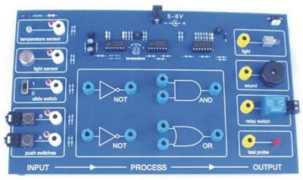
S3 CfE Physics

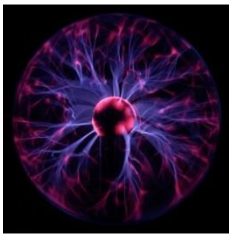
Summary

Monifieth High School







Name:

Form Class:

Physics teacher:

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Exploring Space

How much of this do you think you can do?

Level	**Lesson 1: Why do we explore space?**	Before	After
3	Give examples of the impact that space exploration has had on my day to day life		
3	State what is meant by the terms back hole, galaxy, milky way, star and planet		
4	State what is meant by the term exo-planet		

Level	**Lesson 2: Optical telescopes**	Before	After
3	Identify the key parts of a refracting telescope		
2	Explain how a refracting telescope works		
3	Identify the key parts of a reflecting telescope		
2	Explain how a reflecting telescope works		
2	Describe the difference between a reflecting and a refracting telescope		
1	I can evaluate the effectiveness of a telescope and make suggestions to improve the design		

Level	**Lesson 3 and 4: Dip in star brightness causes by exo-planets**	Before	After
2	Explain how a telescope can be used to identify exo-planets		
1	I can design an experiment to investigate how the diameter of an exo-planet affects the apparent brightness of the exo-planets star		
1	I can design an experiment to investigate how the distance of an exo-planet from its star affects the apparent brightness of that star		

Level	**Lesson 5 – 7: Goldilocks zone**	Before	After
3	State what a planet needs in order to sustain life		
4	State what is meant by the goldilocks zone		
1	I can use my understanding of the goldilocks zone to predict the likely hood of life on an exo-planet		
Level	**Lesson 8 and 9: Analysing exo-planet atmospheres**	Before	After

3	Describe the advantages of having a telescope in orbit above the Earth's atmosphere		
3	Describe how astronomers work out what gasses make up an exo-planet's atmosphere		
4	State what is meant by the term electromagnetic spectrum		
3	Name all of the members of the electromagnetic spectrum in order from highest to lowest energy		
3	For each member of the electromagnetic spectrum name an object in space that gives out that type of electromagnetic radiation		
2	Describe a non-astronomy use for each of the members of the electromagnetic spectrum		

Level	**Lesson 10: Careers using Physics**	Before	After
3	Give examples of careers related to exploring space		

Overall level descriptors for the end of exploring space

Level 5: I'm still a bit confused about what an exo-planet is and how they are detected. I'm not sure what the electromagnetic spectrum is or how it relates to space.

Level 4: I know one thing about how telescopes work, how exo-planets are detected and the electromagnetic spectrum.

Level 3: I know at least three things about how telescopes work, how exo-planets are detected and the electromagnetic spectrum.

Level 2: I can use my knowledge about how telescopes work, how exo-planets are detected and the electromagnetic spectrum to:

- explain how telescopes work and describe a method used to detect exoplanets.
- explain what the goldilocks zone is and why it is important for planet hunters.
- explain what the electromagnetic spectrum is and why it is important for both astronomers and other people who aren't astronomers.

Level 1: I can use my understanding of telescopes, how exo-planets are detected and the electromagnetic spectrum to:

- based on data presented to me I can justify my opinion of whether the cost of space exploration is worth it or not.
- design experiments to investigate factors that affect exo-planets.
- estimate the likely hood of alien life being found on an exoplanet.

Before we begin exploring space we need to understand the meanings of the words and language we will use: Black hole, galaxy, milky way, star and planet. Definitions of these terms are given below.

Black hole - A region in space where matter has collapsed in on itself and which has such a large gravitational force that nothing can escape from it, including visible light.

The huge gravitational force is the result of very dense matter being 'squeezed' into a very small space. Black holes can be formed when a star ends its life in a supernova explosion and most galaxies are thought to have a black hole (or several) at the centre of them.

Galaxy - A collection of many millions of stars, along with gases, dust and dark matter.

The word galaxy comes from the Greek word 'Galaxia' which means milky, a reference to our own galaxy, the Milky Way. There are hundreds of billions of galaxies in the observable universe and the nearest galaxy to our own Milky Way is Andromeda, which is so far away it takes light from there about 2 million years to reach us. Galaxies form in different shapes. The Milky Way is a spiral galaxy but there are many others which are elliptical or irregularly shaped.

Milky Way – Our own galaxy.

Our Sun (and solar system) is only one star in a spiral arrangement of approximately 100 billion stars. There are different types of stars in the Milky Way which cannot be distinguished individually by the naked eye, giving the night sky a milky appearance. The Milky Way is so large it takes light approximately 100,000 years to travel across it, from one edge to the other.

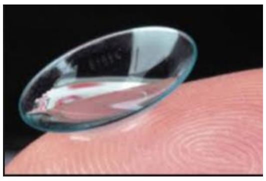
Star - A giant ball of very hot gases held together by its own gravity.

Stars generate energy by nuclear fusion (you will find out more about this process in National 5 Physics) and give out large amounts of heat and light. The hottest stars are blue, then white, then yellow, the coolest stars are red. Our own sun is a yellow dwarf star.

Planet – An astronomical body orbiting a star, not undergoing nuclear fusion and big enough to be rounded by its own gravity.

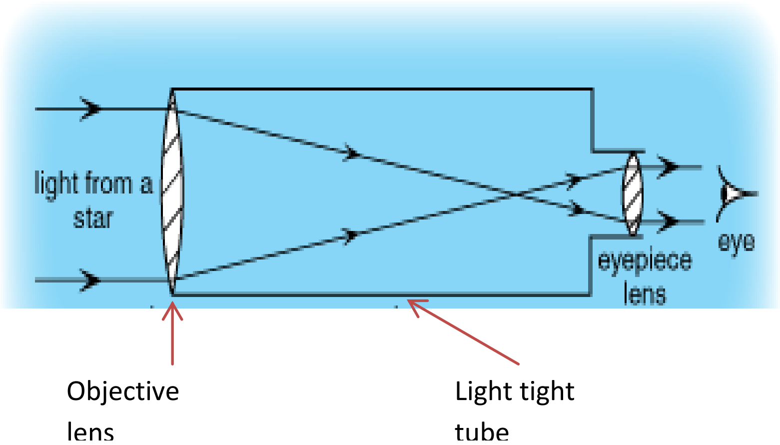
To be classified as a planet the object must have cleared its own neighbourhood of other smaller objects. There are 8 planets in our own solar system. The word planet comes from the Greek for wanderer.

Exploring space using **telescopes** has allowed us to learn about the solar system, galaxy and universe in which we live. The technologies that have been developed for these telescopes have led to useful applications such as spectacles, contact lenses and digital cameras.



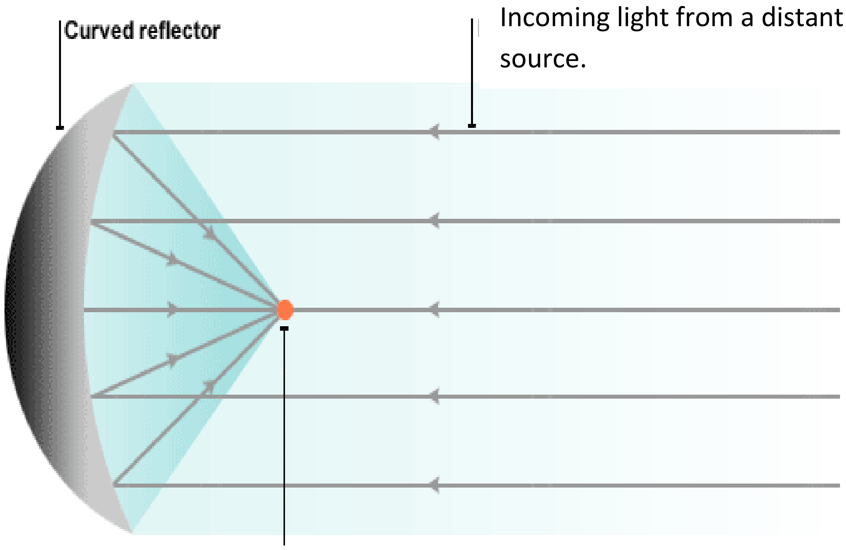
Optical telescopes (telescopes that collect light that is too dim for our eyes to see) use either lenses or curved mirrors to collect and focus light. A telescope that uses lenses is called a “ref**ra**ctor” because the light refracts (changes direction and speed) as it enters the lens. A telescope that uses mirrors is called a “ref**le**ctor” because the light reflects from the mirror to a focus.

Diagram of a REFRACTING telescope



Refracting telescopes use lenses to obtain images of distant objects. A refracting telescope consists of an **objective lens**, an **eyepiece lens** and a **light tight tube**. The objective lens produces an image which is then magnified by the eyepiece lens and the light tight tube cuts out light from other sources. The larger the diameter of the objective lens the more light it can collect and therefore the brighter the image.

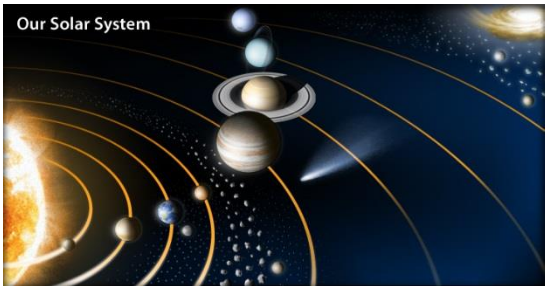
Curved reflectors as part of REFLECTING telescopes



Curved reflectors are used to reflect light to increase the brightness of the image of a distant star or other source. The curved shape of the reflector collects the light from over a large area and brings it to a focus. The detector of light is placed at the focus so that it receives a brighter image.

