THERMAL TRANSFER

Convection is the transfer of heat by the actual movement of the warmed matter. Heat leaves the coffee cup as the currents of steam and air rise. Convection is the transfer of heat energy in a gas or liquid by movement of currents. (It can also happen is some solids, like sand.) The heat moves with the fluid. Consider this: convection is responsible for making macaroni rise and fall in a pot of heated water. The warmer portions of the water are less dense and therefore, they rise. Meanwhile, the cooler portions of the water fall because they are denser.

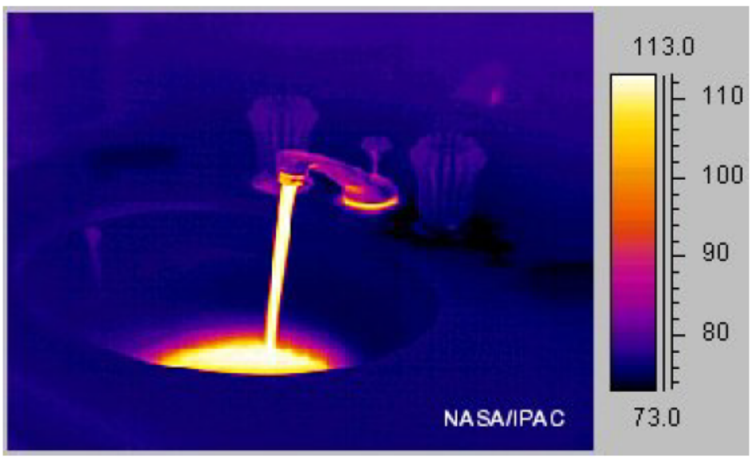
Conduction is the transfer of energy through matter from particle to particle. It is the transfer and distribution of heat energy from atom to atom within a substance. For example, a spoon in a cup of hot soup becomes warmer because the heat from the soup is conducted along the spoon. Conduction is most effective in solids-but it can happen in fluids. Fun fact: Have you ever noticed that metals tend to feel cold? Believe it or not, they are not colder! They only feel colder because they conduct heat away from your hand. You perceive the heat that is leaving your hand as cold.

Radiation: Electromagnetic waves that directly transport ENERGY through space. Sunlight is a form of radiation that is radiated through space to our planet without the aid of fluids or solids. The energy travels through nothingness! Just think of it! The sun transfers heat through 93 million miles of space. Because there are no solids (like a huge spoon) touching the sun and our planet, conduction is not responsible for bringing heat to Earth. Since there are no fluids (like air and water) in space, convection is not responsible for transferring the heat. Thus, radiation brings heat to our planet.

The Difference Between Heat and Temperature?

We often refer to infrared radiation as being primarily heat (or thermal) radiation. But what exactly is heat, and how does it differ from temperature? Simply put, heat is a measurement of energy. All molecules contain some amount of kinetic energy, that is to say, they have some intrinsic motion. The hotter an object is, the faster the motion of the molecules inside it. Thus, the heat of an object is the total energy of all the molecular motion inside that objec

Temperature, on the other hand, is a measure of the average heat or thermal energy of the molecules in a substance. When we say an object has a temperature of 100 degrees C, for example, we do not mean that every single molecule has that exact thermal energy. In any substance, molecules are moving with a range of energies, and interacting with each other as well, which changes their energies. But if we average the thermal energies of all the molecules together, we can obtain an object's temperature.



Heat energy flows from a hot object to a cooler one. This causes:

- hot objects to cool down
- cool objects to warm up.

When heat energy is transferred to an object, its temperature increase depends upon:

- the mass of the object
- the substance the object is made from
- the amount energy transferred to the object.

For a particular object, the more heat energy transferred to it, the greater its temperature increase.

FORCES

Balanced forces

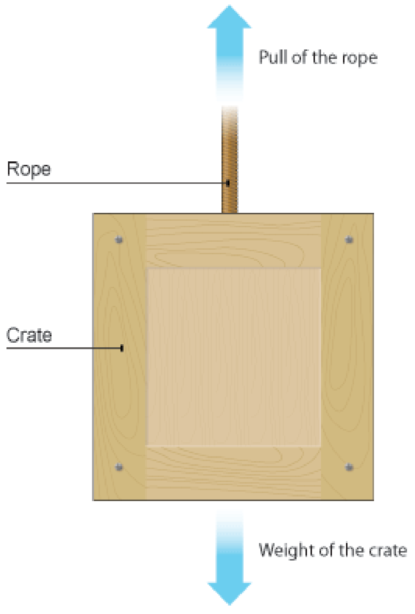
Force diagrams

We can show the forces acting on an object using a **force diagram**. In a force diagram, each force is shown as a force arrow. An arrow shows:

the size of the force (the longer the arrow, the bigger the force)

the direction in which the force acts.

