# OCR (A) Physics GCSE

## Topic P3: Electricity

### Summary Notes

(Content in bold is for Higher Tier only)

# P3.1 Static and Charge

## Charge

Charge is a property of all matter and can be **positive or negative.** If a body has the same amount of positive and negative charge they cancel out, forming a neutral body (i.e. protons and electrons in a neutral atom).

Like charges repel and opposite charges attract.

Insulators **don't conduct** charge as their charged particles **cannot flow** throughout the material, and are fixed.
Conductors **can conduct** charge as their charged particles are delocalised and **can flow** instead of being fixed.

## Static Electricity

When two insulators are rubbed together electrons are **transferred** from one to the other. This forms a **positive** charge on the object losing electrons and a **negative** charge on the object gaining electrons. The object that loses or gains electrons depends on the materials involved. These insulators become charged because the electrons cannot flow.

If conductors are rubbed, electrons will **flow** in and out of them cancelling any overall effect, so they remain neutral.

**Sparking** occurs when enough charge builds up, and the objects are close but not touching. The "spark" is when the charge jumps through the air from the **highly** negative object to the **highly** positive object to balance out the charges.

## Forces exerted

Charged objects experience a force called **electrostatic force** which can be attractive or repulsive. **Greater charge** and **smaller separations** results in **greater force** as the force is proportional to the inverse square of the distance.

Electrostatic force is a non-contact force, as it is experienced even when the objects are not touching.

## Testing the Force

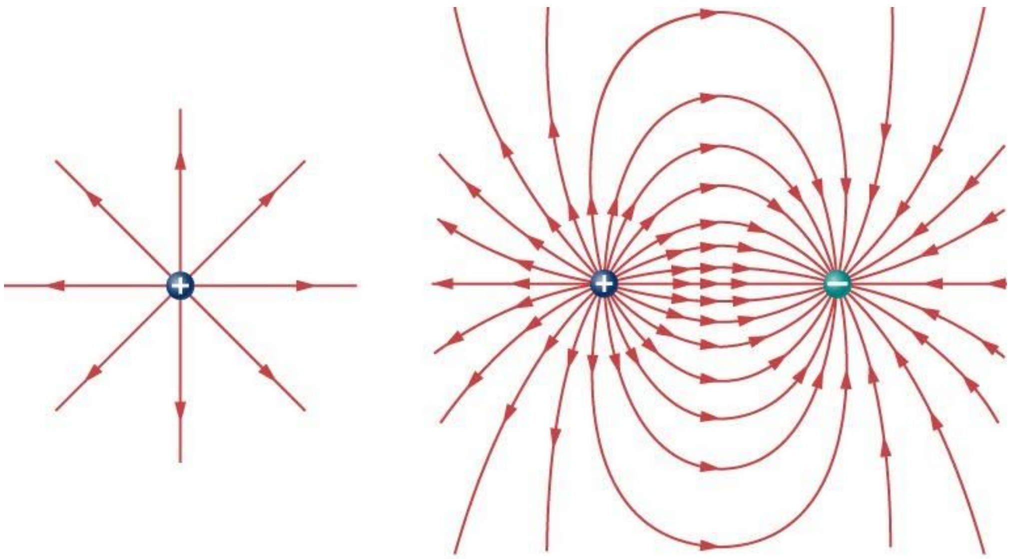
Charged objects attract small neutral objects placed near them because the positive/negative charge on the object will attract/repel the electrons within the small objects, inducing a charge inside them causing them to be attracted.

e.g. A stream of water will bend towards a charged object due to induced attraction

## Electric Fields (Physics Only)

Like magnetic fields for magnets, **electric fields are for charges.** They point in the direction a positive charge would go (i.e. **away from positive** charges, and **towards negative** charges.). The fields point charges at right angles to the surface.

The stronger the charge, the more field lines there are and the stronger the force felt.



