5.1 Electric potential difference, current and resistance

5.1.1 Define electric potential difference.

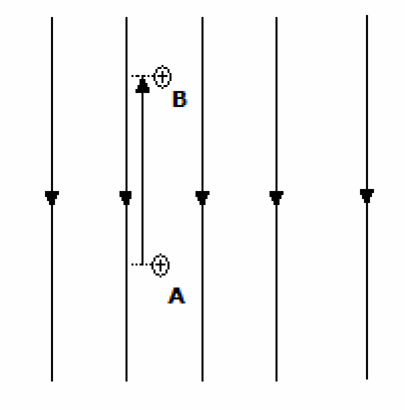
The potential difference is defined as the work done per unit charge to move a positive test charge between A and B.

$$PotentialDifference = \frac{EnergyDifference}{Charge}$$

The base unit for potential difference is the Joule per Coulomb (JC^{-1}).

5.1.2 Determine the change in potential energy when a charge moves between two points at different potentials.

To move a charge in an electric field work must be done. The change in the electrical potential energy (which is equal to the work done) is the potential difference.



When the charge, q, moves from point A to point B it gains electrical potential energy. Work must be done to move the charge.

Change in potential energy = Force x distance

= F x d

= E x q x d

E is the Electric Field Strength and is explained further in Topic 6

5.1.3 Define the electronvolt.

The joule is too large a measure of energy to be used at a subatomic level. For very small energies electronvolts (eV) are used.

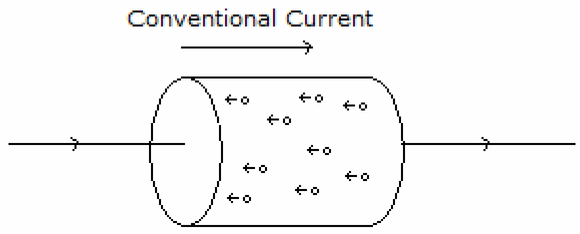
$1\ eV = 1.6 \times 10^{-19}\ J$

5.1.4 Solve problems involving electric potential difference.

5.1.5 Define electric current.

Electrical current is the flow of charged particles through a material when a potential difference is applied across it. By convention the current carriers are the positively charged particles.

In a metallic conductor the charge carriers are electrons so the conventional current flows in the opposite direction to the charge carriers.



Electrical current is defined as the rate of flow of electrical.

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

$$I = \frac{Q}{t}$$

5.1.6 Define resistance.

Resistance is a measure of how easily a charge can flow in a material. The resistance is defined as the ration of the potential difference across a material to the current flowing through it.

$$Resistance = \frac{PotentialDifference}{Current}$$

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

The unit of resistance is the ohm (Ω). One ohm is defined as the resistance of a material through which a current of one amp flows when a potential difference of one volt is applied across it.

5.1.7 Apply the equation for resistance in the form R=ρl / A

The resistance on a wire (at a constant temperature) depends upon

- Length
- Cross sectional area
- Resistivity.

The resistivity of a material tells us how well that material conducts. Good conductors have a very small resistivity ($\approx 10^{-8}$ Ωm). Insulators have a very large resistivity (Glass $\approx 10^{12}$ Ωm)

5.1.8 State Ohm's law.

Ohm's Law

Providing the physical conditions such as temperature are kept constant, the resistance is constant over a wide range of applied potential differences and therefore the potential difference is directly proportional to the current.

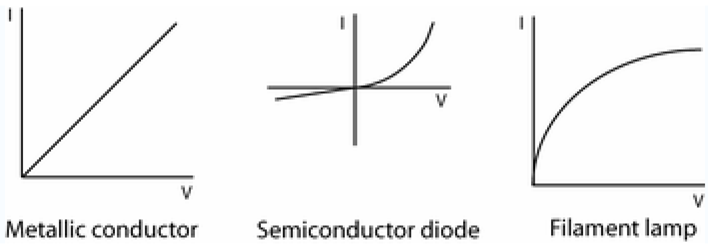
Ohm's law is commonly written as

Voltage = Current x Resistance

V = I R

5.1.9 Compare ohmic and non-ohmic behaviour.

In non-ohmic behavior V and I are not proportional to each other. Examples of this include light bulb filaments and semi-conductor devises like diodes and transistors.