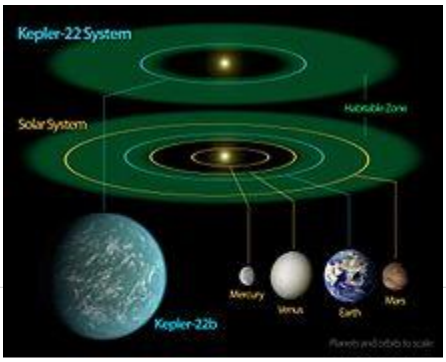
Some telescopes such as the Hubble telescope orbit the Earth outside of the atmosphere so that they can see a much clearer picture of the universe.

Telescopes were used to identify the planets in our solar system. A planet can be distinguished from a star in the night sky as planets do not twinkle. The planet does not twinkle because it is large enough for a human eye to be able to see it as more than a point of light.

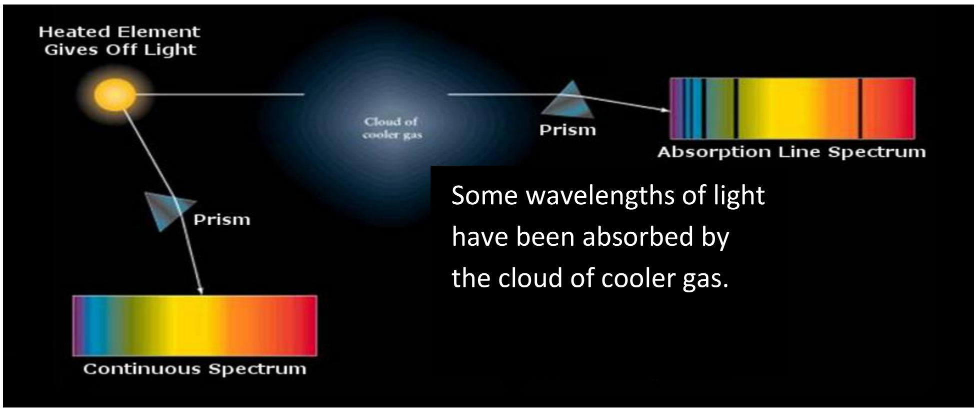


Telescopes can be used to identify planets out with our solar system. Planets that orbit stars other than our sun are called **exo-planets**. When a planet passes in front of a star the light from the star dims slightly. This effect can be used to identify exo-planets. Thousands of exo-planets have been discovered so far. As technology improves even more exo-planets are being discovered. Some of these are in our galaxy, the Milky way, others are even further away.

Astronomers think that some of these planets might be able to sustain life. If a planet it too close to a star it will be too hot to sustain life. If a planet it too far from a star it will be too cold to sustain life. The distance from a star where the temperature is just right for a planet to sustain life, as we know it, is called the Goldilocks zone.

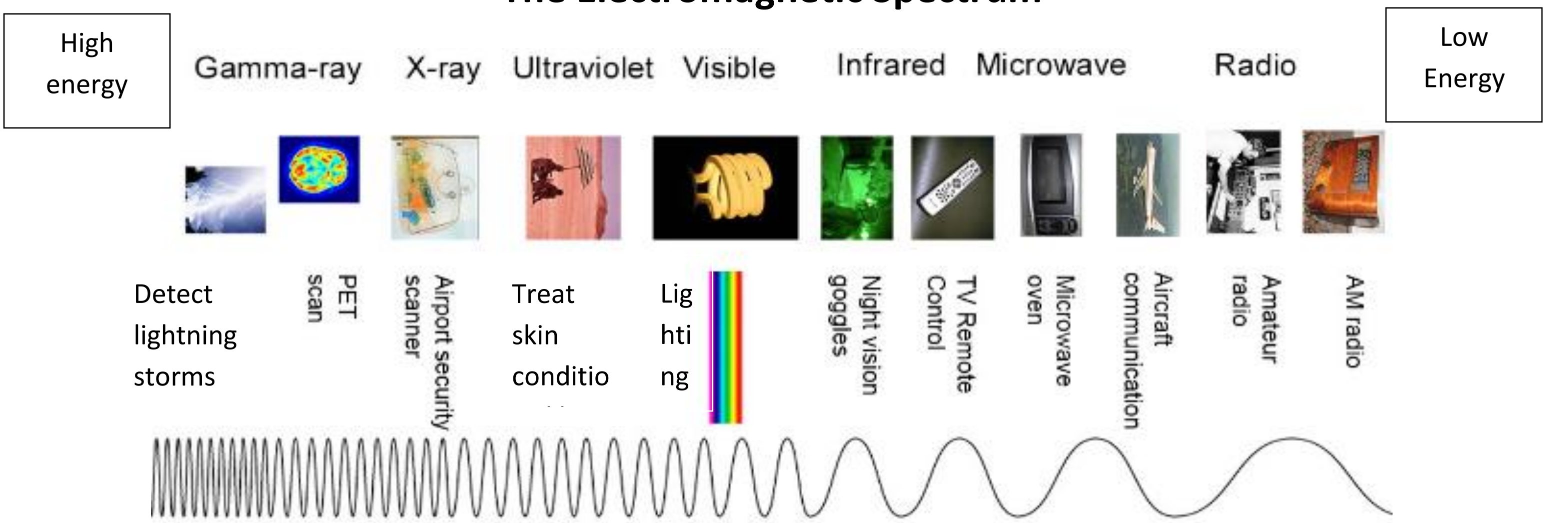


Planets are surrounded by a mixture of different gases and it is these gases which make up the planet's atmosphere. When light passes through these gas mixtures some of the colours of light are absorbed by the gases. Scientists can examine in detail exactly which gases are present by detecting which colours have made it through the gas cloud and which ones were absorbed. They do this using a **spectrometer,** which is a scientific instrument, containing a prism, used to split light into all its different colours.



The black lines in the absorption spectrum, that we see, represent the 'missing' or absorbed colours of light.

The Electromagnetic Spectrum



This is the name for all the different types of visible and invisible light waves that we know about. You encounter many of these waves in your everyday life. All the waves within the electromagnetic spectrum travel at the same speed; 3 hundred million metres every second, in a vacuum or in air, which is 300,000,000 m/s. We write this as **$3x10^8$ ms^{-1}** Some of these waves can be harmful to human life. They come from space but our atmosphere provides a protective layer, through which many cannot pass. Different waves within the electromagnetic spectrum are emitted from many different objects in the Universe. The Sun, other stars within the Milky Way and other galaxies emit all of the different types of electromagnetic waves. X-rays can be used to detect black holes. It is not the black holes themselves that emit the x-rays but the stars and gasses which are being stretched as it enters the black holes. Planets do not emit electromagnetic waves but they do absorb and reflect them. These waves are detected by a variety of different detectors, often located on satellites above the Earth's atmosphere. Knowledge of this helps astronomers to map out the Universe.

THE NEED FOR SPEED

- I can use appropriate methods to measure, calculate and display graphically the speed of an object, and show how these methods can be used in a selected application. **SCN 4-07a**

How much of this do you think you can do?

level	**Lesson 1: Why build a car that can travel 1000 mph?**	before	after
4	Give examples of everyday and unusual speeds.		
3	Give examples of jobs that require an understanding of speed.		
level	**Lesson 2: Determination of the land speed record.**		
2	**Calculate the average speed of an object using:** $d = vt$		
2	**Measure the average speed of an object.**		
1	**Suggest improvements to experimental procedures.**		
2	**Use a TSA to measure a gap time.**		
level	**Lesson 3: Practical activities to measure and differentiate between average and instantaneous speeds.**		
3	Explain the difference between average speed and instantaneous speed.		
2	Measure the instantaneous speed of an object.		
2	Describe a method for measuring the instantaneous and average speed of an object.		
level	**Lesson 4: Acceleration from rest**		
4	State what is meant by acceleration.		

2	Carry out calculations using the relationship between acceleration, change in speed and time.		
1	Carry out multi-step calculations using the relationship between time, acceleration and, change in instantaneous speed.		
2	Explain the difference between speed and acceleration.		
level	**Lesson 9: Acceleration as change in speed**		
2	Measure the acceleration of an object using a TSA to measure the initial and final instantaneous speeds and a stopwatch to measure the gap time.		
2	Compare the above method of finding acceleration with the method using a double mask to get acceleration directly.		
1	Carry out multi-step calculations to determine acceleration.		
level	**Lesson 10: Engineering design challenge**		
1	Design, construct, and test a balloon propelled car using TSA system, focusing on average speed, instantaneous speed, and acceleration.		
level	**Lesson 11: Slowing the blood hound**		
2	Describe how high speed cars may be slowed down by friction from the road.		
2	Describe how high speed cars may be slowed down by air resistance from flaps.		
2	Describe how high speed cars may be slowed down by air resistance from a parachute.		
2	Use the concept of balanced forces and unbalanced forces to describe the motion of a car when accelerating, moving at constant speed, and coming to a stop.		
level	**Lesson 12: Car safety**		
2	Describe how seat belts are used as a safety feature in modern cars.		
2	Describe how airbags are used as a safety feature in modern cars.		
2	Describe how crumple zones are used as safety features in modern cars.		
level	**Lesson 13: Motion graphs**		
2	Describe speed-time graphs for vehicles accelerating, travelling at a		

	constant speed, and decelerating.		

Overall level descriptors for the end of the topic

Level 5: I'm still a bit confused about what is motion of an object in relation to its speed and acceleration.

Level 4: I know one thing about motion of an object in relation to its speed and acceleration.

Level 3: I know at least three things about motion of an object in relation to its speed and acceleration.

Level 2: I can use my knowledge of motion of an object in relation to its speed and acceleration to:

- solve problems requiring calculations and conversion of units;
- compare two or more methods of finding acceleration;
- describe how high speed cars may be slowed down;
- describe the physics of the safety features in modern cars
- interpret speed/time graphs.

