

Circuits Notes

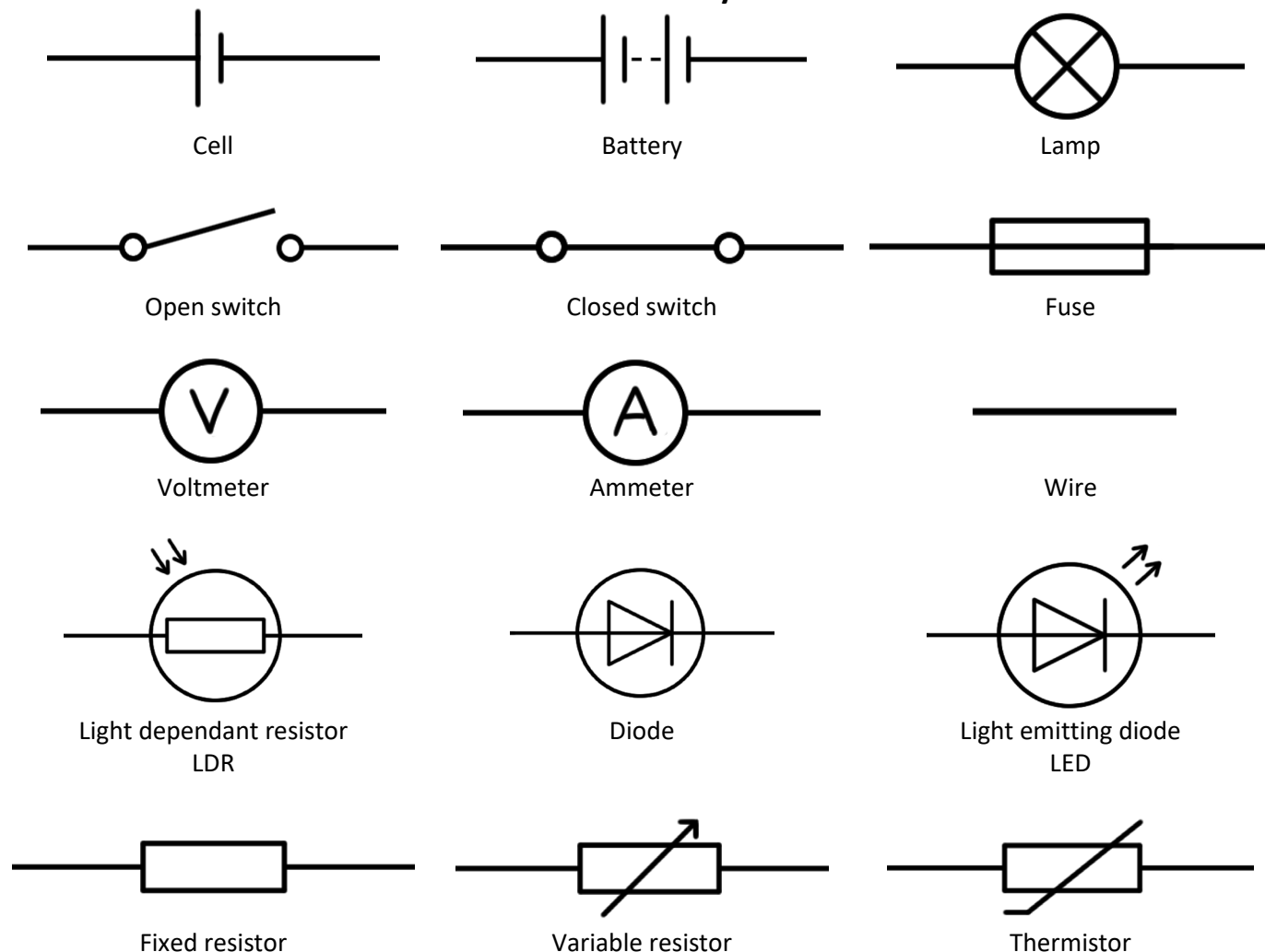
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There are two types of circuit that we need to know for GCSE, series and parallel circuits. But, before we look at those let's look at the symbols for the electrical components that go into making a working circuit.

Electrical Circuit Symbols



The meters we use		
	Ammeter	Voltmeter
What does it measure?	The <u>current</u> in a circuit.	The <u>potential difference</u> between two points.
How is it used?	In series with the circuit.	In parallel to the circuit.

