Edexcel GCSE Physics

Your notes

Mains Electricity

Contents

AC & DC

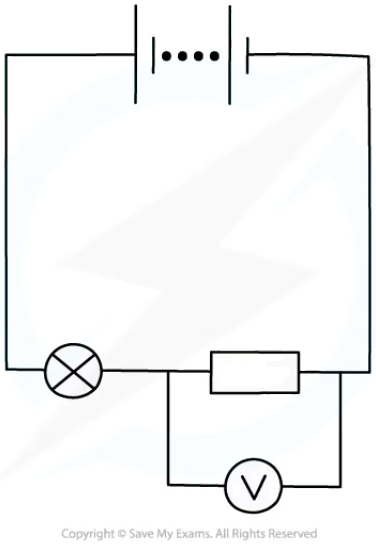
Your notes

Direct Current (DC)

- A direct current (d.c.) is defined as

  A current that is steady, constantly flowing in the same direction in a circuit, from positive to negative

- The potential difference across a cell in a d.c. circuit travels in **one direction only**
  - This means the current is only positive or only negative
- A d.c. power supply has a fixed positive terminal and a fixed negative terminal
- Electric **cells**, or **batteries**, produce direct current (d.c.)



Circuits powered by cells or batteries use a d.c. supply

Examiner Tips and Tricks

All the circuits you have studied so far are d.c. circuits. Don't be put off by an exam question if you are asked to calculate the current, potential difference or resistance in a d.c. series circuits, you don't have to do anything different from what you have already learned!

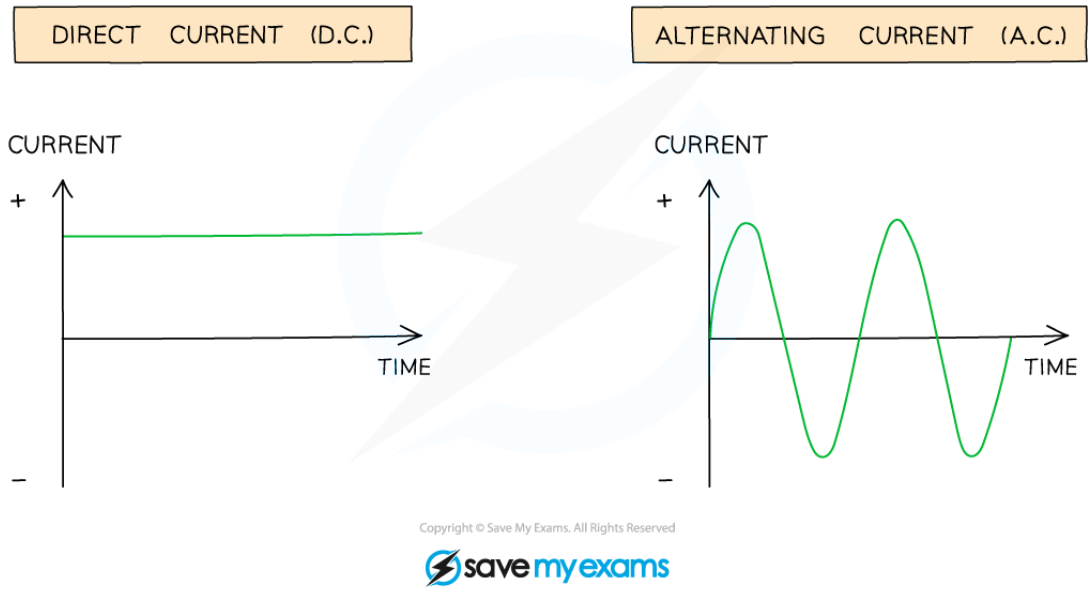
Your notes

Alternating Current (AC)

- An alternating current (a.c.) is defined as

  A current that continuously changes its direction, going back and forth around a circuit

- An a.c. power supply has two identical terminals that switches between positive and negative
  - The current is therefore defined as positive **or** negative, depending on which direction it is flowing at that time
- The **frequency** of an alternating current is the number of times the current changes direction back and forth each second
- In the UK, mains electricity is an alternating current with a frequency of 50 Hz and a potential difference of around 230 V
- On an oscilloscope, direct current and alternating current are represented in the following way:



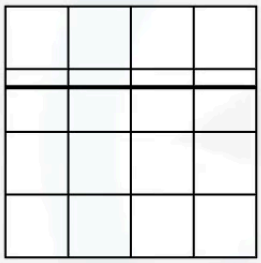
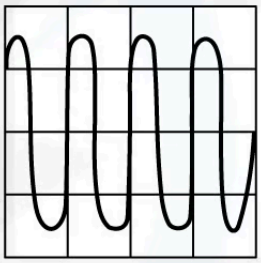
Two graphs showing the variation of current with time for alternating current and direct current

Comparing AC & DC

- The following table summarises the differences between d.c. and a.c.

Your notes

Direct Current vs. Alternating Current Table

Direct Current (d.c.)	Alternating Current (a.c.)
Continuous and in one direction	Constantly changing direction
	
Produced by cells and batteries	Produced by electrical generators i.e. mains electricity
Has a positive and negative terminal	Has two identical terminals

Examiner Tips and Tricks

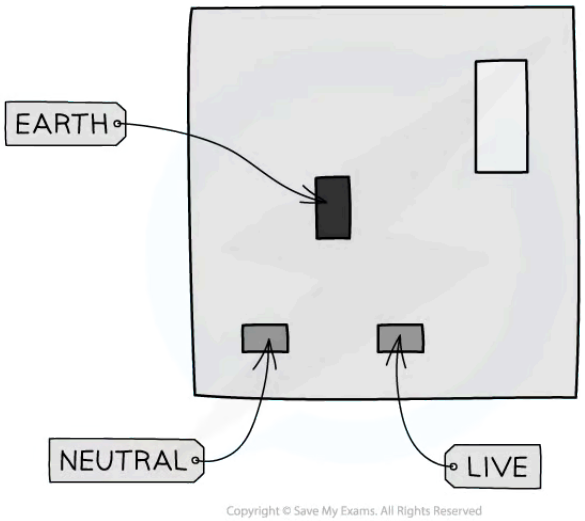
If you are asked to explain the difference between alternating and direct current, sketching and labelling the graphs shown above can earn you full marks. All the circuits you have studied so far are d.c. circuits. Don't be put off by an exam question if you are asked to calculate the current, potential difference or resistance in a d.c. series circuits, you don't have to do anything different from what you have already learned!

Mains Electricity

Your notes

Mains AC

- Mains electricity is the electricity generated by power stations and transported around the country through the National Grid
  - Everyone connects to the mains when plugging in an appliance such as a phone charger or kettle
- Mains electricity is an **alternating current** (a.c.) supply
- In the UK, the domestic electricity supply has a **frequency** of **50 Hz** and a **potential difference** of about **230 V**
  - A frequency of 50 Hz means the direction of the current changes back and forth 50 times every second
- Mains electricity, being an alternating current, does not have positive and negative sides to the power source
  - The equivalent to positive and negative are called **live** and **neutral** and these form either end of the electrical circuit



The live and neutral wires deliver the electricity to the device. The Earth wire is purely for safety