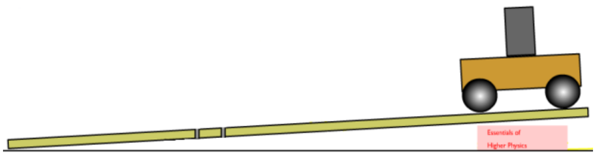
Level 1: I can use my understanding of motion of an object in relation to its speed and acceleration to:

- design, construct, and test a rocket propelled car;
- carry out calculations that involve multiple formulae including conversion of units.

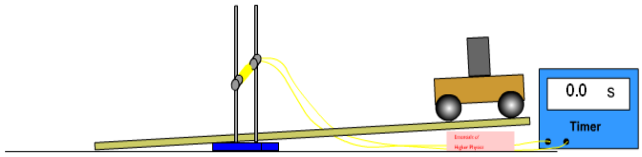
The Bloodhound Project **is made up of a team of scientists and engineers attempting to create the ultimate Land Speed Record car.** The target is to reach an average speed of 1,000 mph (about 500 ms^{-1}) over two fixed distances. One distance is a mile (1,600 m) and the other is a kilometer (1,000 m). The cars speed increases at about 60 mph every second achieving a maximum acceleration of 25 ms^{-2}. The car however cannot stop in a distance less than 4.5 miles (7,242 m). This is about the distance from Monifieth High School to the Odeon cinema in Dundee! You can find out more at www.bloodhoundssc.com.

Speed is the distance travelled by an object in one second (ms^{-1}).

The **average speed** ($\bar{v}$) of an object is the average for the whole journey. To calculate average speed the total **distance travelled** can be measured with a ruler and the **time taken to travel the distance** can be measured with a stop clock.



The **instantaneous speed** (v or u) of an object is its speed at one particular point during the journey. To calculate instantaneous speed the **length of card** is measured with a ruler and the **time taken for the card to pass through a light gate** is measured with



an electronic timer.

When a trolley runs down a slope in the classroom its average speed will be around 0.2 ms^{-1} and its maximum instantaneous speed will be about 0.5 ms^{-1}. In a built up area traffic is limited to maximum instantaneous speeds of 30 mph which is about 15 ms^{-1}. On motorways, most vehicles are limited to 70 mph which is about 35 ms^{-1}.

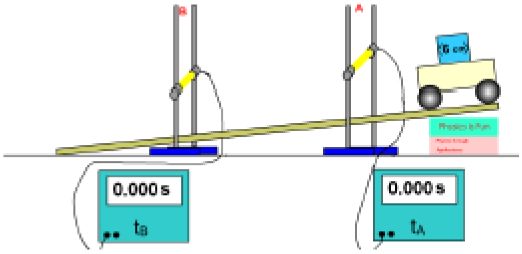
$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

$$v = \frac{d}{t}$$

The **acceleration** of a vehicle is how much its speed changes each second. Acceleration is usually measured in meters per second per second (ms^{-2}). Acceleration can be calculated by dividing the change in speed by the time taken for the change.

$$\text{acceleration} = \frac{\text{change in speed}}{\text{time}}$$

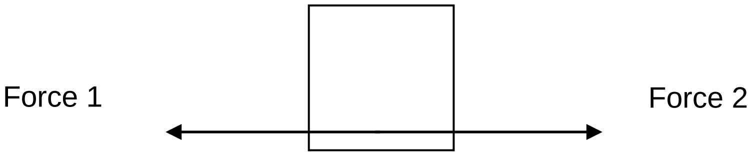
$$a = \frac{v - u}{t}$$



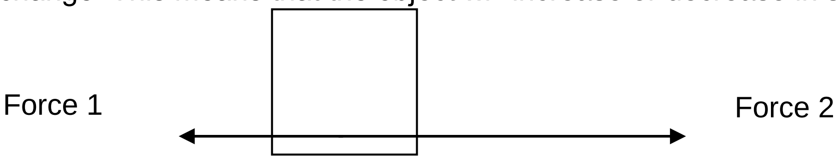
Friction is a force that constantly opposes an object's motion and is the reason why all objects slow down on a flat surface. The Bloodhound is designed to reduce the amount of friction acting on it to ensure that it can travel with the least resistance possible from the road surface and air (drag).

Forces can have an effect on objects by changing its speed. There are 2 very important rules regarding forces that have an effect on an object's speed:

1. When a moving object has 2 forces acting on it in opposite directions that are equal in size then the object will travel at a constant speed.
2.

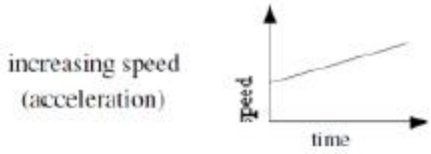


3. When a moving object has 2 forces acting on it in opposite directions that not equal in size then the object's speed will change. This means that the object will increase or decrease in speed.

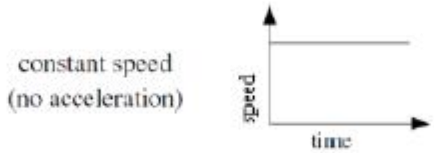


Examples of the effect of forces on the Bloodhound:

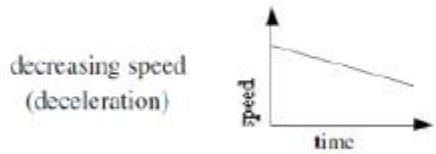
At launch (accelerating): The force from the engine is greater than the force of friction therefore the Bloodhound will increase in speed.



Travelling at a constant speed: The force from the engine is equal to the force of friction therefore the Bloodhound will travel at a constant speed. Notice as the speed of the Bloodhound increases, so does the frictional forces.



Braking (decelerating): The force from the engine is smaller than the force of friction therefore the Bloodhound will decrease in speed. In order to slow the Bloodhound down, the driver can increase the size of friction in a number of ways depending on the Bloodhound's speed.



Bloodhound SSC has three primary braking systems: airbrakes, parachutes and wheel brakes. These will be used one-by-one to slow the car down from its top speed of over 1,000mph, taking advantage of the inherent benefits of each one:

- 1000mph: close the throttle
- 800mph: start to deploy the airbrake

- 650mph: deploy first parachute
- 400mph: deploy a second chute if required
- 200mph: apply the wheel brakes.

Airbrakes

The airbrakes are fitted at the rear of the car, one on either side in front of the rear wheels. As they fold out they will produce an extra 6 tonnes of drag (roughly equivalent to a big elephant).

Parachutes

The parachutes are stored at the back of the car and are the same as those used in world record breaking Thrust SSC. They will be on the end of a 20 metre line to avoid the turbulence immediately behind the car. These provide around 9 tonnes of drag when deployed (that's more than a double-decker bus).

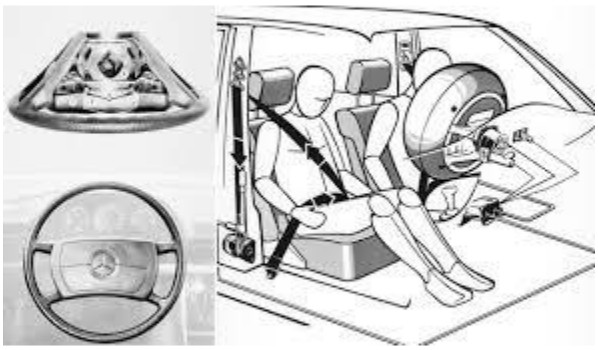
Wheel brakes

When Bloodhound was tested at the Aerohub, Newquay it was fitted with carbon wheel brakes front and rear, which are the same as those used on aircraft and high performance race cars. However, these simply won't work at the extremes required by the desert runs in South Africa – we know, because we tested one and it exploded. Instead the desert wheel brake disks will be made from steel and fitted to the front wheels only.

http://www.bloodhoundssc.com/project/car/braking-systems

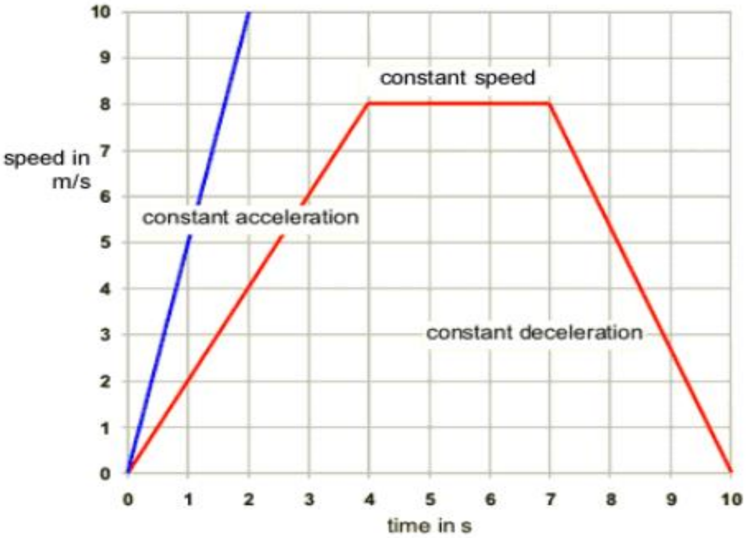
Safety features in modern cars

Moving cars have kinetic energy, which is changed into heat energy when they brake. Safety features in modern cars, such as **seat belts, airbags, and crumple zones**, are designed to absorb kinetic energy in a crash.



All these features reduce injuries to the people in the car by **absorbing energy when they change shape**. As they deform they **increase the amount of time the person takes to come to a stop**. This **reduces** the **acceleration** and **force** on the person, so reducing injury. Seat belts have to be replaced after a crash because the large forces may damage them.

Speed-time Graphs



A speed-time graph tells us how the **speed** of an object changes over **time**. A **horizontal line** indicates a **steady speed**. If a line has a **slope** then the **speed is changing**. The **steeper the gradient** of the line, **the greater the acceleration** (a bigger change in speed in the same time).