What does "in series" mean? It means that it is in the circuit itself 😊

What does "in parallel" mean? It means that it is on its own branch 😊

Current: the rate of flow of charged particles (usually electrons). Current is measured in Amps (A).

Potential difference: is a difference in electrical potential between two components or objects. It is measured in volts (V). A potential difference produces an electric field, this will then produce a force on the charged particles in the field. The bigger the potential difference the bigger the force on the particles 😊

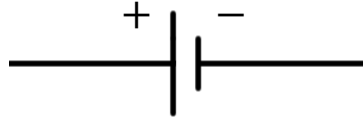
How do we draw electricity moving?

Before we look at circuits properly, let's take a chance to explain how we draw electricity moving in a circuit.

On the previous page, we looked at the circuit symbols that go into making a working circuit. Let's use the symbol for a cell to explain how the flow of electricity is drawn.

First, in the symbol of a cell, the larger of the two lines shows the positive end of the cell and the smaller of the two lines represents the negative end. This is the exact same for a battery symbol, big positive and small negative.

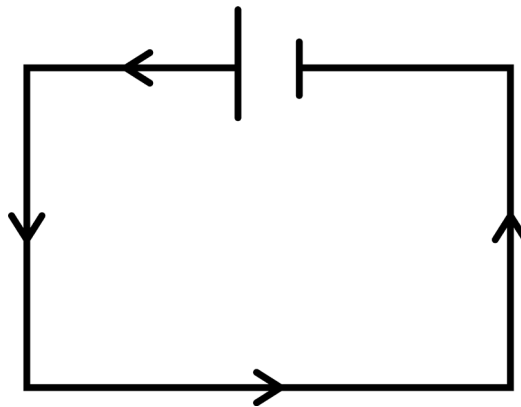
The cell symbol below shows this with signs.



Exam note: whether or not the signs are there on a cell or battery symbol, we are expected to know which end is positive and which end is negative simply by looking at it.

Now, for the **odd** part of all of this... How is the movement of electricity shown on diagrams?

Electricity is shown as moving from the positive end of the cell or battery to the negative end. This is known as **conventional current** and this is how we draw it for the GCSE exams. Check out the figure below which shows this.



Current moves from positive to negative 😊

But here's the thing... In real life, electricity actually moves from the negative side to the positive side of the cell or battery or, negative to positive for short.

If that's the case, why don't we draw it to show it moving in the correct direction? Good point! It has to do with laziness really 😊 because so many parts of early electrical physics were drawn with the current moving from positive to negative we would have to rewrite all of these old books and a few rules as well (Fleming's left hand rule for example) so it's just easier to keep using the old incorrect model of the flow of current for our diagrams.

Electrons moving from the negative to positive is known as **electron flow**. It works on the law of opposite charges. Opposite charges attract and like charges repel. The negative electrons are pushed away from the negative side of a battery, as like charges repel, and they are pulled toward the positive side, as opposite charges attract.

Now, let's look at circuits themselves 😊

Series Circuits

A series circuit: is a circuit that is made of only one loop.

Current and Potential Difference in a Series circuit

Current: is the same at all points in a series circuit.

The potential difference: is shared equally between components **IF** the resistance of the components is equal. If the resistance of the components is not equal then the potential difference will not be shared equally.

The sum of the potential differences across each component is equal to the potential difference of the source.

Please do learn this as it is very important!

Below are two figures which show the relationship between current and potential difference in a series circuit.

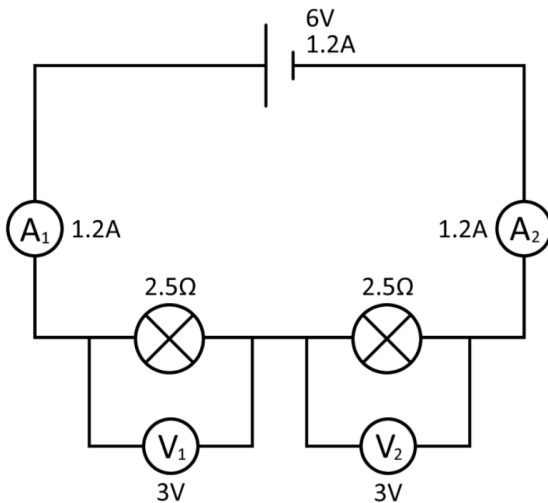


Figure 1

We can see in figure 1 that both ammeters read 1.2 A. This shows us that current is the same at all points on a series circuit.

