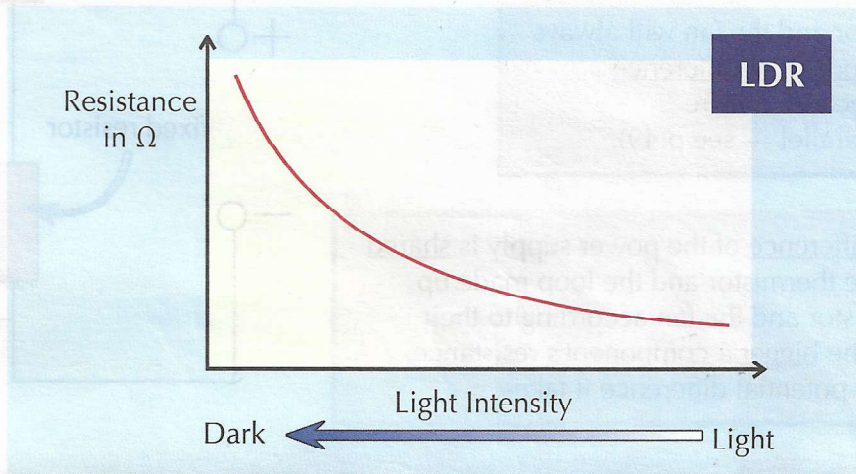
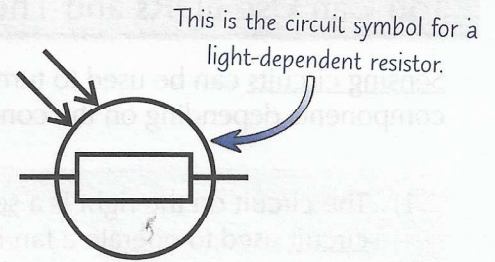


Circuit Devices

You might consider yourself a bit of an expert in circuit components — you're enlightened about bulbs, you're switched on to switches... Just make sure you know these ones as well — they're a bit trickier.

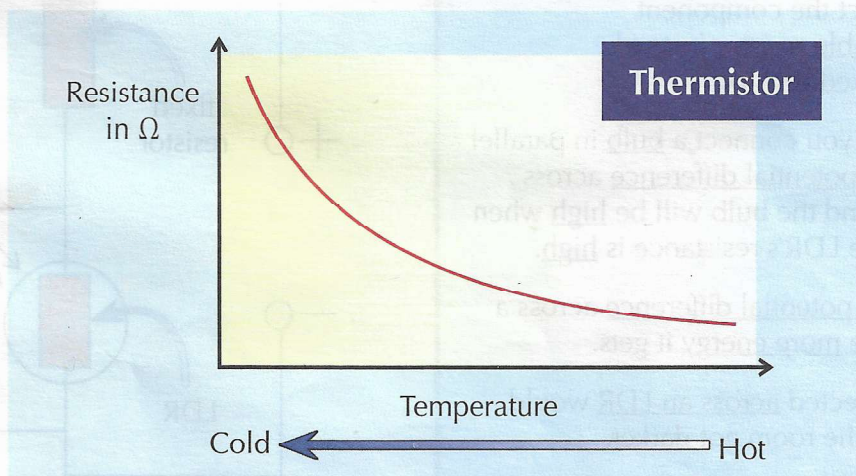
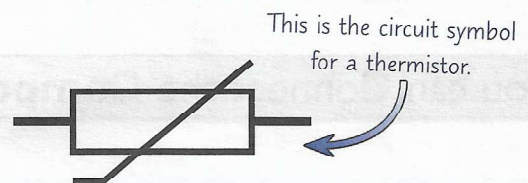
A Light-Dependent Resistor or "LDR"

- 1) An LDR is a resistor that is dependent on the intensity of light. In bright light, the resistance falls.
- 2) In darkness, the resistance is highest.
- 3) They have lots of applications including automatic night lights, outdoor lighting and burglar detectors.