Sound Engineering

How much of this do you think you can do?

level	**Lesson 1: What is sound?**	before	after
4	State what is meant by the term sound wave in relation to energy.		
3	Explain how sound waves can be transmitted with reference to the movement of particles.		
3	**State at least 3 examples of how sound waves can be produced.**		
4	**State what is meant by the term longitudinal wave.**		

level	**Lesson 2: Speed of sound**	before	after
2	Describe a method for measuring the speed of sound in air.		
2	Calculate the speed of a sound wave using the relationship: $d = vt$		
1	Identify the strength and weaknesses of a method used to measure the speed of sound in air.		

level	**Lesson 3: Frequency and pitch**	before	after
3	Define the term frequency and state it’s unit of measurement.		
4	State the relationship between pitch and frequency.		
2	Carry out calculations using the relationship between frequency and number of waves in a given time: frequency = number of waves ÷ time		
2	Analyse oscilloscope traces to compare the pitch and frequency of sound waves.		
4	Define the term period.		
2	Carry out calculations using the relationship between frequency and period: $T = \frac{1}{f}$		
2	Convert from kHz and MHz to Hz		

level	**Lesson 4: Wavelength and wave equation**	before	after
3	Define the term wavelength of a sound wave and state it's unit of measurement.		
2	Work out the wavelength of a sound wave from a diagram of its longitudinal wave.		
2	Carry out calculations using the relationship between speed, frequency and wavelength: $v = f\lambda$		
2	Convert from mm and cm to m		
1	Carry out calculations that involve multiple steps and multiple formulas including conversion of unit.		

level	**Lesson 5: Amplitude and Loudness**	before	after
4	Define the term amplitude.		
4	State the relationship between loudness and amplitude.		
2	Analyse oscilloscope traces to compare the loudness and amplitude of sound waves.		
4	State the name of the device used to measure sound levels.		
1	Sketch changes to oscilloscope traces that show specific differences in both amplitude and frequency of sound waves.		

level	**Lesson 9: Reflection of sound applications**	before	after
3	State 2 practical applications of reflection of sound waves.		
2	Carry out calculations for reflection of sound (echo's) using the relationship: $d = vt$		

Overall level descriptors for the end of the topic

Level 5: I'm still a bit confused about what sound is. I'm not sure what the properties of sound are.

Level 4: I know one thing about sound and its properties.

Level 3: I know at least three things about sound and its properties.

Level 2: I can use my knowledge of sound and its properties to:

- solve problems requiring calculations and conversion of units;
- explain the physics behind the practical applications of reflection of sound;
- analyse oscilloscope traces to compare loudness and amplitude of sound.

Level 1: I can use my understanding of sound and its properties to:

- identify the strengths and weaknesses of a method: to measure the speed of sound in air;

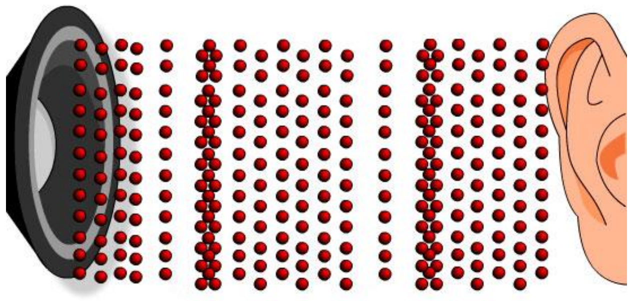
- carry out calculations that involve multiple formulae including conversion of units;
- sketch oscilloscope traces that show specific differences in amplitude and frequency of sound waves.

What is sound?

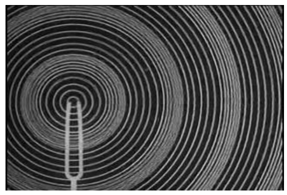
Sound is a way of transferring **energy** through the vibration of particles.

A source of sound must be given energy to vibrate in some way in order to produce a sound. This could be done by **plucking a string, vibrating a ruler, blowing air over a hole or between vocal chords**.

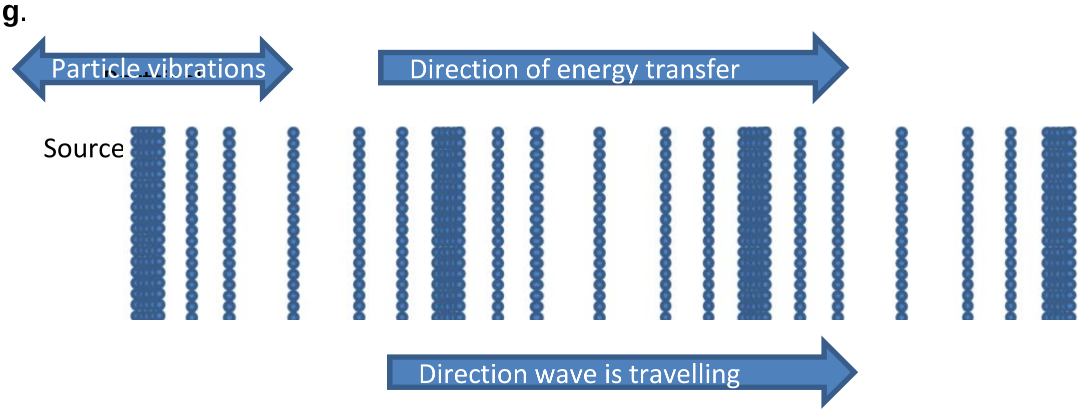
The sound produced by the source is transmitted by **vibrating particles** passing on their energy to neighbouring particles. In a loud speaker for example the particles will be pushed together as the cone of the speaker moves outwards and spaced out as the cone moves backwards. When these vibrations reach our ear we hear them as sounds.



When sound is produced at a source the vibrations are passed on and spread out like the ripples on a pond.



Ripples are very small water waves. Sound can be categorised as a longitudinal wave. This means that the **direction in which the energy is passed on is in the same direction as the sound waves appears to be travelling**.



The speed of sound in air

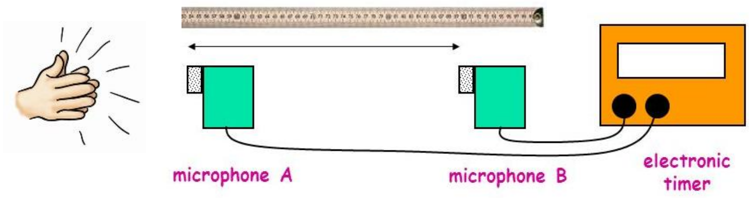
The speed of sound in dry air at 20^{o}C is **340 m/s**. This means that in 1s sound will travel 340 m. This is a speed of 768 miles per hour which is also a speed of 1,236 kilometres per hour.

Trundle wheel and stop watch method:

The source of sound is a symbol being struck. The distance between the stop watch operator and the source of the sound is measured with a trundle wheel. The stop watch is started when the symbol is seen to be struck. The stop watch is stopped when the sound is heard.

Microphone and electronic timer method:

The source of sound is a loud clap. The distance between the two microphones is measured with a meter stick. The electronic timer is started when the sound reaches the first microphone. The electronic timer is stopped when the sound reaches the second microphone.



The relationship distance equals speed multiplied by time is used to calculate the speed of sound:

$$d = vt$$

Example:

distance measured by trundle wheel = 100m

time on stop watch = 0.3s

$$d = vt$$

$$100 = v \times 0.3$$

$$v = \frac{100}{0.3}$$

$$v = 333m/s$$

Example:

distance between microphones = 1m

time on electronic timer = 0.003s

$$d = vt$$

$$1 = v \times 0.003$$

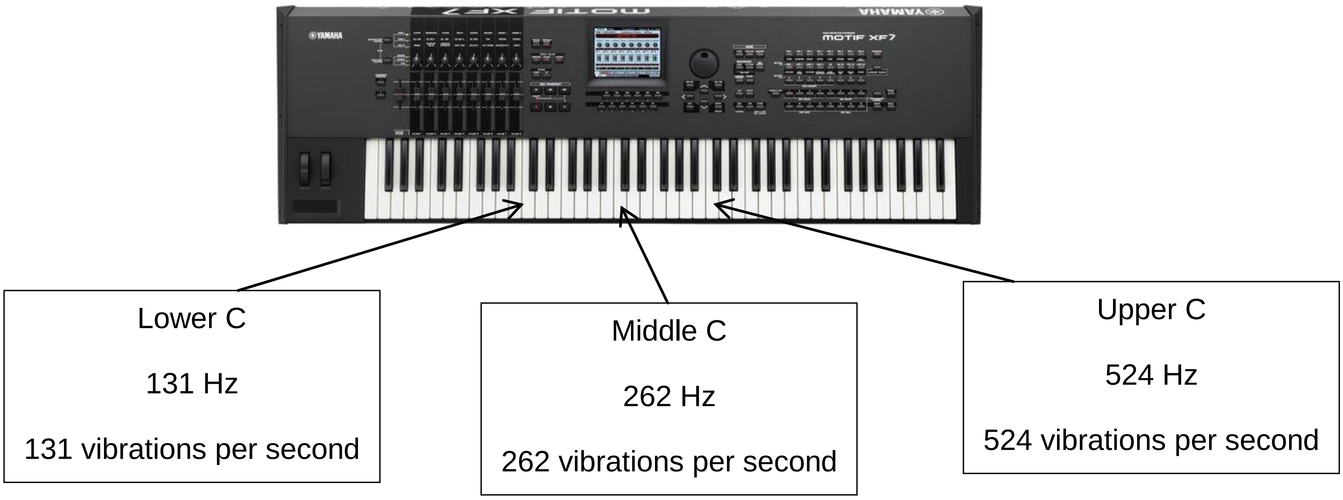
$$v = \frac{1}{0.003}$$

$$v = 333m/s$$

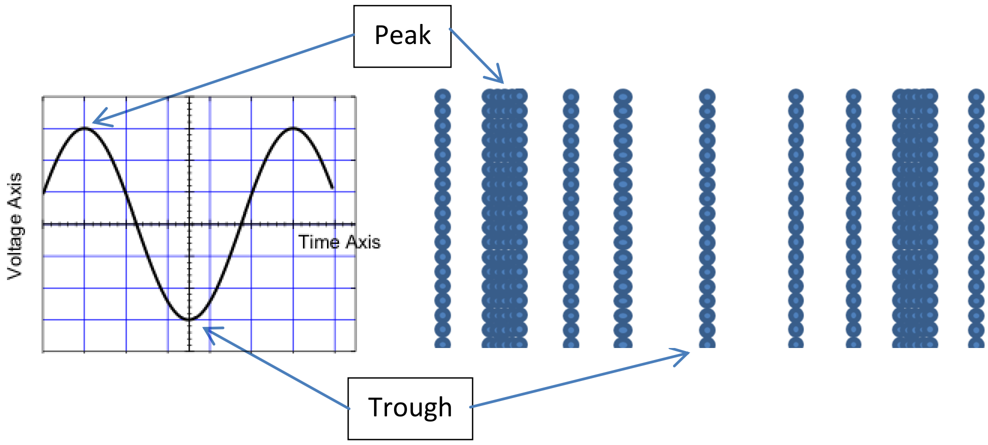
The values calculated from the experimental results are different from the expected value of 340 m/s this may because the temperature of the air was not 20^{0}C or the air was not completely dry and still.

