Electrical Circuits

Key terms

Current is the flow of electrical charge. Measured in amps (A)

Potential difference is the force that pushes the charge around. Measured in volts (V).

Resistance is something that flows down the flow of current. Measured in ohms (Ω).

Charge

Current depends on the rate of flow of charge.

$$Q = It$$

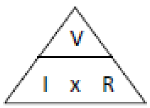
Charge (coulombs, C) → Q; Current (A) → I; Time (s) → t

Resistance

Resistance of a component can be calculated if you know the potential difference and the current.

$$V = IR$$

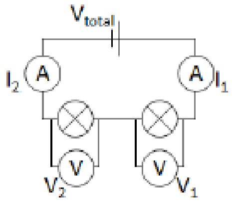
Potential difference (V) → V; Resistance (Ω) → R



Re-arranged to:

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

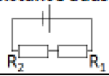
Series Circuits



Current is the same throughout the circuit: $I_1 = I_2 = \ldots$

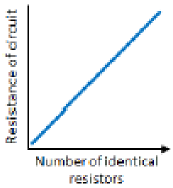
Potential difference is shared across the components: $V_{total} = V_1 + V_2 + \ldots$

Resistance adds up: $R_{total} = R_1 + R_2 + \ldots$

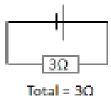


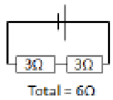
Investigating Resistance

REQUIRED PRACTICAL
SEE PRACTICAL SHEET FOR DETAIL

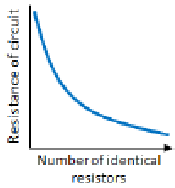


As more resistors are added in series the total resistance will increase.





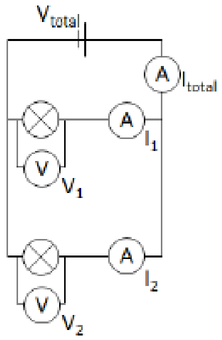
As more resistors are added in parallel the total resistance will decrease.



This is because resistors in parallel have the same pd across them as the power supply. Adding another loop to the circuit means the current has more than one way it has to go. Therefore the total current around the circuit increases. An increase in current means a decrease in resistance (V = IR)

V stays the same. If I goes up then R must go down.

Parallel Circuits



Current is shared across the components: $I_{total} = I_1 + I_2 + \ldots$

Potential difference is the same across all components: $V_1 = V_2 = \ldots$

Total resistance will fall if two or more resistors are added in parallel.

Factors Affecting Resistance

REQUIRED PRACTICAL
SEE PRACTICAL SHEET FOR DETAIL

Length or diameter of wire, temperature and the types of components affect resistance. These can be investigated.

Electricity In The Home

AC and DC

With **alternating current** (AC) the current constantly changes direction. It is produced by an alternating voltage where the positive and negative ends keep alternating.

The UK mains supply is AC at 230V. It has a frequency of 50Hz.

With **direct current** (DC) the current always flows in the same direction. Batteries produce a DC voltage.

Electrical Wiring

Most electrical appliances are connected to the mains with a three core cable (3 copper wires coated in insulating plastic):

- **Live** (brown) – Provides the alternating pd at 230V.
- **Neutral** (blue) – Completes the circuit carrying the current out of the appliance at 0V.
- **Earth** (green and yellow) – A safety feature. Prevents the appliance becoming live if there is a fault so does not normally carry a current. It is at 0V.

Live Wire

If you touch the live a large pd is produced across your body and the current flows through you. This electric shock can injure or kill you.

A connection between the live and earth creates a low resistance path to earth so a large current will flow. This could cause a fire.

Power

Energy in an electrical circuit is transferred by a moving charge. The charge has to work against resistance, so work is done. Work done is the same as energy transferred and depends upon power.

Energy transferred (J) → $E = Pt$ ← Time (s)

Power (W)

Appliances have a power rating, the maximum operating power.

An appliance with a lower power rating will be cheaper to run (less energy transferred per second).