Thermistor Resistance Decreases as Temperature Increases

- 1) A thermistor is a temperature dependent resistor.
- 2) In hot conditions, the resistance drops.
- 3) In cool conditions, the resistance goes up.
- 4) Thermistors make useful temperature detectors, e.g. car engine temperature sensors and electronic thermostats.



Thermistors and LDRs have many applications...

And they're not just limited to the examples on this page. Oh no. For example, LDRs are used in digital cameras to control how long the shutter should stay open for. If the light level is low, changes in the resistance cause the shutter to stay open for longer than if the light level was higher. How interesting.

Sensing Circuits

Now you've learnt about what LDRs and thermistors do, it's time to take a look at how they're put to use.

You Can Use LDRs and Thermistors in Sensing Circuits

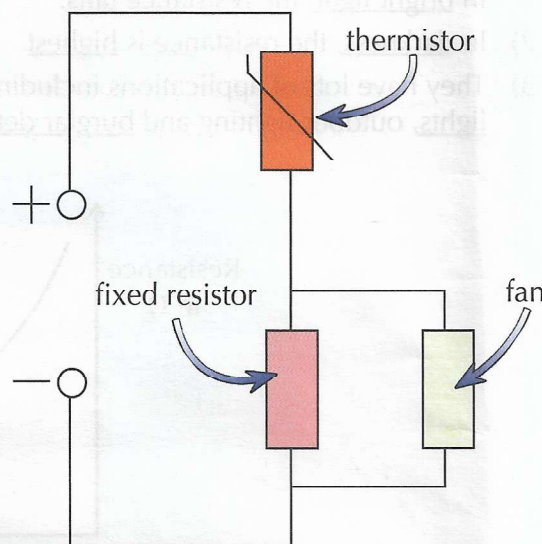
Sensing circuits can be used to turn on or increase the power to components depending on the conditions that they are in.

1) The circuit on the right is a sensing circuit used to operate a fan in a room.

2) The fixed resistor and the fan will always have the same potential difference across them (because they're connected in parallel — see p.49).

3) The potential difference of the power supply is shared out between the thermistor and the loop made up of the fixed resistor and the fan according to their resistances — the bigger a component's resistance, the more of the potential difference it takes.

4) As the room gets hotter, the resistance of the thermistor decreases and it takes a smaller share of the potential difference from the power supply. So the potential difference across the fixed resistor and the fan rises, making the fan go faster.



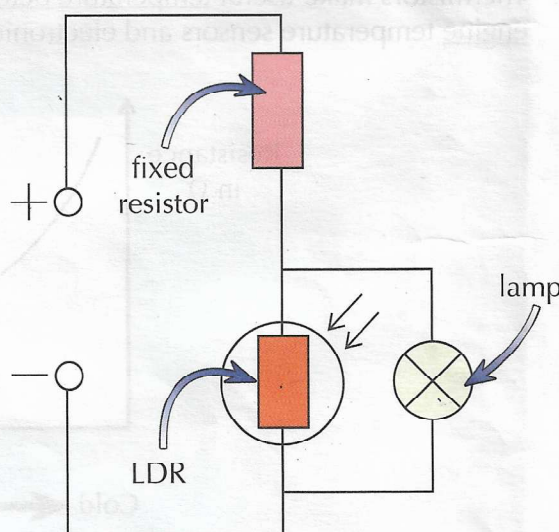
You can Connect the Component Across the Variable Resistor

1) You can connect the component across the variable resistor instead of across the fixed resistor.

2) For example, if you connect a bulb in parallel to an LDR, the potential difference across both the LDR and the bulb will be high when it's dark and the LDR's resistance is high.

3) The greater the potential difference across a component, the more energy it gets.

4) So a bulb connected across an LDR would get brighter as the room got darker.



Sensing circuits react to changes in the surroundings...