The arrow is usually labelled with the name of the force and its size in newtons. Text books often show a force with a thick coloured arrow, but it is best if you just use a pencil and ruler to draw an arrow with a single line.



Balanced forces

When two forces acting on an object are equal in size but act in opposite directions, we say that they are balanced forces.

If the forces on an object are balanced (or if there are no forces acting on it) this is what happens:

an object that is not moving stays still

an object that is moving continues to move at the same speed and in the same direction

So notice that an object can be moving even if there are no forces acting on it.

Example

Here are some examples of balanced forces.

Hanging objects

The forces on this hanging crate are equal in size but act in opposite directions. The weight pulls down and the tension in the rope pulls up.

The forces on this hanging crate are balanced.

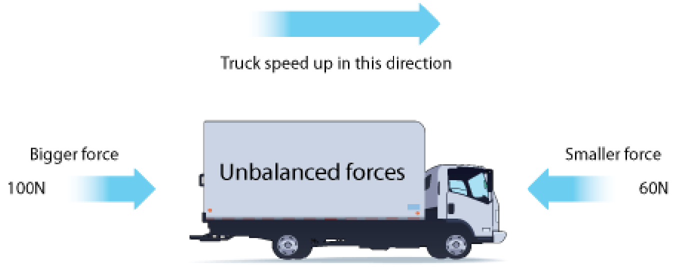
Unbalanced forces

When two forces acting on an object are not equal in size, we say that they are **unbalanced** forces.

If the forces on an object are **unbalanced** this is what happens:

an object that is not moving starts to move

an object that is moving changes speed or direction



Unbalanced forces make the truck speed up.

Resultant forces

The size of the overall force acting on an object is called the **resultant force**. If the forces are balanced, this is zero. In the example above, the resultant force is the difference between the two forces, which is 100 - 60 = 40 N.

SPEED

You should recall from your Key Stage 3 studies how to calculate the speed of an object from the distance travelled and the time taken.

The equation

When an object moves in a straight line at a steady speed, you can calculate its speed if you know how far it travels and how long it takes. This equation shows the relationship between speed, distance travelled and time taken:

$$\text{speed (metre per second, m/s)} = \frac{\text{distance travelled (metre, m)}}{\text{time taken (second, s)}}$$

For example, a car travels 300 metres in 20 seconds.
Its speed is 300 ÷ 20 = 15m/s.

SATELLITES

Artificial satellites

Artificial satellites are built by people and launched by rockets into space, where they orbit around the Earth. These are some of the things that artificial satellites are used for:

- communications, including broadcasting television programmes and relaying telephone calls
- Global Positioning System (GPS) and Galileo satellites for navigation
- collecting information to help with weather forecasts
- scientific surveys of the Earth's surface
- map making
- spying

Space telescopes

Hubble Space Telescope - image courtesy of NASA

Some satellites are used to collect information about the planets and stars. The **Hubble Space Telescope** can see further into space than telescopes based on the ground. Its view is not blocked by clouds and it doesn't have to wait for night-time. However, it is difficult and expensive to launch and maintain. If anything goes wrong, only astronauts can fix it.

Space probes

Space probes **do not** orbit the Earth. Instead, they travel to other planets to collect scientific information. Some space probes go into orbit around other planets, some land on them, and some even journey out of the solar system.

Space exploration

People have flown to the Moon and landed on it. But so far that is the furthest people have travelled from Earth. It takes years to travel to other planets, like Mars, and people have not done this yet.

SOLAR SYSTEM

The universe contains over 100 billion galaxies. A galaxy is a group of billions of stars. Our own galaxy is called the Milky Way, and it contains about 300 billion stars (300,000,000,000) and one of these is our Sun.
Planets and other objects go round the Sun, and these make up the **solar system**, with the Sun at the centre. The solar system contains different types of objects including:

- a star - the Sun
- planets, which go around the Sun
- satellites, which go around planets
- smaller objects such as asteroids and comets

Mercury to Neptune

There are **eight** planets in the solar system. Starting with Mercury, which is the closest to the Sun, the planets are:

Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune

If you can't remember the correct order, try this sentence, or make one up of your own:

My **V**ery **E**asy **M**ethod **J**ust **S**peeds **U**p **N**aming

Pluto and the dwarf planets

Scientists have discovered other objects orbiting the Sun. These include**comets**, **asteroids** and **dwarf planets**, like Pluto and Eris.