(a) (b)

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## Current

For a current to flow there needs to be a **closed circuit** and a **source of potential difference** (i.e. a battery). This p.d. source is needed to "push" the current through the resistance of the circuit and needed for the "difference in potential" which causes electrons to flow.

$$charge = current \times time$$

Current has the same value at any point in a single, closed loop.

## P3.2 Simple Circuits

**Potential Difference (p.d)**, represented by 'V' is measured in Volts and is the energy transferred per unit charge. P.d. is measured across two points using a **voltmeter** placed in **parallel** across a component.

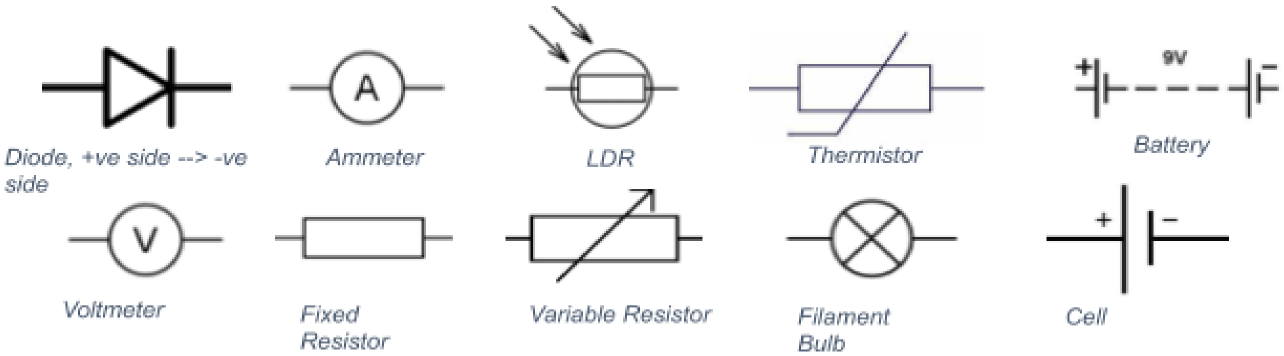
**Current**, represented by 'I' is measured in Amps and is the rate of flow of charge (electrons). It can be measured at any single point on the circuit using an **ammeter** placed in **series**.

### Series and Parallel Circuits

A series circuit is a closed circuit where the current only follows a single path. This current is the same everywhere.

A parallel circuit is a branched circuit where the current splits into multiple paths. This current may be different in the different branches but voltage is the same across each branch.

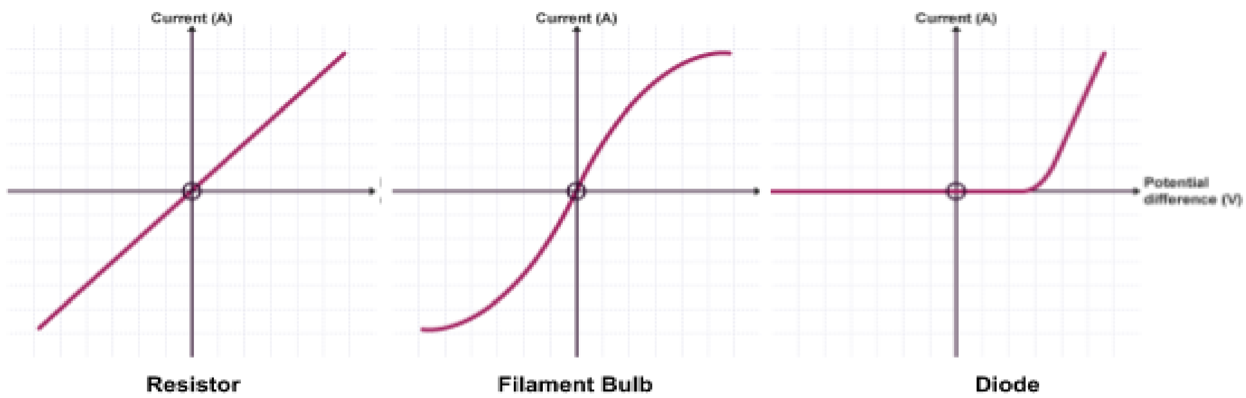
### Common Circuit Symbols




### Relationships between R, V and I

If resistance (R) is constant, the graph of current (I) against voltage (V) is **linear** for all values of current. If R changes, the graph of I against V is **nonlinear**. This change in resistance may be due to heat, current or length of wire.