Frequency and pitch

The **frequency** of a sound is the **number of vibrations produced by the source each second**. Frequency has the symbol *f* and is measured in the units of Hertz which is shortened to Hz. The more vibrations that are produced each second the higher the **pitch** of the sound will be.



An **oscilloscope** can be used to investigate the frequency of sound waves. The top of the trace on the oscilloscope trace shows where the particles have been squashed together by the vibrations and is called the peak of the trace. The bottom of the trace shows where the particles have been moved apart and is called the trough of the trace.

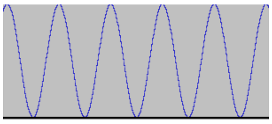


The more peaks and troughs that are shown on the oscilloscope trace the higher the frequency and pitch of the sound.

Lower C

131 Hz

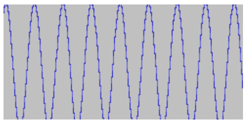
131 vibrations per second



Middle C

262 Hz

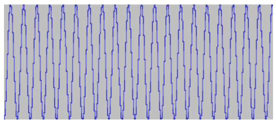
262 vibrations per second



Upper C

524 Hz

524 vibrations per second



We can use the meaning of the term frequency to calculate the frequency of sound waves, how many sound waves will be produced in a certain time or how long it will take to produce a certain number of waves.

frequency = number of waves ÷ time in seconds

Example: Lower C

7,860 waves in 1 minute

7,860 ÷ 60 = 131 Hz

Example: Middle C

How many waves in 2 minutes?

262 x 120 = 31,400 waves

Example: Upper C

How long to produce 1000 waves?

1000 ÷ 524 = 1.9 s

The time between the waves (which is also the tim between the vibrations) is called the **period** of the wave has the symbol *T* and is measured in seconds.

$$T = \frac{1}{f}$$

Example: Lower C

$$T = \frac{1}{131} = 0.0076s$$

Example: Middle C

$$T = \frac{1}{262} = 0.0038s$$

Example: Upper C

$$T = \frac{1}{262} = 0.0038s$$

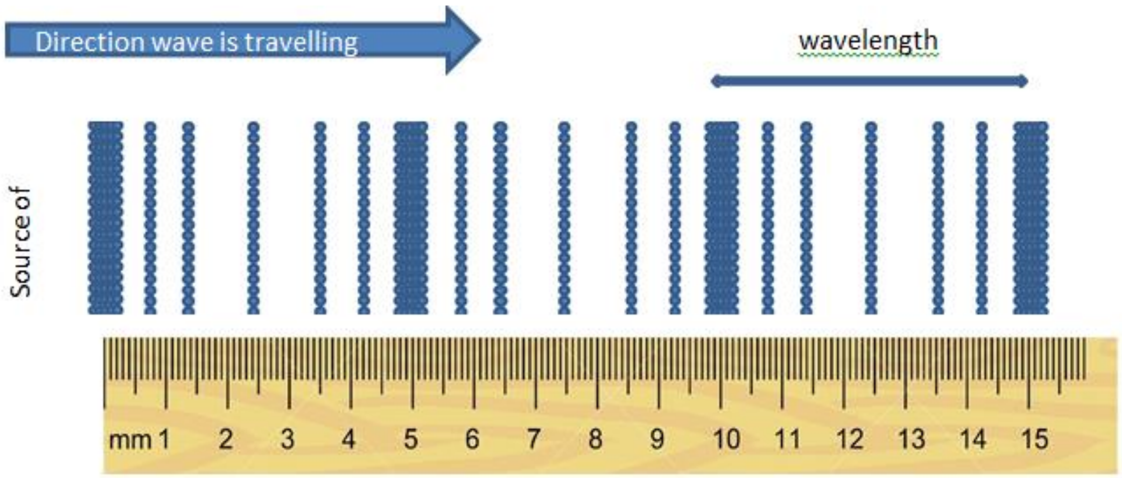
The smaller the period of a sound the higher it's frequency will be. The time between some sound waves is so small that the frequency of the sound is in thousands or millions of Hertz. A shortcut of **kHz** can be used to represent thousands of Hertz and a shortcut of **MHz** can be used to represent millions of Hertz.

e.g. 2,300 Hz = 2.3 x 10^3 Hz = 2.3 thousand Hertz = 2.3 kHz

e.g. 6,700,000 Hz = 6.7 x 10^6 Hz = 6.7 million Hertz = 6.7 MHz

Wavelength

The **wavelength** of a sound wave is the **distance between consecutive compressions** of the vibrating particles. The wavelength is measured in **meters** and is given a Greek letter called lambda as a shorthand. The Greek symbol lambda is written as **λ**.



In the diagram above there are 3 wavelengths in 15mm. To work out the wavelength the distance of 15mm is divided by the number wavelengths. 15 divided by 3 is 5 so the wavelength of the sound wave is 5mm.

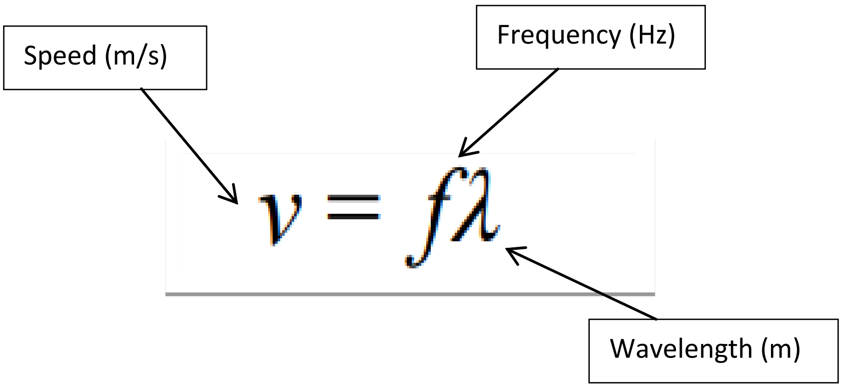
Wavelength should be measured in meters so the final answer for wavelength needs to be converted from mm to meters. 1mm is one thousandth of a meter so to convert from **mm to m** we can **divide by 1000** or use scientific notation of **$\mathbf{x10^{-3}}$**.

e.g. 5 mm = 0.005 m = 5 x 10^{-3} m

If a wavelength measurement has been made in **cm** it can be converted **to m** by **dividing by 100** or using scientific notation of **$\mathbf{x10^{-2}}$**. 1cm is one hundredth of a meter.

Wave equation

The **wave equation** is a relationship which links together the frequency, wavelength and speed of a wave. The formula is a mathematical way of showing that for waves that travel at the same speed **the higher the frequency of a wave the shorter it's wavelength will be**.



Note: The symbol *v* rather than *s* is used as the equation is technically used to calculate the velocity of the wave. Velocity will be explored more in N5 Physics.

Wave equation examples

(a) A sound of frequency 294 Hz is produced by this finger positioning on a guitar. **Calculate the wavelength** of the sound wave in air.

$$v = f\lambda$$
$$340 = 294\lambda$$
$$\lambda = \frac{340}{294}$$
$$\lambda = 1.16m$$

(b) A sound of wavelength 0.98m is produced by this finger positioning on a guitar. **Calculate the frequency** of the sound wave in air.

$$v = f\lambda$$
$$340 = f \times 0.98$$
$$f = \frac{340}{0.98}$$
$$f = 347Hz$$

(c) A sound of frequency 370 Hz and wavelength 92 cm is produced by this finger positioning on a guitar. **Calculate the speed** of the sound wave in air.