Pluto used to be considered the ninth planet in our solar system. But in 2006 scientists renamed it as a dwarf planet. So now we have 8 planets in the solar system.

Heliocentric model

People used to think that the Earth was at the centre of the universe, with everything going around it. We now know that this is not correct. Scientific observations and space exploration show that the Sun is at the centre of our solar system. The Earth and other planets go around it. We say that the planets are in orbit around the Sun.

This model is called the **heliocentric model**. (Helios is the ancient Greek word for Sun.)

FORMING STARS

Stars form when enough dust and gas clump together because of gravitational forces. Nuclear reactions release energy to keep the star hot. Planets form when smaller amounts of dust and gas clump together because of gravitational forces.

Stable stars like the Sun change during their lifetime to form other types of stars, such as red giants, white dwarfs, neutron stars and black holes. The fate of a star depends upon how much matter it contains.

Formation of a star

Stars form from massive clouds of dust and gas in space.

Gravity pulls the dust and gas together.

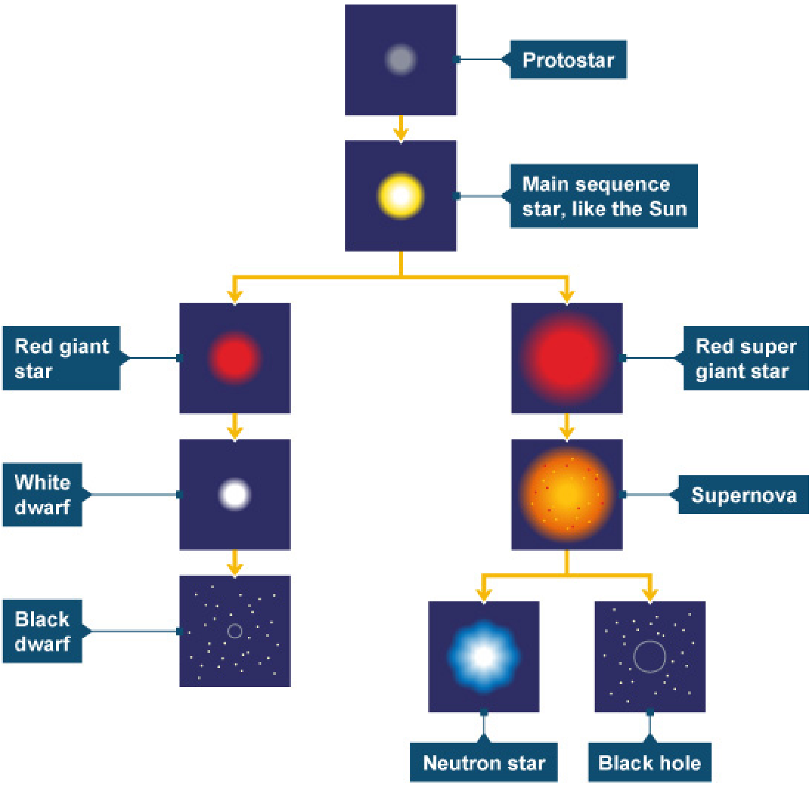
As the gas falls together, it gets hot. A star forms when it is hot enough for nuclear reactions to start. This releases energy, and keeps the star hot.

During its 'main sequence' period of its life cycle, a star is stable because the forces in it are balanced. The outward pressure from the expanding hot gases is balanced by the force of the star's gravity.

Gravity pulls smaller amounts of dust and gas together, which form planets in orbit around the star.

Life cycles of stars

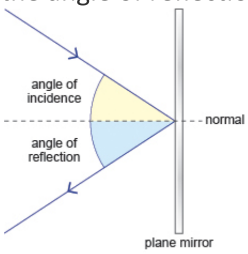
A star goes through a life cycle. This is determined by the size of the star. The diagram below summarises the stages you need to know:



OPTICS

Reflection

Light waves reflect from surfaces. When waves reflect, they obey the law of reflection: the angle of incidence equals the angle of reflection.



The normal is a line drawn at right angles to the reflector.
The angle of incidence is between the incident (incoming) ray and the normal.
The angle of reflection is between the reflected ray and the normal.
Smooth surfaces produce strong echoes when sound waves hit them, and they can act as mirrors when light waves hit them. The waves are reflected uniformly and light can form images. In the plane (flat) mirror, the image appears to be behind the mirror.

Refraction

Sound waves and light waves **change speed** when they pass across the boundary between two substances with different densities, such as air and glass. This causes them to **change direction** and this effect is called **refraction**.
There is one special case you need to know. Refraction doesn't happen if they cross the boundary at an angle of 90° - in that case they carry straight on.
Remember that sound and light waves behave just like water waves in a ripple tank. The bending follows a regular pattern.