Examiner Tips and Tricks

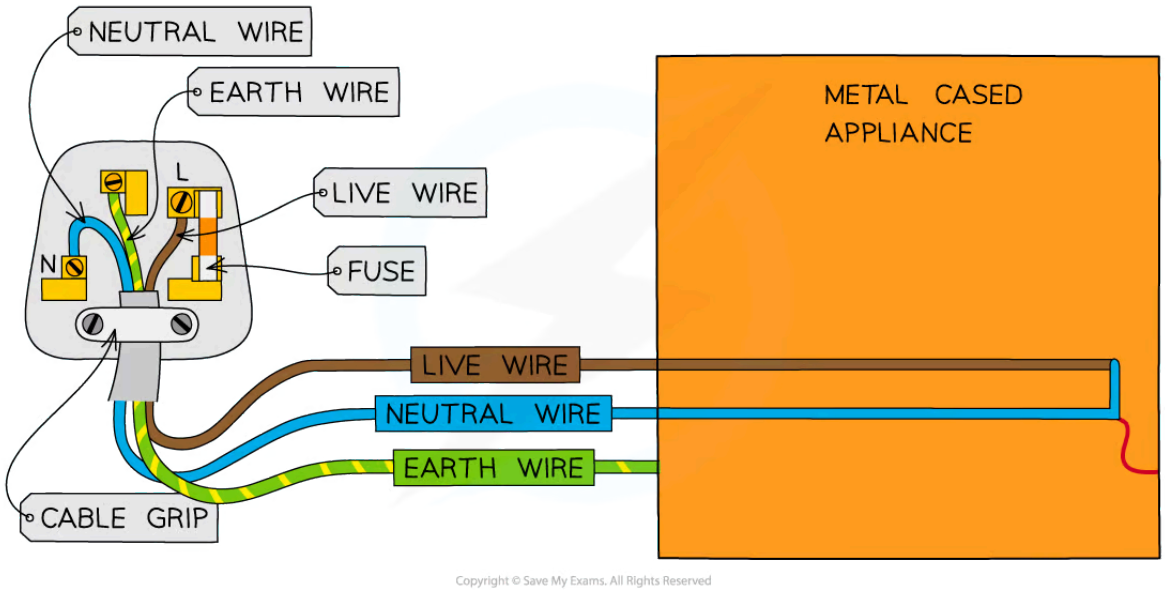
You will be expected to remember the values of frequency and potential difference for mains electricity in the UK, so make sure you memorise these numbers:

- Frequency = 50 Hz
- Potential difference ~ 230 V

Your notes

Live & Neutral

- All electrical appliances are connected to the mains using at least a live wire and a neutral wire
- In the UK, most electrical appliances are connected to the mains using a three-core cable consisting of
  - A live wire
  - A neutral wire
  - An Earth wire
- The insulation covering each wire is colour coded for easy identification:
  - Live wire – **brown**
  - Neutral wire – **blue**
  - Earth wire – **green and yellow stripes**



A diagram showing the three wires going to a mains powered appliance: Live, Neutral and Earth

The Live Wire

- The **live** wire:

  Carries the alternating potential difference from the supply to a circuit

- It is the most dangerous of the three wires
- If it touches the appliance without the Earth wire, it can cause electrocution

The Neutral Wire

- The **neutral** wire:

  Forms the opposite end of the circuit to the live wire to complete the circuit

- Because of its lower voltage, it is much less dangerous than the live wire

Examiner Tips and Tricks

One way to remember which colours is which wire on the diagram, try looking at the second letter of each colour which corresponds to its position:

- B**l**ue = **L**eft (Neutral)
- B**r**own = **R**ight (Live)
- S**t**riped = **T**op (Earth)

The Earth Wire

- Many electrical appliances have metal cases
- This poses a potential safety hazard:
  - If a live wire (inside the appliance) came into contact with the case, the case would become electrified and anyone who touched it would risk being electrocuted
- The earth wire is an additional safety wire that can reduce this risk
- If this happens:
  - The earth wire provides a **low resistance path to the earth**
  - It causes a **surge of current in the earth wire** and hence also in the live wire
  - The high current through the fuse causes it to **melt and break**
  - **This cuts off the supply of electricity to the appliance**, making it safe

Your notes

- Every country has a slightly different configuration, with many using two-pin plugs and plug sockets such as in the USA and mainland Europe
  - The earth wire is still present in the two-pin plugs, just more hidden
- The **earth** wire:

  Acts as a safety wire to stop the appliance from becoming live

Fuses & Circuit Breakers

- Fuses and circuit breakers are safety devices designed to **cut off the flow of electricity** to an appliance if the **current becomes too large** (due to a fault or a surge)

The circuit symbol for a fuse (not to be confused with a resistor)

- Fuses usually consist of a glass cylinder containing a thin metal wire
- If the current in the wire becomes too large:
  - The wire **heats up** and **melts**
  - This causes the wire to break, breaking the circuit and stopping the current
- A circuit breaker consists of an automatic electromagnet switch that breaks the circuit if the current exceeds a certain value
- This has a major advantage over a fuse because:
  - It doesn't melt and break, hence it can be reset and used again
  - It works much faster
- For these reasons, circuit breakers are used in mains electricity in homes
  - Sometimes they are misleadingly named "Fuse boxes"