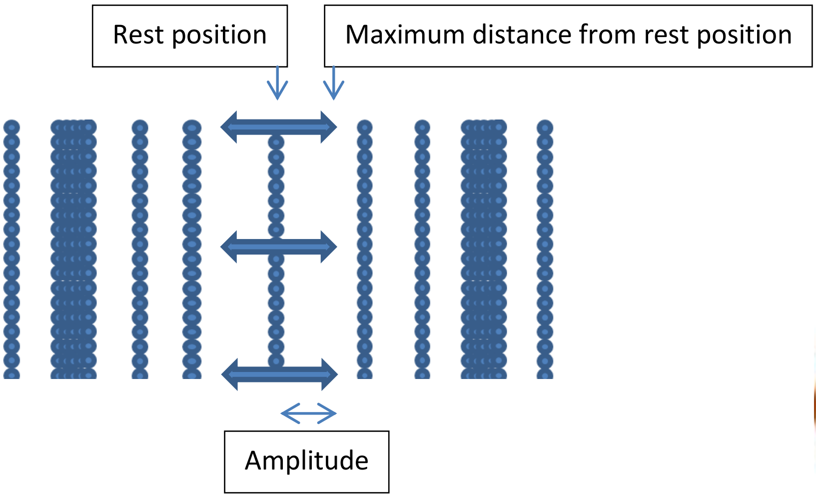
$$v = f\lambda$$

$$v = 370 \times 0.92$$

$$v = 340m/s$$

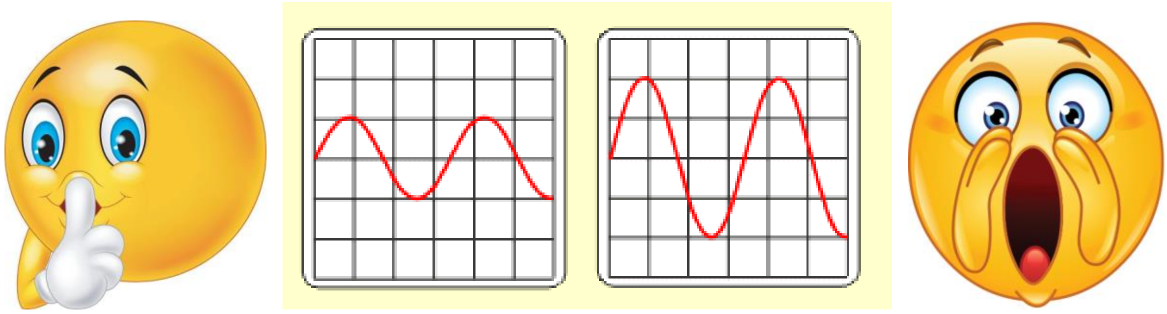
Amplitude and Loudness

When a sound wave passes through the air each particle vibrates, moving backwards and forwards from a rest position. The energy of the wave is passed on from one vibrating particle to the next. The **amplitude** of a sound wave is **the maximum distance away from its rest position that the particles travel during their vibration**.



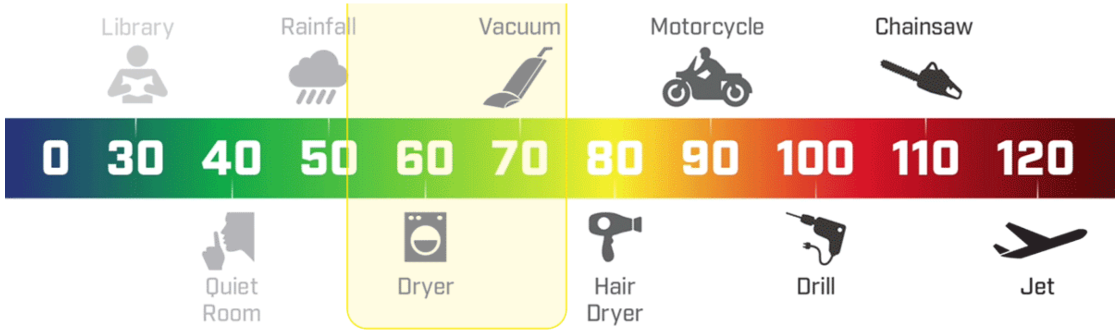
The larger the amplitude of the waves the further the particles vibrate away from their rest position and **the louder the sound will seem**.

The amplitude of sound waves can be studies on an oscilloscope. **The larger the amplitude of the waves the taller the trace** displayed on the oscilloscope.



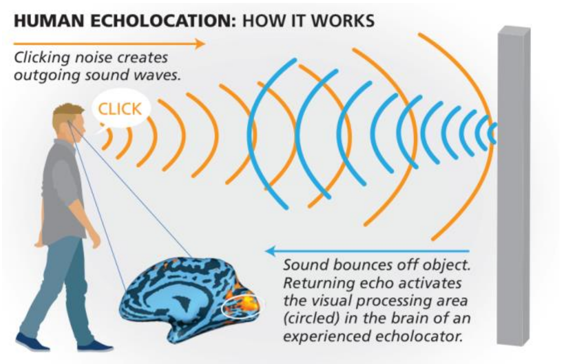
The **loudness** of sound waves can be measured directly using a **decibel meter**.

Examples of some loudness levels measured using a decibel meter:



Reflection of sound applications

Echoes are caused by the reflection of sound and can be used to work out how far away an object is. The closer an object is the sooner an echo will be heard. Some visually impaired people are able to find their way around and bypass obstacles using the reflection of sound, this technique is called echolocation. This is a similar process to the one used by bats and dolphins.



To calculate the exact distance to an object using an echo the time taken between the sound being emitted and being heard after the reflection needs to be measured. Knowing that the speed of sound in air is **343.2 m/s** and using the formula $d = vt$ the distance travelled by the sound can be calculated. The sound will have travelled from the source to the reflecting surface and and back so the distance to the reflecting object will be **half** of the distance worked out using the formula $d = vt$.

For an echo heard after 0.8s

$d = v\,t$ = 343.2 x 0.8 = 274.56 m

274.56 ÷ **2** = 137 m

The object is 174 m away

When sound travels into a material where the particles are more closely packed the vibrations can pass on more easily and sound can travel faster. This change in speed of the sound wave causes part of the wave to reflect. The larger the change in speed of the sound the larger the amplitude of the reflection will be. The reflection of sound can be used in many applications. These applications often use ultrasound waves which are high frequency sounds waves that have frequencies higher than those that humans can usually hear.

Ultrasound scanning

Ultra sound scans can be used to monitor the development of unborn babies. The sound waves are sent from a transmitter through the tissue in the mother's body. When they reach the unborn babies bones the speed of the sound increases and a lot of the sound waves energy is reflected. The reflected sound waves are picked up by a receiver placed next to the transmitter. This reflected wave is shown on a computer screen as a bright point. Ultrasound scans can also be used to form images of patients heart, blood vessels and muscles.

Ocean mapping

Ultrasound waves can also be used to measure the depth of the ocean and to monitor fish numbers. The time taken for the sound to reflect can be used to calculate the depth of the ocean. The speed of sound in water is much higher than it is in air because the particle's in the water are much closer together than they are in the air. Ultrasound which is used in this way is often called sonar.

The higher the frequency of the sound waves the shorter the wavelength of the sound waves and the more details that can be picked up in the images formed and measurements made.

SHOCK AND AWE

How much can you do?

Level		before	after
3	Identify and draw common electrical symbols for lamps, wires, switches, cells, batteries, ammeters, voltmeters, resistors and variable resistors.		
4	State that current is the rate of flow of electrons.		
2	Apply an understanding of current to explain the rules for current in series and parallel circuits.		
4	State that current is measured in amperes (A) using an ammeter that must be connected in series into the circuit.		
4	State that voltage is a measurement of the energy given to move the electrons around a circuit.		
2	Apply an understanding of voltage to explain the rules for current in series and parallel circuits.		
4	State that voltage is measured in volts (V), using a voltmeter connected in parallel with a component		
2	Explain what is meant by the term resistance.		
3	Give examples of factors that affect resistance.		
3	State the relationship between current and resistance in a simple circuit.		
4	State that the unit of resistance is the ohm (Ω).		
2	Convert between kΩ and Ω.		
2	Measure current in a series circuit and the voltage across a fixed value resistor to identify the relationship. Ohm's Law		
2	Relate the gradient of a current against voltage graph to the resistance of an ohmic conductor.		
2	Explain that as resistance in a variable resistor increases, the voltage across it also increases.		
2	State and apply the relationship $V = I R$. Ohm's Law		
2	Convert between mA and A and between kV and V.		

1	Relate the theory of variable resistors to explain their uses in everyday life.		
1	Use your understanding of resistance to design a circuit to solve problems.		

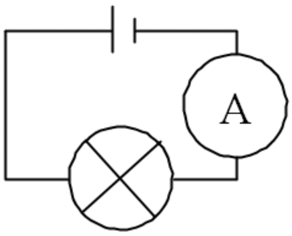
Measuring Current.

Current is measured in Series.

Current is measured by inserting into the circuit.

Current is a measurement of flow of electrons.

Current is measured in Amperes, Amps for short (A).



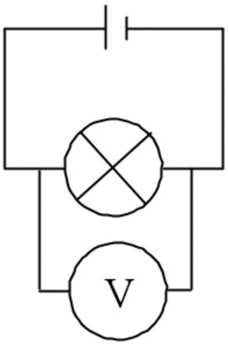
Measuring Voltage.

Voltage is measured in Parallel

Voltage is measured by adding outside the circuit

Voltage is the measurement of the energy of the electrons

Voltage is measured in Volts (V)

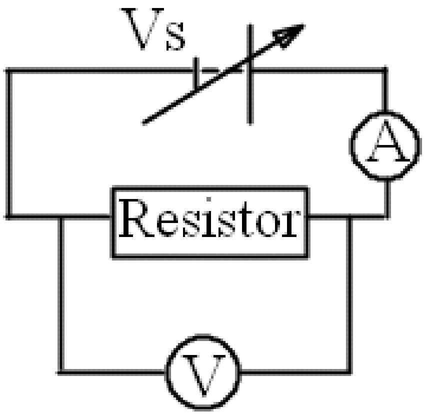


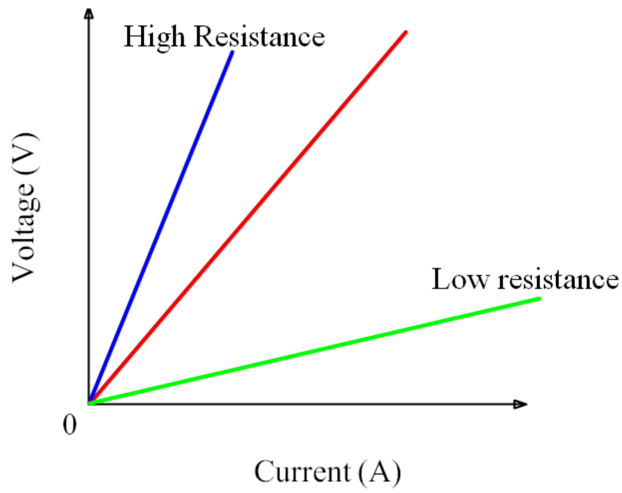
Ohm's Law.