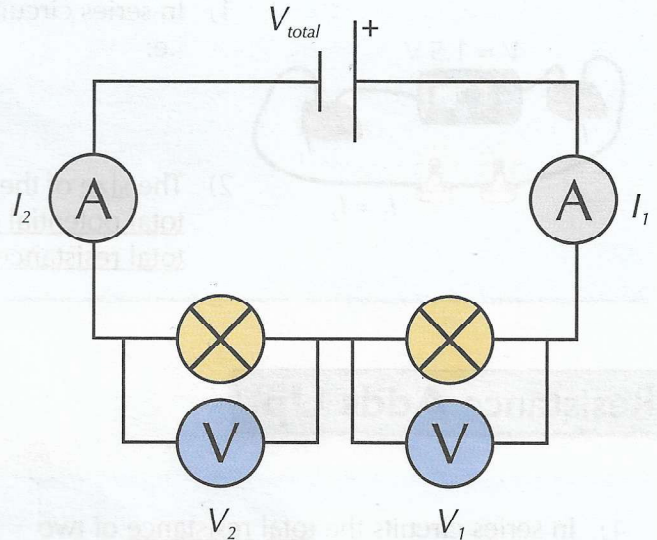
Sensing circuits are a useful application of thermistors and LDRs, but they can be tricky to make sense of. They rely on the properties of series and parallel circuits — read on to learn all about them.

Series Circuits

You need to be able to tell if components are connected in series or parallel just by looking at circuit diagrams. You also need to know the rules about what happens with both types. Read on to find out more.

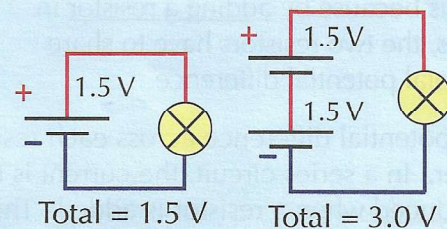
Series Circuits — All or Nothing

- 1) In series circuits, the different components are connected in a line, end to end, between the +ve and -ve of the power supply (except for voltmeters, which are always connected in parallel, but they don't count as part of the circuit).
- 2) If you remove or disconnect one component, the circuit is broken and they all stop. This is generally not very handy, and in practice very few things are connected in series.
- 3) You can use the following rules to design series circuits to measure quantities and test components (e.g. the test circuits on p.43 and p.50 and the sensing circuits on the last page).



Cell Potential Differences Add Up

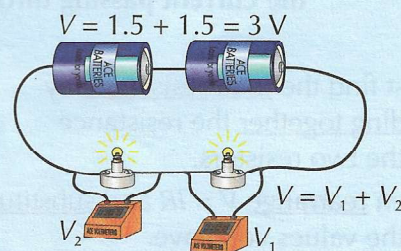
- 1) There is a bigger potential difference when more cells are in series, provided the cells are all connected the same way.
- 2) For example, when two batteries of voltage 1.5 V are connected in series they supply a total of 3 V.



Total Potential Difference is Shared

In series circuits, the total potential difference of the supply is shared between the various components. So the potential differences round a series circuit always add up to the source potential difference:

$$V_{\text{total}} = V_1 + V_2 + \dots$$



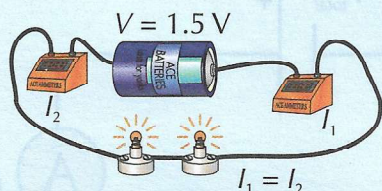
There are two main types of circuit — series and parallel...

Remember, ammeters should always be connected in series, and voltmeters should always be connected in parallel. These components don't count towards how you define a circuit — you can have a parallel circuit (p.49) with ammeters connected in series, or a series circuit with voltmeters connected across components.

Series Circuits

We're not done with series circuits yet. Here's the low-down on current and resistance...

Current is the Same Everywhere



- 1) In series circuits the same current flows through all components, i.e:

$$I_1 = I_2 = \dots$$

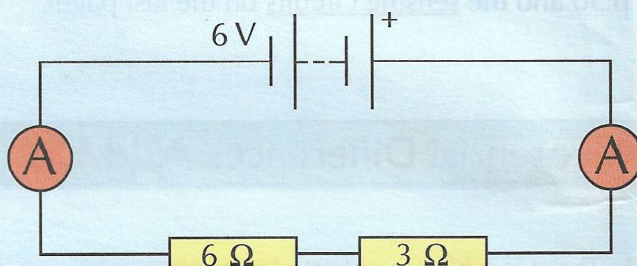
- 2) The size of the current is determined by the total potential difference of the cells and the total resistance of the circuit: i.e. $I = V \div R$.