Total internal reflection

You should be able to describe a use of total internal reflection with the help of a diagram.

Beyond the critical angle

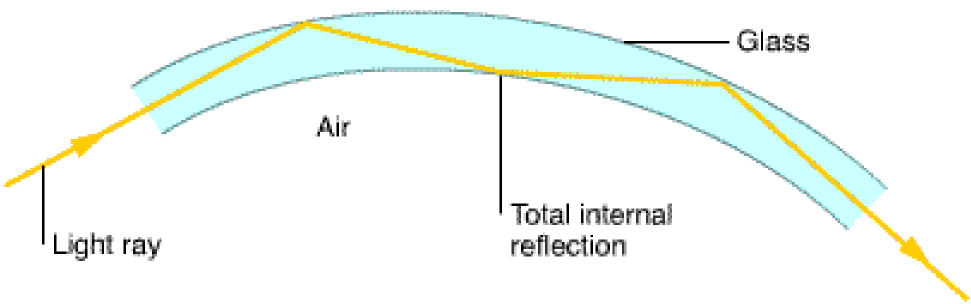
Waves going from a dense medium to a less dense medium speed up at the boundary. This causes light rays to bend when they pass from glass to air at an angle other than 90º. This is refraction.
Beyond a certain angle, called the **critical angle**, all the waves reflect back into the glass. We say that they are totally internally reflected. Have a go at the animation to check your understanding of this.
All light waves, which hit the surface beyond this critical angle, are effectively trapped. The critical angle for most glass is about 42 °.

Optical fibres

An optical fibre is a thin rod of high-quality glass. Very little light is absorbed by the glass. Light getting in at one end undergoes repeated total internal reflection, even when the fibre is bent, and emerges at the other end.

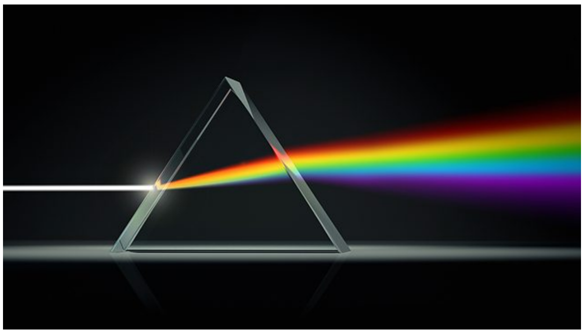
Optical fibres are used in endoscopes that allow surgeons to see inside their patients.

Optical fibres can also carry enormous amounts of information as pulses of light.



Colour

White light is a mixture of many different colours, each with a different**frequency**. White light can be split up into a **spectrum** of these colours using a prism, a triangular block of glass or Perspex.
Light is refracted when it enters the prism, and each colour is refracted by a different amount. This means that the light leaving the prism is spread out into its different colours, a process called **dispersion**.



The spectrum

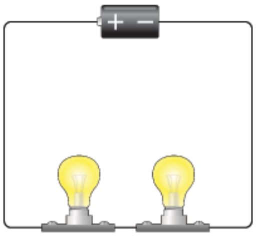
Here are the seven colours of the spectrum listed in order of their frequency, from the lowest frequency (fewest waves per second) to the highest frequency (most waves per second):
Red, orange, yellow, green, blue, indigo, violet

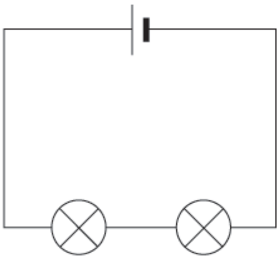
This mnemonic is one way to remember the order: 'Richard Of York Gave Battle In Vain'.

CIRCUITS

Series & parallel circuits
There are two types of circuit we can make, called **series** and **parallel**.
The components in a circuit are joined by wires.

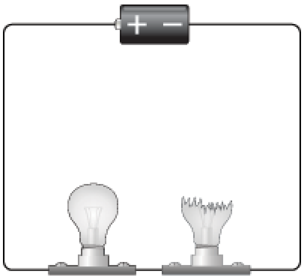
- if there are no branches then it's a series circuit
- if there are branches it's a parallel circuit





Series circuits

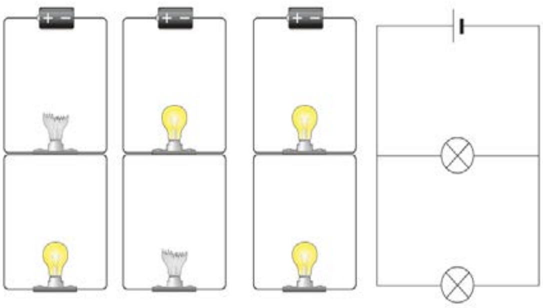
In a television series, you get several episodes, one after the other. A series circuit is similar. You get several components one after the other.
If you follow the circuit diagram from one side of the cell to the other, you should pass through all the different components, one after the other, without any branches.