Current (A)

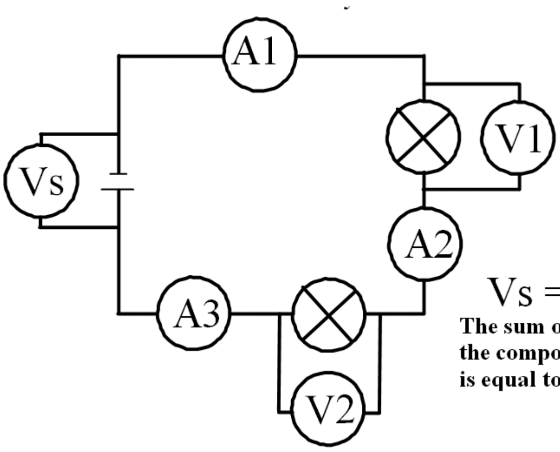
$$V = IR$$

Voltage (V) Resistance (Ω)





Summary of a series circuit.



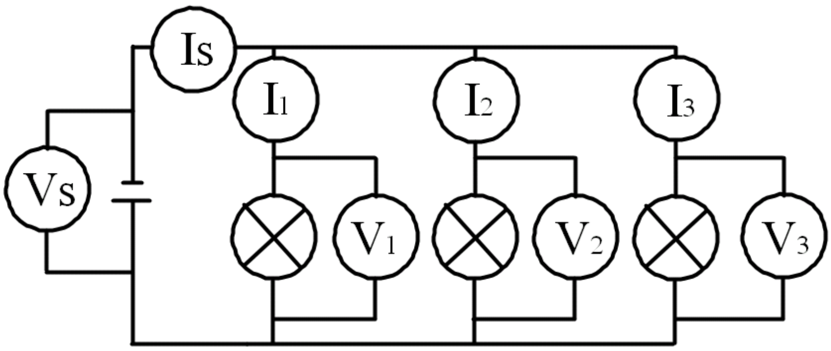
$I1 = I2 = I3$

In a series circuit the current flowing is the same at all points in the circuit.

$Vs = V1 + V2$

The sum of the voltages across the components in a series circuit is equal to the supply voltage.

Summary of a parallel circuit.



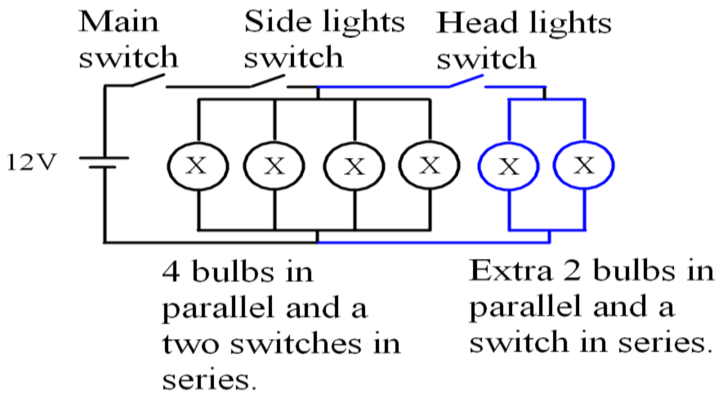
$Vs = V1 = V2 = V3$

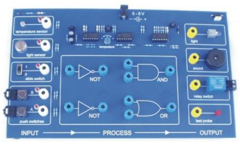
The potential difference across components in parallel is the same for each component.

$Is = I_1 + I_2 + I_3$

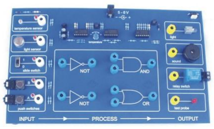
The sum of the currents in parallel branches is equal to the current drawn from the supply.

Circuit applications.





ELECTRONICS



How much of this do you think you can do?

Levels		**Before**	**After**
3	State the differences between analogue and digital systems		
3	Draw a block diagram linking the 3 main parts of an electronic system (INPUT, PROCESS and OUTPUT)		
3	Identify the circuit symbols for commonly used electronic components: microphone, loudspeaker, buzzer, motor, LDR, thermistor, LED and relay switch.		
3	Categorise the above components as input or output devices.		
2	Plan an investigation into how changing light level affects the resistance of a light dependent resistor, LDR.		
2	Identify the relationship between light levels and resistance from your LDR investigation, LURD		
2	Plan an investigation into how changing temperature affects the resistance of a temperature dependent resistor, thermistor.		
2	Identify the relationship between temperature and resistance from your thermistor investigation. TURD		
2	Draw a graph of data you have generated, with correctly labelled axes, even scales, accurate plots and the line or curve of best fit.		
1	Compare data you have generated from an investigation with another source of data, such as that found on a reputable internet site or contained in a book.		
4	Identify the symbols for the logic gates; AND, NOT and OR		
4	State that logic gates are examples of process devices		
2	Explain what the three logic gates do, using the terms input and output.		

4	State that a high input, or 'on' can be represent by 1 and a low output, or 'off' can be represented by 0		
2	Draw truth tables for each of the logic gates; AND, NOT and OR		
1	Create a simple electronic system to perform a specific function using one of the logic gates.		
1	Create a complex electronic system, using a combination of logic gates, to perform a specific function.		
1	Create truth tables for complex design tasks.		
3	Give examples of careers related to Electronics		

Overall level descriptors for the end of Electronics

Level 5: I am still a little confused about the differences between an electronic/digital system and an analogue system. I am not sure what input, process and output devices are and how they are used in everyday life.

Level 4: I can name one of the logic gates. I can identify its symbol and can draw its truth table.

Level 3: I know what the 3 logic gates are. I can identify the symbols and draw the truth tables for each of them. I can identify the symbols for all the input and output devices covered in this unit.

Level 2: I can use my knowledge of how logic gates and electronic systems work to:

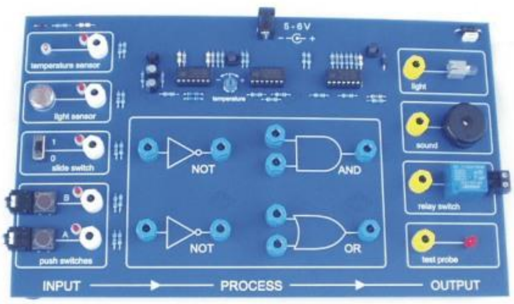
a) Explain how a thermistor and an LDR can be used as input devices.
b) Explain how combinations of logic gates can be used in different ways
c) Explain why an understanding of electronic systems is important to me and to society

Level 1: I can use my understanding of electronic systems to:

a) Design complex systems requiring several input devices
b) Predict how electronics engineering will develop and impact further on my life
c) Justify my opinion of whether further increased research and development within the electronics industry is worth it.

No matter how complex electronic devices are they can be simplified down into three parts represented in this block diagram:

The first is "**input**" and these types of components are shown on the left hand side of the board below. The second part is "**process**" and examples of these are shown in the middle of the board. The process devices on this board are referred to as "**logic gates**". The final part of the electronic system is an "**output**" component. The output components are shown on the right hand side of the board.



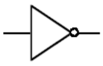
The **temperature sensor / thermistor** is used in circuits where detecting temperature is important such as a thermostatically controlled central heating system. As the temperature of the sensor rises its resistance decreases. This causes a change in the signal given out from the input device that is being passed to the process device. When the sensor is warm it is described as given out a "logic 1" signal but when the sensor is cold it gives out a "logic 0" signal.

The **light sensor / LDR** is used in circuits where detecting light levels is important such as automatic street lights. As the light level falling on the sensor decreases its resistance increases. This also causes a change in the signal given out from the input device that is being passed to the process device. When the sensor is bright light it is described as given out a "logic 1" signal but when the sensor is in low light levels it gives out a "logic 0" signal.

The **relay switch** makes use of electromagnetism to close a switch in a remote circuit. The advantage of this is that almost any component could be connected in this additional circuit and could have its own power supply to run. In many cases it is useful to have an additional output device of a **motor** switched on by the relay switch.

NOT Gate (Inverter)

Symbol:



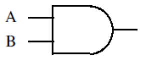
Truth table:

input	output
0	1
1	0

Function: The output is the inverse of the input

AND Gate

Symbol:



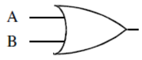
Truth table:

input A	input B	output
0	0	0
0	1	0
1	0	0
1	1	1

Function: The output is only 1 with both inputs A and B are 1.

OR Gate

Symbol:

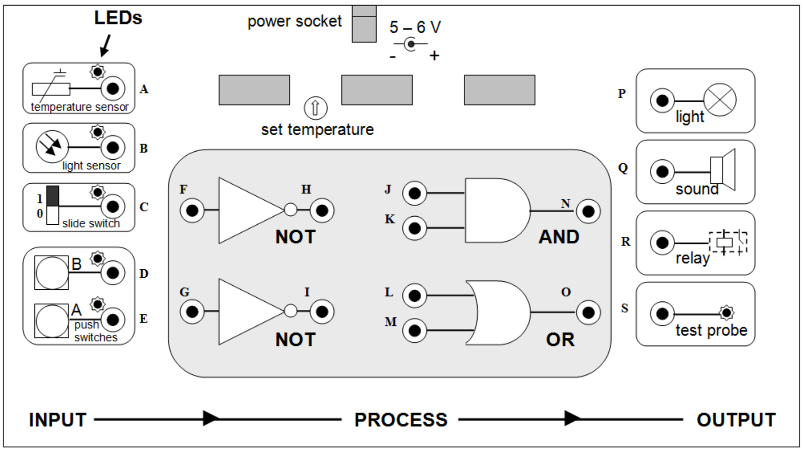


Truth table:

input A	input B	output
0	0	0
0	1	1
1	0	1
1	1	1

Function: The output is 1 if either input A or input B is 1 (or both).

These logic gates can be combined together in different ways, with a variety of input and/or output devices to carry out specific jobs. Here is an example of a combined logic gate circuit design.