Resistance Adds Up

- 1) In series circuits the total resistance of two components is just the sum of their resistances:

$$R_{\text{total}} = R_1 + R_2$$

- 2) This is because by adding a resistor in series, the two resistors have to share the total potential difference.



$$\text{Total resistance} = 6 + 3 = 9 \Omega$$

- 3) The potential difference across each resistor is lower, so the current through each resistor is also lower. In a series circuit, the current is the same everywhere so the total current in the circuit is reduced when a resistor is added. This means the total resistance of the circuit increases.
- 4) The bigger a component's resistance, the bigger its share of the total potential difference.

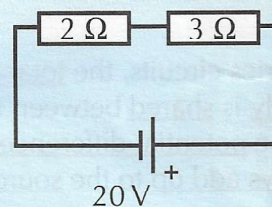
EXAMPLE:

For the circuit diagram on the right, calculate the current passing through the circuit.

- 1) First find the total resistance by adding together the resistance of the two resistors.
- 2) Then rearrange $V = IR$ and substitute in the values you have.

$$R_{\text{total}} = 2 + 3 = 5 \Omega$$

$$\begin{aligned} I &= V \div R \\ &= 20 \div 5 \\ &= 4 \text{ A} \end{aligned}$$



Series circuits aren't used very much in the real world...

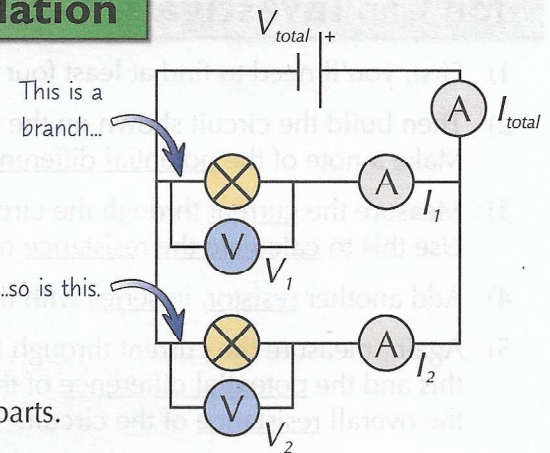
Since series circuits put all components on the same loop of wire, and the current is the same through each component, if one component breaks, it'll break the circuit, and all other components will stop working too. Parallel circuits are much more useful and can avoid this problem — as you're about to find out...

Parallel Circuits

Parallel circuits can be a little bit trickier to wrap your head around, but they're much more useful than series circuits. Most electronics use a combination of series and parallel circuitry.

Parallel Circuits — Independence and Isolation

- 1) In parallel circuits, each component is separately connected to the +ve and -ve of the supply (except ammeters, which are always connected in series).
- 2) If you remove or disconnect one of them, it will hardly affect the others at all.
- 3) This is obviously how most things must be connected, for example in cars and in household electrics. You have to be able to switch everything on and off separately.
- 4) Everyday circuits often include a mixture of series and parallel parts.



Potential Difference is the Same Across All Components

- 1) In parallel circuits all components get the full source pd, so the voltage is the same across all components: $V_1 = V_2 = V_3 = \dots$
- 2) This means that identical bulbs connected in parallel will all be at the same brightness.

Current is Shared Between Branches

- 1) In parallel circuits the total current flowing around the circuit is equal to the total of all the currents through the separate components: $I_{total} = I_1 + I_2 + \dots$
- 2) In a parallel circuit, there are junctions where the current either splits or rejoins. The total current going into a junction has to equal the total current leaving it.
- 3) If two identical components are connected in parallel then the same current will flow through each component.

