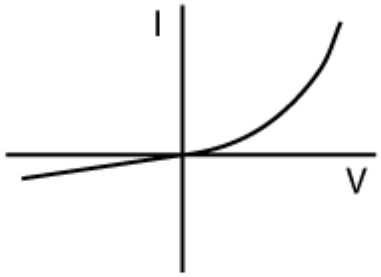
- Any Electrical device or component that obeys "Ohms Law" that is, the current flowing through it is proportional to the voltage across it ($I \propto V$), such as resistors or cables, are said to be **"Ohmic"** in nature,
- Devices that do not, such as transistors or diodes, are said to be **"Non-ohmic"** devices.

Ohmic nonOhmic Graphs

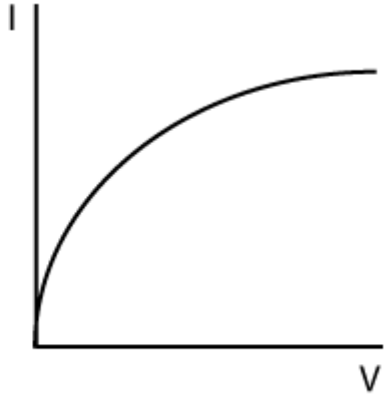
- Below you can see 3 graphs with current on the vertical axis, and voltage on the horizontal axis.
- Where the graph is a straight line, the voltage is proportional to the current.
- Therefore, only the metallic conductor is an ohmic conductor.



Metallic conductor



Semiconductor diode



Filament lamp

Resistivity

- The **resistivity** of a material is the property that determines its resistance for a unit length and unit cross sectional area of that material.
- Copper, for example, is a better conductor than lead, in other words lead has a higher resistivity than copper.
- You can compare different materials in this way.

Resistivity Equation

- Resistivity, ρ (the Greek letter rho), is defined by the equation:

$$\rho = \frac{RA}{l} \qquad R = \frac{\rho l}{A}$$

- Where ρ is resistivity, R is the resistance, A is the cross sectional area of the material, and l is the length of the material.
- The units of resistivity are Ohm-meters, Ωm.

The Equations

- **V = I x R (Voltage = Current multiplied by Resistance)**
- **R = V / I (Resistance = Voltage divided by Current)**
- **I = V / R (Current = Voltage Divided by Resistance)**

Finding the Voltage

- **Knowing any two of the values of a circuit**, one can determine (calculate) the **third,** using Ohm's Law.
- **For example, to find the Voltage in a circuit:**
- **If the circuit has a current of 2 amperes, and a resistance of 1 ohm, (these are the two "knowns"), then according to Ohms Law and the formulas above, voltage equals current multiplied by resistance:**
- **(V = 2 amperes x 1 ohm = 2 volts).**

Finding the Current

- **To find the current in the same circuit *assuming we did not know it* but we know the voltage and resistance:**
  I = 2 volts divided by the resistance 1 ohm = 2 amperes.

Finding the Resistance

- **In this third example we know the current (2 amperes) and the voltage (2 volts)....what is the resistance?**
  Substituting the formula:
  R = Volts divided by the current (2 volts divided by 2 amperes = 1 ohm