We can also see that the potential difference of 6 V has been shared equally between the two lamps as they have the same resistance.

Note: we can see here that the ammeters are both used in series.

We can also see that the voltmeters are used in parallel. 😊

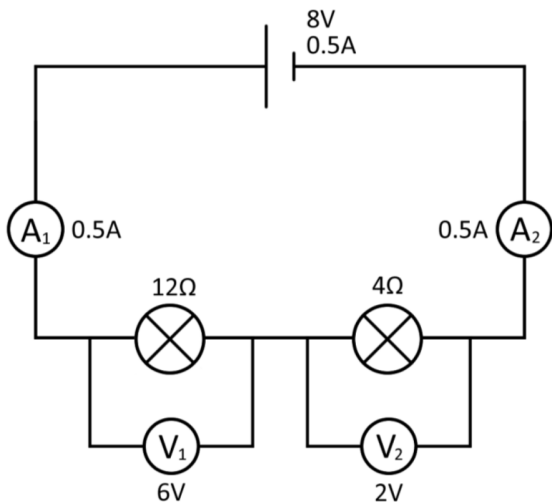


Figure 2

We can see in figure 2 that both ammeters read 0.5 A. This shows us that current is the same at all points on a series circuit.

We can also see that the potential difference of 8 V **has not** been shared equally between the two lamps as the resistance of each is different.

Note: we can see here that the ammeters are again used in series.

We can also see that the voltmeters are again used in parallel. 😊

Use: series circuits don't have many uses on their own. The best-known example are cheap Christmas lights.

Advantages of Series Circuits

- They are cheap to make.
- They don't need lots of wires.

Disadvantages of Series Circuits

- If one component breaks the circuit is broken.
- The more lamps you add the dimmer they all become.
- You **can't** control components individually.

Parallel Circuits

A **parallel circuit**: is a circuit made up of two or more loops.

Current and Potential Difference in a Parallel Circuit

Current: is shared equally between components **IF** the resistance of the components is equal on each branch. The sum of the currents in the individual branches is equal to the total current flowing from the source.

The potential difference: is the same on each branch as it is across the power supply.

Note: as we can see this is almost the opposite of series circuits but not the exact opposite.

Below are two figures which show the relationship between current and potential difference in a parallel circuit.

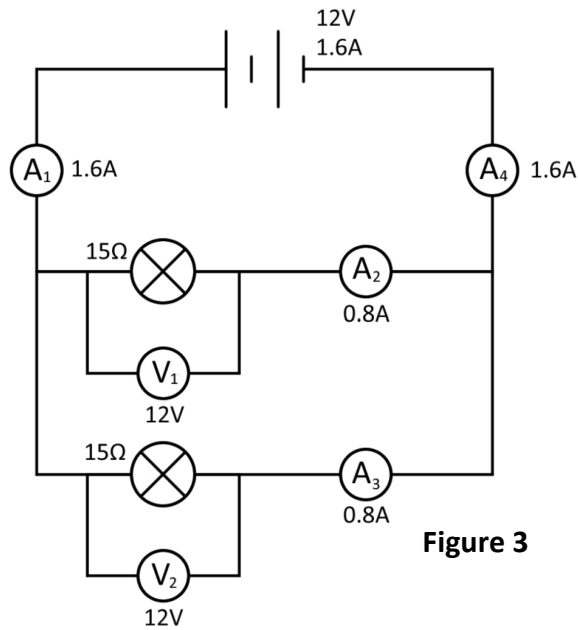


Figure 3

We can see in figure 3 that ammeters A_1 and A_4 read 1.6 A.

While ammeters A_2 and A_3 both read 0.8 A.

This shows us that current has been shared equally between the branches as each branch has the same resistance.

We can also see that the potential difference of 12 V is the same on each branch as it is across the power supply.

Note: we can see here that the ammeters are both used in series.