Your notes

Dangers of Mains Electricity

Your notes

Switches & Fuses

- The live wire, having a voltage of around 230 V, is the most dangerous one
- As a result of this, fuses and switches are always connected to the live wire
  - This means that when a switch is turned off (or a fuse blows) a device will no longer be connected to the live supply

The circuit symbol for a fuse

Potential Difference of Live, Neutral and Earth Wires

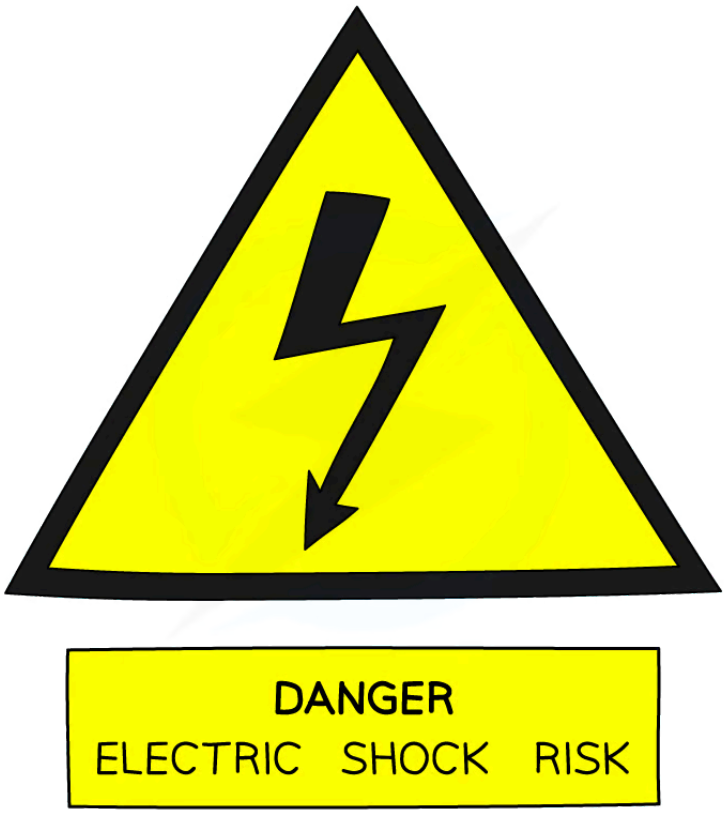
- The **live** wire carries most of the power to the circuit and, as a result, it is the most dangerous wire
  - It has a voltage of around **230 V**
- The **neutral** wire is much safer than the live wire, although it can deliver a small shock
  - It has a voltage **close** to **0 V**
- The **earth** wire only carries a current to the ground if there is a fault in the appliance
  - It has a voltage of **0 V**

Dangers of Mains Electricity

- Normally, the earth wire does not carry any electricity – it is there for **safety** only
- As a result, in most circumstances, its potential difference is 0 volts
- Many electrical appliances have metal cases that pose a potential safety hazard:
  - If a live wire (inside the appliance) came into contact with the case, the case would become electrified

Your notes

- Therefore if anyone touched it, they would risk electrocution
- The earth wire is an additional safety wire that can reduce this risk
- If this happens:
  - The earth wire provides a **low resistance path** to the Earth
  - This causes a **surge** of current in the **earth wire** and hence also in the live wire
  - The high current through the **fuse** causes it to melt and break
  - This cuts off the supply of electricity to the appliance, making it **safe** to touch



Signs, like the above, warn of the risk of electrocution

- Because of the large potential difference between the live (230 V) and the earth (0 V), if the two are connected together, a **very large current** can be created
- If a person provides the connection between **live** and **earth** then a large current can pass through them, providing a potentially **lethal** shock

- Electricians will always switch off the mains electricity supply to the whole house, or section of a house when they are working with electrical appliances
  - This is because they will come into contact with **live wires** when they are working
  - The potential difference of the live wire is 230 V and the potential of the electrician is 0 V
  - Therefore, there is a large potential difference between the live wire and the electrician, so, a current would pass through the electrician's body to reach the earth
  - Even if a device is switched **off** but the mains supply is **on**, the live wire can **still** cause an electric shock


Your notes