5.1.10 Derive and apply expressions for electrical power dissipation in resistors.

Electrical power is the rate that an electrical devise uses energy.

$$P = \frac{E}{t} = I^2 R = \frac{V^2}{R}$$

5.1.11 Solve problems involving potential difference, current and resistance.

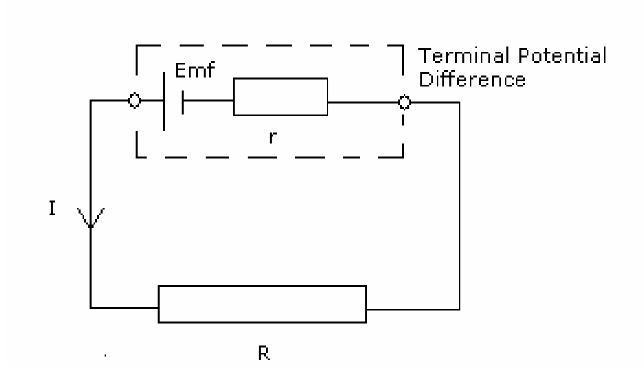
5.2 Electric circuits

5.2.1 Define electromotive force (emf).

The emf is the amount of energy per unit charge supplied to a circuit by a power source. For a call it is the amount of chemical energy converted to electrical energy per unit charge..

5.2.2 Describe the concept of internal resistance.

When a battery supplies a current to an external circuit it gets warm. This is due to the battery having a small internal resistance.



The Emf of the supply is the sum of the potential dropped across the internal resistor and the external resistor.

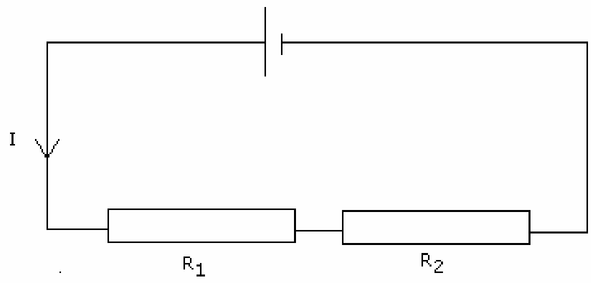
$$\varepsilon = Ir + IR$$

$$\varepsilon = Ir + \text{Terminal Potential}$$

$$\text{Terminal Potential} = \varepsilon - Ir$$

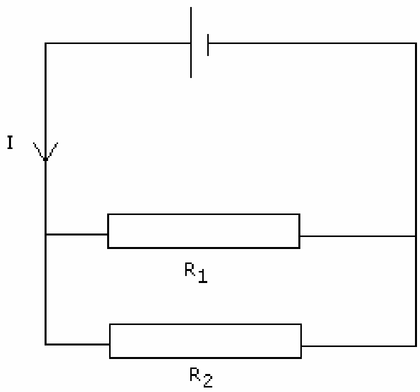
5.2.3 Apply the equations for resistors in series and in parallel.