$$voltage = current \times resistance$$



## How Does Resistance Change?

### With Current

As current increases, electrons (charge) have **more energy.** When these electrons flow through a resistor, they collide with the atoms in the resistor. This transfers energy to the **atoms**, causing them to **vibrate more.** These increased vibrations make it more **difficult** for electrons to flow through the resistor, so resistance increases, and the current decreases.

### With Temperature

For normal wires the same process occurs as above due to increased atoms vibrations when hot.
For Thermistors, resistance is lower at higher temperatures. This feature makes thermistors very useful in temperature detectors and thermostats.

### With Length

- Greater length, the more resistance, and the lower the current.
- Electrons have to make their way through more resistor atoms, so it is harder than using a shorter wire.

### With Cross Sectional Area

Thinner wires give greater resistance because less overall room for electrons to pass through between atoms.

### With Light

For light dependant resistors (LDRs) : a greater the intensity of light means there is a lower resistance, so resistance is greatest when dark. This feature means LDRs are commonly used in automatic night lights.

### With Voltage

Diodes allow current to flow freely in one direction. In the opposite direction, they have a very high resistance so no current can flow. Therefore diodes can be used to get direct current (DC) output from alternating current (AC) input.

## Testing Relationships Experimentally

When conducting these experiments it is important to make sure components **do not overheat**. Always leave to cool down between each reading.

### Varied Wire Resistance

- Use wires of resistance $1\Omega$ to $10\Omega$.
- Connect to DC of 2, 4, 6, …, 10, 12V.
- Connect in series to an ammeter and in parallel to a voltmeter.
- Make sure all the other wires used have **negligible resistance.**
- Measure I for each voltage and for each wire, then **plot a graph** to show the relationship.

**Filament Lamps**

- Connect to DC of 2, 4, 6, …, 10, 12V.
- Connect a filament lamp to an ammeter and a voltmeter.
- Measure the current for each voltage.
- **Plot an I-V graph** to show the relationship.
- Non-linear shows R varies.

**Diodes**

- Connect to DC of 1, 1.5, 2, 4, 6, …, 10, 12V.
- Connect an ammeter and a voltmeter.
- Measure current for each voltage.
- Switch the diode the other way around to record current for -1, -1.5, -2, -4V.
- **Plot and I-V graph.**

**LDR**

- Use a constant voltage of 12V.
- Connect to an ammeter.
- Shine a lamp immediately onto the thermistor and measure the current.
- Move the lamp ~10cm away and measure current again.
- Repeat until the lamp is 50cm away.
- Calculate resistance at each light intensity.
- **Plot graph** of resistance against light intensity.

**Thermistor**

- Use a constant voltage of 12V.
- Connect to an ammeter.
- Place in ice water with a thermometer.
- Measure current at 0ºC.
- Add hot water and stir, measuring current at 10, 20, …, 60ºC.
- Calculate the resistance at each temperature.
- **Plot graph** of resistance against temperature.

## Resistors in Series & Parallel

**Series**

Components are connected end to end so all the current flows through all the components. The total resistance is the **sum** of the resistance in each component. Resistance of two components is bigger than just one of them, because the charge has to push through both of them when flowing round the circuit.

**Parallel**

Components are connected separately to the power supply so current flows through each one separately. Total resistance is **less** than the branch with the smallest resistance and is calculated as the **sum of the reciprocals** of resistance.Two resistors in parallel will have a smaller overall resistance than just one because charge has more than one branch to take, so only some charge will flow along each branch.

**Power Transfer**

$$Power = Current \times Voltage = IV$$

$$P = I^2 R$$

$$(unit = Watts)$$

$$Energy = Charge \times Potential\ Difference = QV$$

$$Energy = Power \times Time = Pt = IVt$$