Adding a Resistor in Parallel Reduces the Total Resistance

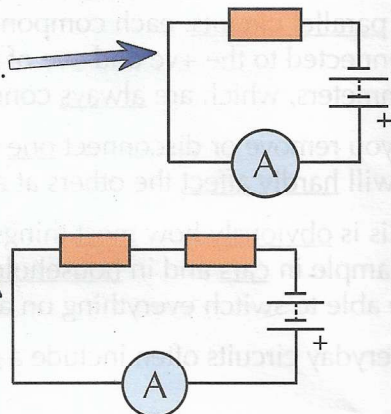
- 1) If you have two resistors in parallel, their total resistance is less than the resistance of the smallest of the two resistors.
- 2) This can be tough to get your head around, but think about it like this:
 - In parallel, both resistors have the same potential difference across them as the source.
 - This means the 'pushing force' making the current flow is the same as the source potential difference for each resistor that you add.
 - But by adding another loop, the current has more than one direction to go in.
 - This increases the total current that can flow around the circuit. Using $V = IR$, an increase in current means a decrease in the total resistance of the circuit.

PRACTICAL**Circuits and Resistance**

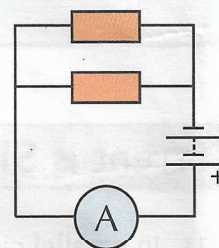
You saw on page 42 how the length of the wire used in a circuit affects its resistance. Now it's time to do an experiment to see how placing resistors in series or in parallel can affect the resistance of the whole circuit.

You Can Investigate Adding Resistors in Series...

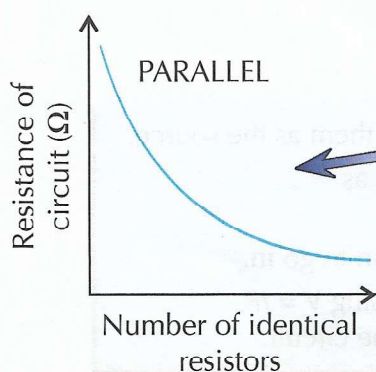
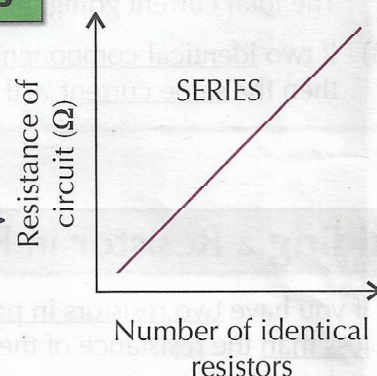
- 1) First, you'll need to find at least four identical resistors.
- 2) Then build the circuit shown on the right using one of the resistors. Make a note of the potential difference of the battery (V).
- 3) Measure the current through the circuit using the ammeter. Use this to calculate the resistance of the circuit using $R = V \div I$.
- 4) Add another resistor, in series with the first.
- 5) Again, measure the current through the circuit and use this and the potential difference of the battery to calculate the overall resistance of the circuit.
- 6) Repeat steps 4 and 5 until you've added all of your resistors.
- 7) Plot a graph of the number of resistors against the total resistance of the circuit (see below).

**... or in Parallel**

- 1) Using the same equipment as before (so the experiment is a fair test), build the same initial circuit.
- 2) Measure the total current through the circuit and calculate the resistance of the circuit using $R = V \div I$ (again, V is the potential difference of the battery).
- 3) Next, add another resistor, in parallel with the first.
- 4) Measure the total current through the circuit and use this and the potential difference of the battery to calculate the overall resistance of the circuit.
- 5) Repeat steps 3 and 4 until you've added all of your resistors.
- 6) Plot a graph of the number of resistors in the circuit against the total resistance.

**Your Results Should Match the Resistance Rules**

- 1) You should find that adding resistors in series increases the total resistance of the circuit (adding a resistor decreases the total current through the circuit).
- 2) The more resistors you add, the larger the resistance of the whole circuit.



- 3) When you add resistors in parallel, the total current through the circuit increases — so the total resistance of the circuit has decreased.
- 4) The more resistors you add, the smaller the overall resistance becomes — as shown by the graph on the left.
- 5) These results agree with what you learnt about resistance in series and parallel circuits on pages 48 and 49.