We can also see that the voltmeters are used in parallel. 😊

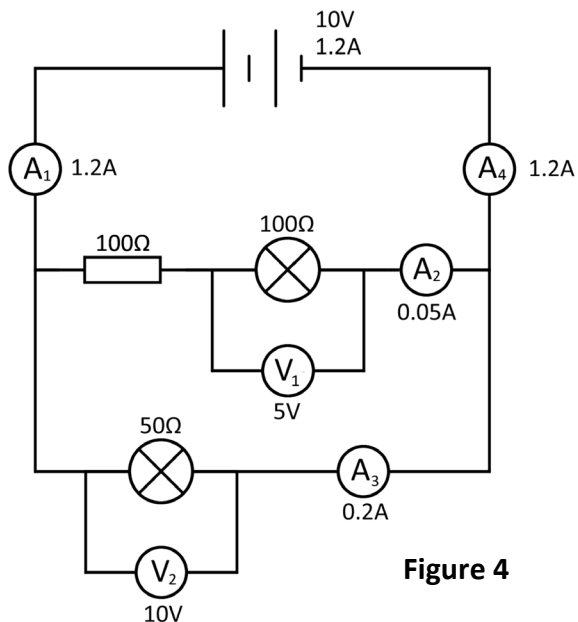


Figure 4

We can see in figure 4 that ammeters A_1 and A_4 read 1.2 A.

While ammeter A_2 reads 0.05 A and A_3 reads 0.2 A.

This shows us that current has **not** been shared equally between the branches as each branch has a different resistance.

We can also see that the potential difference of 10 V is the same on each branch as it is across the power supply.

V_1 reads 5 V as the 10 V on the branch is shared between the fixed resistor and the lamp as they have the same resistance.

Note: we can see here that the ammeters are again used in series.

We can also see that the voltmeters are again used in parallel. 😊

Use: the circuits found in smart phones or computers and almost all devices.

Advantages of Parallel Circuits

If one component breaks the circuit continues to work.

The brightness of lamps is not affected by adding more lamps.

You **can** control components individually.

Disadvantages of Parallel Circuits

It can be expensive to make.

More wires are needed.

Resistance in Circuits

Resistance: is the ability of a component or a material to resist the movement of current through it.

Resistance is measured in Ohms (Ω)

Each component that you add to a circuit has its own resistance, and the more components that you add the greater the resistance of the circuit. Even the wires themselves have a resistance (it's not much of course) and the greater the length of wire the greater the resistance.

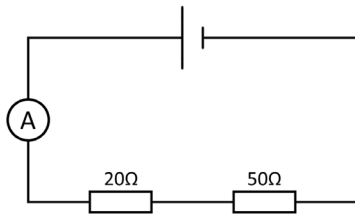
Note: a variable resistor is just a device that allows you to change the length of wire that the current must move through. A small length of wire gives a low resistance and a long length of wire gives a high resistance.

How do we calculate the resistance in a series circuit?

It's a nice question to get and it's a lot easier than it looks 😊

Method: add together all of the resistances that you are given. Check out the two examples below.

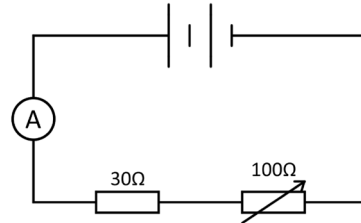
Example 1



$$\text{Resistance} = 20\ \Omega + 50\ \Omega$$

$$\text{Resistance} = 70\ \Omega$$

Example 2



$$\text{Resistance} = 30\ \Omega + 100\ \Omega$$

$$\text{Resistance} = 130\ \Omega$$

That's it, calculating resistance in series doesn't get harder than that 😊

How do we calculate the resistance in a parallel circuit?

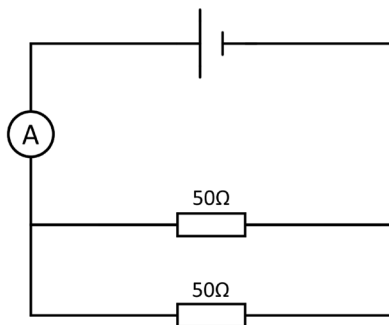
Method: use the following equation

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

I know it looks like a bit of a hard to use equation but it's actually fine 😊

R_T means the resistance total. R_1 is the resistance of the first resistor and R_2 is the resistance of the second resistor.