Resistors in Series



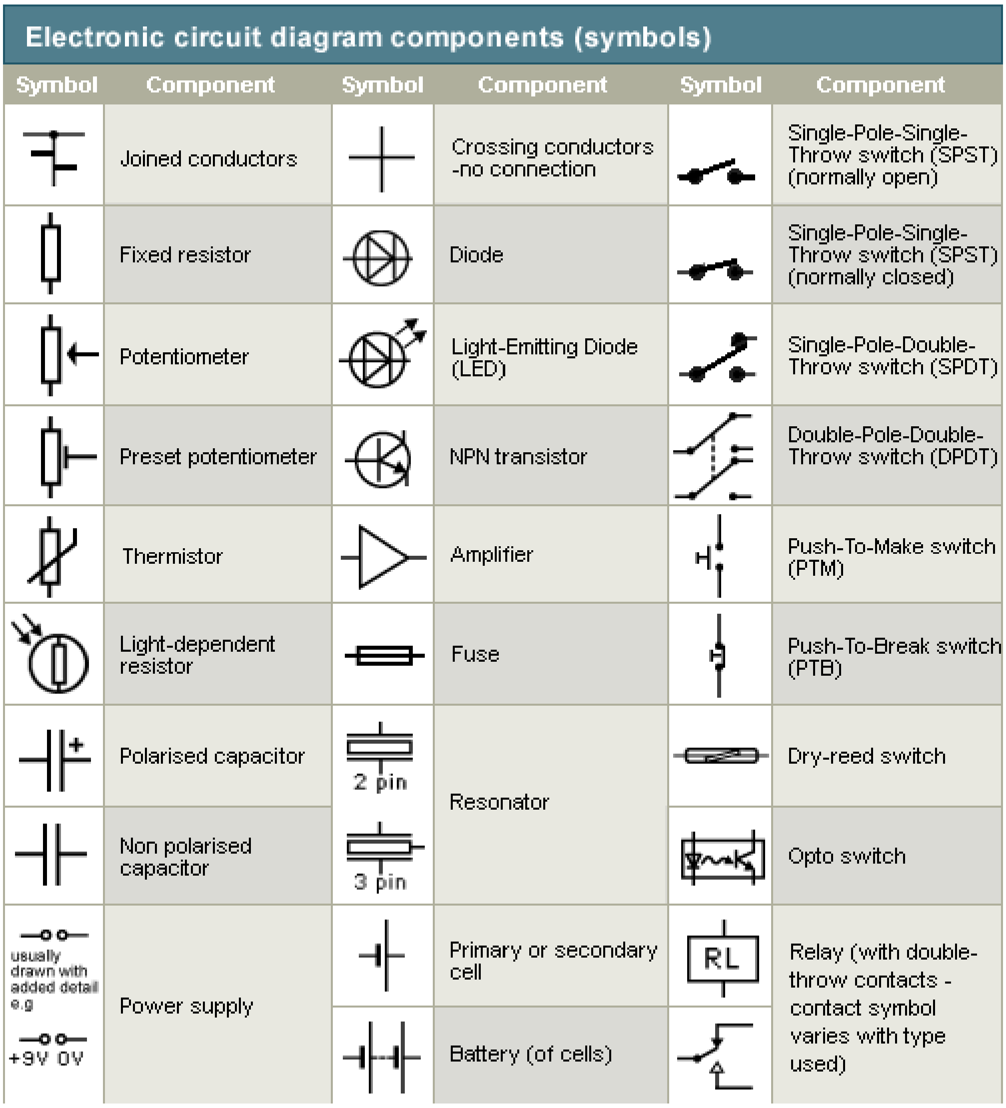
$$R_{Total} = R_1 + R_2 + \ldots\ldots$$

Resistors in Parallel



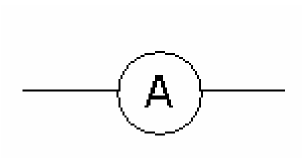
$$\frac{1}{R_{Total}} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots\ldots$$