A higher power rating might not mean more energy is transferred usefully. It could be less efficient than another appliance so only transfer the same amount, or less, energy to useful stores.

Charge

Energy is supplied to the charge at a power source, 'raising' through a potential.

Energy is given up by the charge at components as it falls through a potential drop.

$E = QV$ ← Potential difference (V)

Charge flow (Coulombs, C)

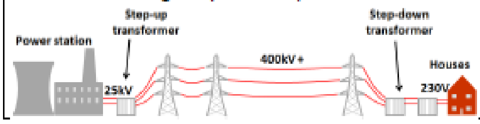
Meeting Demand

Power stations have to meet the demand for electricity, which varies during the day. They usually run below maximum capacity so more electricity can be generated to meet demand, such as during big sporting events.

National Grid

A network of cables that connects power stations to consumers.

A huge amount of power is needed. This is achieved with a **high pd** but a **low current**. A high current would cause the wires to heat up, wasting a lot of energy. It is cheaper to increase the pd and keep the current low for a given power output.



Power Calculations

Power (W) depends upon the potential difference (V) and current (A):

$P = VI$ Or, if the potential difference is not known: $P = I^2R$

Proton

One of the three fundamental particles* that make up atoms. Of the three fundamental particles, protons are the second largest by mass. They have a positive electrical charge of +1.6 × 10^{-19} C.

Charge (Q)

Electrical charge is a property or quality that some particles*(and hence bodies) can have which gives rise to forces of attraction or repulsion between those particles. Charge is measured in coulombs* and is represented by the symbol, Q.

Coulomb

The unit of electrical charge*. 1 coulomb is abbreviated to C.

Current (I)

Electrical current is the flow of charges*. In wires, the charges are carried by electrons*. In fluids*, the charges are carried by ions*. Current is measured in amperes* and is represented by the symbol, I.

Ampere

The unit of electrical current, normally abbreviated to amp or A. 1 amp is equal to a flow of 1 coulomb* of charge* per second.

This translates to the formula, amps = coulombs ÷ seconds.

Ammeter

A device for measuring current. An ammeter is always connected directly into a circuit in series* with the components through which the current is flowing. A good ammeter will have virtually no resistance*.

Conductor

A conductor is a medium through which an electric current*will flow.

Circuit

An electrical circuit is a closed loop consisting of an energy source connected by conductors to electrical components.

Cell

A cell is a store of chemical energy used to do electrical work.

Battery

A group of electrical cells connected in series to provide an energy source for a circuit*.

Potential Difference

The measure of energy available to drive a current*. Potential Difference is measured in volts* and is represented by the symbol, V. Potential difference can sometimes be referred to as voltage.

Volt

The unit of potential difference* or voltage .

Voltmeter

A device for measuring potential difference* or voltage .

Circuit

An electrical circuit is a closed loop consisting of an energy source connected by conductors to electrical components.

Parallel

In a parallel electrical circuit, the potential difference is the same across all components. The current is shared between the components.

Series

In a series electrical circuit, the current is the same at all points in the circuit. The potential difference is shared between the components.

Power

The amount of energy transferred per second. Power is measured in watts and is represented by the symbol, P.

Watt

The unit of power. 1 watt is defined as the consumption of energy at the rate of 1 joule per second.

Resistance (R)

Resistance is the extent to which a conductor* slows (hinders) the flow of an electric current. Resistance is measured in ohms* and is represented by the symbol, R.

Ohm

The unit of electrical resistance*.

Resistor

A resistor is a circuit component designed to reduce current.

Ohm's Law

Ohm's Law quantifies the relationship between voltage*,resistance*, and current* . This relationship states that: The potential difference (voltage) across an ideal conductor is proportional to the current through it. The constant of proportionality is called the "resistance", R.

LDRs (light-dependent resistors)

Are used to detect light levels, for example, in automatic security lights. Their resistance decreases as the light intensity increases

Thermistors

Are used as temperature sensors, for example, in fire alarms. Their resistance decreases as the temperature increases