Example 3



$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

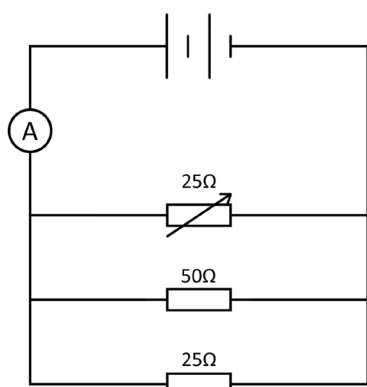
$$\frac{1}{R_T} = \frac{1}{50} + \frac{1}{50}$$

$$\frac{1}{R_T} = \frac{2}{50}$$

$$R_T = 1 \div \frac{2}{50}$$

$$R_T = 25\ \Omega$$

Example 4



$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$\frac{1}{R_T} = \frac{1}{25} + \frac{1}{50} + \frac{1}{25}$$

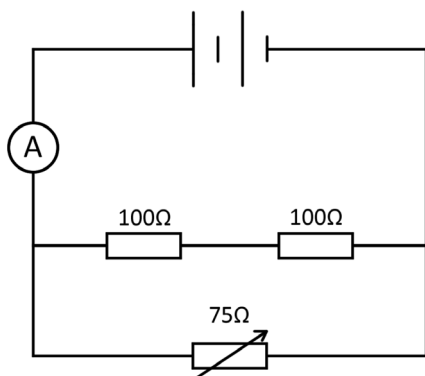
$$\frac{1}{R_T} = \frac{1}{10}$$

$$R_T = 1 \div \frac{1}{10}$$

$$R_T = 10\ \Omega$$

Now, what if the question we are given were to have two resistors on one branch?

Example 5



Step 1: The two 100 Ω resistors are in series.

So, simply add those together.

$$\text{Resistance} = 100\ \Omega + 100\ \Omega = 200\ \Omega$$

Step 2: use the resistance in parallel equation.

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$\frac{1}{R_T} = \frac{11}{600}$$

$$\frac{1}{R_T} = \frac{1}{200} + \frac{1}{75}$$

$$R_T = 1 \div \frac{11}{600} = 54.5\ \Omega$$

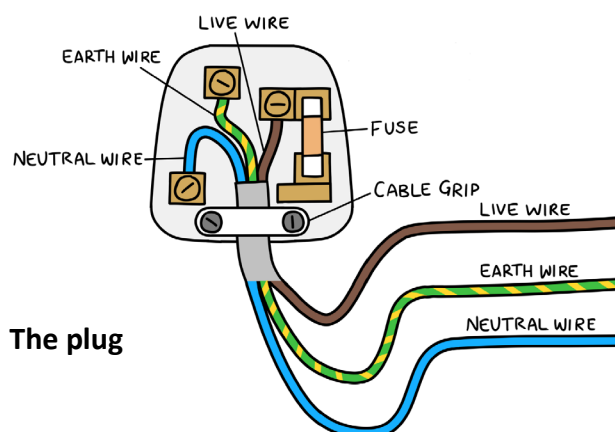
The Plug

Plugs are one of those everyday items that we use without ever really thinking about them. But quite a lot of thought has gone into their development and design.

What questions could I be asked about plugs?

The most common question to be asked is to label a diagram of a plug.

Apart from that we could be asked what some of the different parts of the plug do.



The plug

Structure	Function
Live wire	This is a copper wire that is covered with a <u>brown</u> plastic sheath. Current moves through this wire to enter the device.
Neutral wire	This is a copper wire that is covered with a <u>blue</u> plastic sheath. This wire completes the circuit. Without the neutral wire current would not be able to flow.
Earth wire	This is a copper wire that is covered with <u>striped</u> plastic sheath. This wire is a safety feature, it allows current to flow away from the device if there is a fault. For example, if the device is made of metal and the live wire were to touch it the device would become live. Anyone who touched it in this state would receive a painful electric shock. The earth wire allows the current to flow away from the device.
Fuse	Is a very important safety component, <u>a fuse is made of a thin copper wire, this will melt if the too much current tries to move though the device.</u> Fuses are a very important safety feature and many fires and deaths have been caused by incorrect fuses being used in devices. For example, we shouldn't put a fuse meant for a washing machine in a phone charger. If there was a fault, and more current than normal tried to move into the phone charger which used a washing machine fuse, the fuse would not melt and there could be a fire.
Cable grip	This <u>holds the main cable in place</u> and prevents the wires being moved, damaged or pulled out of the plug.