If you put more lamps into a series circuit, the lamps will be dimmer than before.
In a series circuit, if a lamp breaks or a component is disconnected, the circuit is broken and all the components stop working.

Series circuits are useful if you want a warning that one of the components in the circuit has failed. They also use less wiring than parallel circuits.

Parallel circuits



In parallel circuits different components are connected on different branches of the wire. If you follow the circuit diagram from one side of the cell to the other, you can only pass through all the different components if you follow all the **branches**.

In a parallel circuit, if a lamp breaks or a component is disconnected from one parallel wire, the components on different branches **keep working**. And, unlike a series circuit, the lamps stay bright if you add more lamps in parallel.

Parallel circuits are useful if you want everything to work, even if one component has failed. This is why our homes are wired up with parallel circuits.

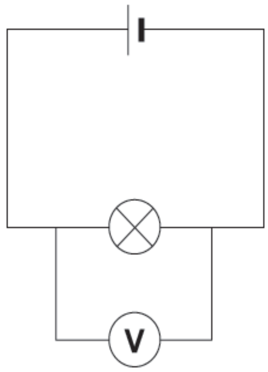
Measuring amps & volts

Current

Current is a measure of how much **electric charge** flows through a circuit. The more charge that flows, the bigger the current.
Current is measured in units called **amps**. The symbol for amps is **A**. For example, 20A is a bigger current than 5A.

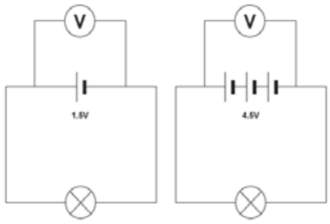
Measuring current
A device called an ammeter is used to measure current. Some types of ammeter have a pointer on a dial, but most have a digital readout. To measure the current flowing through a component in a circuit, you must connect the ammeter in **series** with it.

Voltage

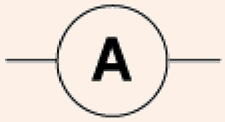
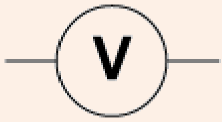


Voltage is a measure of the difference in **electrical energy** between two parts of a circuit. The bigger the difference in energy, the bigger the voltage.
Voltage is measured in **volts**. The symbol for volts is **V**.
For example, 230V is a bigger voltage than 12V.

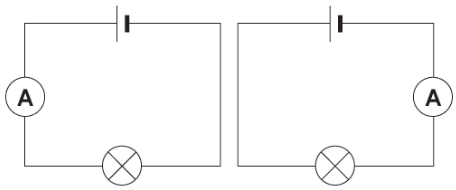
Measuring voltage



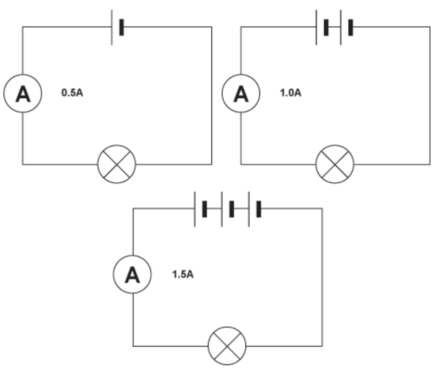
Voltage is meaured using a voltmeter. Some types of voltmeter have a pointer on a dial, but most have a digital readout. To measure the voltage across a component in a circuit, you must connect the voltmeter in **parallel**with it.
You can measure the voltage across a cell or battery. The more cells, the bigger the voltage.

	Current	Voltage
Measured in	amps, A	volts, V
Measured with	ammeter in series	voltmeter in parallel
Circuit symbol of measuring devise		

Current in series circuits



The current is the same everywhere in a **series circuit**. It does not matter where you put the ammeter, it will give you the same reading.
All three ammeters give the same reading in this series circuit



Adding more cells

The current in a series circuit depends upon the number of cells. The more cells you add, the greater the current.
The more cells, the greater the current

Current is not used up

You might think that the current gets less as it flows through one component after another. But it is not like this. The current is not used up by the components in a circuit. This means that the current is the same everywhere in a series circuit, even if it has lots of lamps or other components.