5.2.4 Draw circuit diagrams



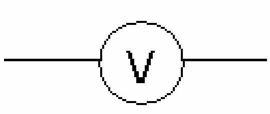
Electronic circuit diagram components (symbols)					
Symbol	Component	Symbol	Component	Symbol	Component
	Joined conductors		Crossing conductors -no connection		Single-Pole-Single-Throw switch (SPST) (normally open)
	Fixed resistor		Diode		Single-Pole-Single-Throw switch (SPST) (normally closed)
	Potentiometer		Light-Emitting Diode (LED)		Single-Pole-Double-Throw switch (SPDT)
	Preset potentiometer		NPN transistor		Double-Pole-Double-Throw switch (DPDT)
	Thermistor		Amplifier		Push-To-Make switch (PTM)
	Light-dependent resistor		Fuse		Push-To-Break switch (PTB)
	Polarised capacitor	2 pin	Resonator		Dry-reed switch
	Non polarised capacitor	3 pin			Opto switch
usually drawn with added detail e.g +9V 0V	Power supply		Primary or secondary cell	RL	Relay (with double-throw contacts - contact symbol varies with type used)
			Battery (of cells)		

5.2.5 Describe the use of ideal ammeters and ideal voltmeters.



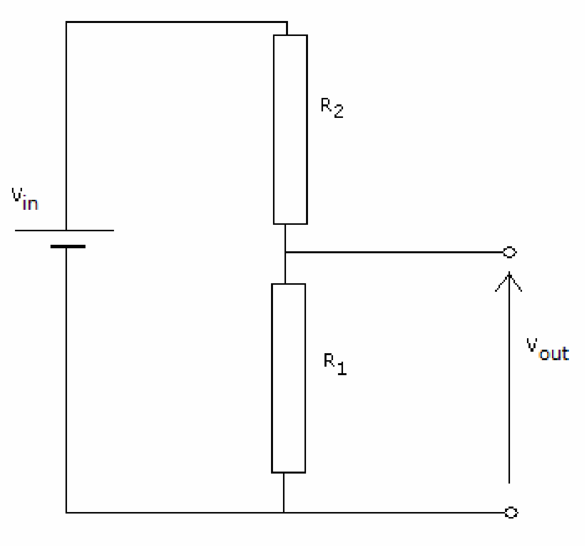
Ammeters are used to measure the current in a circuit. They are connected in series with the component under test. In order to have no effect on the circuit they should have a very small resistance. Ideal ammeters have zero resistance. This means that no potential difference is dropped across them.

Voltmeters are used to measure the voltage in the circuit. They are connected in parallel with the component under test. Voltmeters have a very high resistance so that very little current is allowed to flow through them. An ideal voltmeter has an infinite resistance.



5.2.6 Describe a potential divider.

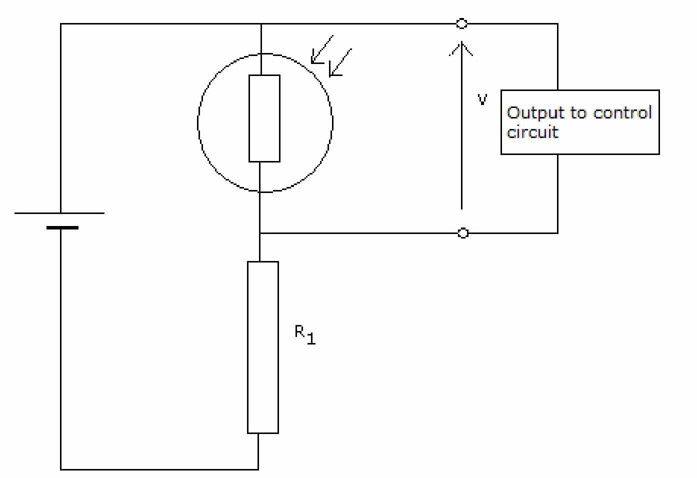
Resistors connected in parallel can be used to control voltages. By changing the ratio of the resistors it is possible to vary how much potential is dropped across either V_1 or V_2.



$$V_{out} = V_{in} \frac{R_2}{R_1 + R_2}$$

5.2.7 Explain the use of sensors in potential divider circuits.

Light Switch



When light stops shining on the LDR then its resistance will increase. As the resistance changes the potential difference dropped across it will change. This change in potential can be detected by an external circuit which can then switch lights on and off as required.