This circuit turns on central heating automatically when the system is turned on with the slide switch, C, and the temperature in the room becomes low. The circuit makes use of a motor connected to the relay to operate the pump in the central heating system. The combined truth table for the circuit would be:

Temperature	A	F	H	Switch	C	J	K	N	R	System
Low	0	0	1	On	1	1	1	1	1	On
Low	0	0	1	Off	0	1	0	0	0	Off
High	1	1	0	On	1	0	1	0	0	Off
high	1	1	0	Off	0	0	0	0	0	Off

UNDER PRESSURE

In this topic you will work through experience and outcome **SCN 4-05a**:

I have developed my understanding of the kinetic model of a gas. I can describe the qualitative relationships between pressure, volume and temperature of gases.

How much of this do you think you can do?

Levels		**Before**	**After**
4	I can state the definition of weight as the force due to gravity acting on an object		
4	I can state the unit of weight as Newtons, N		
2	I can carry out calculations using the formula W = mg where g = 9.8 N/kg		
4	I can state the definition of pressure as force per unit area		
4	I can state the unit of pressure as Pascals, Pa		
2	I can carry out calculations using the formula P = F/A		
3	I can convert cm to m		
3	I can calculate areas in m^2 from measurements made in cm		
1	I can estimate the pressure exerted by an object		
1	I can carry out multistep calculations to calculate the pressure exerted from an object's size and mass		
2	I can explain why pressure increases as depth of water increases		
3	I can give examples of the effect that increased pressure has on the body		
4	I can state what is meant by the term kinetic model of a gas		
2	I can explain how a gas exerts a pressure		
4	I can state how the volume of a gas is affected by the pressure applied to it		

2	I can explain using the kinetic model why the volume of a gas is affected by the pressure applied to it		
2	I can describe an experiment that can be carried out to show how the volume of a gas is affected by the pressure applied to it		
4	I can state how the temperature of a gas affects the speed of the gas particles		
4	I can state how the volume of a gas is affected by its temperature		
Levels		**Before**	**After**
2	I can explain using the kinetic model why the volume of a gas is affected by its temperature		
2	I can describe an experiment that can be carried out to show how the volume of a gas is affected by its temperature		
4	I can state how the pressure of a gas is affected by its temperature		
2	I can explain using the kinetic model why the pressure of a gas is affected by its temperature		
2	I can process experimental results to show how the pressure, volume and temperature of a gas affect each other		
1	I can suggest improvements to experimental procedures designed to show how the pressure, volume and temperature of a gas affect each other		
1	I can make predictions about how a change to the pressure and volume, pressure and temperature or volume and temperature will affect the temperature, volume and pressure of a gas		

Overall level descriptors for the end of Under Pressure

Level 5: I am still a little confused about why a gas has a pressure as well as how that is linked to the temperature and volume of the gas.

Level 4: I can state how the pressure of a gas is affected by the gas' volume or temperature.

Level 3: I can state what pressure is and how the pressure of a gas is affected by the gas' volume and temperature.

Level 2: I can explain how a gas produces a pressure and why a change in the gases volume or temperature affects that pressure. I can carry out calculations to work out the pressure exerted by a force over an area and explain why pressure due to water increases as you travel deeper under water.

Level 1: I can use my understanding of the pressure, volume and temperature of gasses to

d) Predict how changes to the volume, pressure or temperature of a gas will affect the other properties of the gas
e) Carry out multistep calculations to determine the pressure exerted by water from the waters mass and length measurements given in mm or cm.

Mass and Weight

Weight is a force caused by gravity acting on an object's mass. On Earth, it measures the pull of the Earth on the object. It is measured in Newtons, (N).

Weight always acts vertically downwards. Its size does not just depend on the mass of the object, but on the strength of gravity at that place.

Mass measures the amount of matter in an object. It is measured in kilograms (kg). The value of mass does not change from place to place.

The strength of force of gravity in a particular place is called the gravitational field strength. This tells you the weight of 1 kilogram. Its symbol is g and its unit is N/kg. On Earth, g = 9.8 N/kg.

Mass and weight are connected by the following formula:-

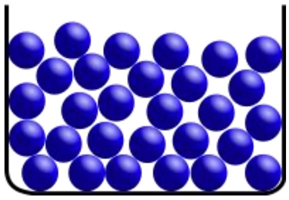
weight = mass x gravitational field strength

also written as

W = m g

where **W** = weight in Newtons (N)
m = mass in kilograms (kg)
g = gravitational field strength in Newtons per kilogram (N/kg or Nkg^{-1}).

Example: Calculate the weight of a 4.5kg tank of water.



W = mg

W = 4.5 x 9.8

W = 44.1 N

Pressure

Pressure on a surface is defined as the force acting per unit area.

It can be calculated using the formula:

$$p = \frac{F}{A}$$

where **p** = pressure in Pascals, Pa

F = force applied at right angles to surface in Newtons, N

A = area in square metres, m^2

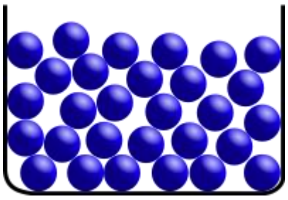
1 Pascal is equivalent to 1 Newton per square metre; ie 1 Pa = 1 N/m^2.

The smaller the area that a force is spread over the higher the pressure will be. This explains why it is more painful to have your foot stepped on by a stiletto than an elephant.

Example: Calculate the pressure exerted by a tank of water with weight 44.1 N when the base of the rectangular tank measures 13 cm by 27 cm.

13 cm = 0.13 m (÷ 100 to convert from cm to m) OR 13 x 10^{-2} m = 1.3 x 10^{-3} m

27 cm = 0.27 m OR 27 x 10^{-2} m = 2.7 x 10^{-3} m



Area of rectangle = length x breadth = 0.13 x 0.27 = 0.0351 m^2

$$p = \frac{F}{A} = \frac{44.1}{0.0351} = 1256Pa$$

(1300 Pa to 2 significant figures)

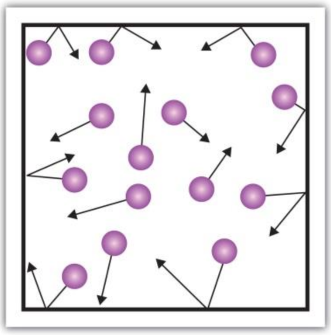
Air pressure

Although air might seem very light there are a lot of air particles above your head. The weight of all of these particles leads to a pressure on you of around 100,000 Pa (1 x 10^5 Pa)!

Pressure under water

The deeper under the surface of water you dive the greater the pressure on your body. This is because as you dive deeper there is more mass of water above your body. Due to gravity acting on this increased mass of water the weight of the water above you is also increased. At 10m below the surface the pressure on your body will be twice what it is on the surface of the water.

Increased pressure on your chest makes it harder to breathe and if the pressure is high enough it can burst your ear drums. If a diver rises too quickly the rapid change in pressure on the body can cause bubbles of gas to form in their blood. This is often called "the bends" and is not only very painful but can also lead to death if not treated in a decompression chamber.



Pressure in a gas and kinetic theory

The pressure of a gas is caused by the particles colliding with the walls of the container. When the particles collide they apply a **force** over the **area** of the inside of the container. The more frequent these collisions or the more violent these collisions, the greater will be the pressure.

The **kinetic theory** tries to explain the behaviour of gases using a model. The model considers a gas to be composed of a large number of very small particles which are far apart and which move randomly at high speeds, colliding elastically with everything they meet.

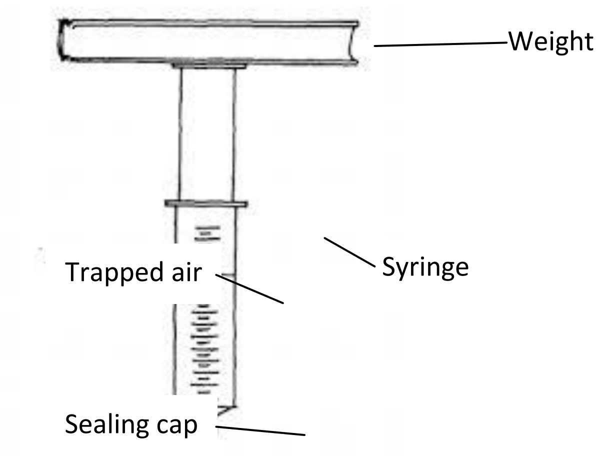
When a balloon is inflated it is the particles of gas inside the balloon hitting against the inside of the balloon skin that keep the balloon in shape.

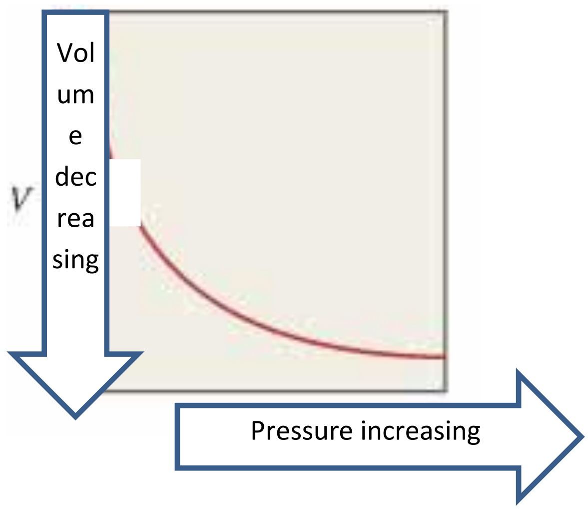
Pressure and volume of a gas

The volume of a gas is taken as the volume of the container. The volume occupied by the gas particles themselves is considered so small as to be negligible.

Consider a volume of a container which can change volume i.e. can be squashed. **If an additional pressure is applied to the container then the volume of the container will be reduced** until the pressure of the gas inside the container is equal to the pressure applied on the outside of the container.

An experiment can be carried out to show this by adding weights to the top of a sealed syringe. The **weight** of the weights can be measured using a **newton balance** and the **dimensions** of the weights measured with a **ruler**. The dimensions can be used to calculate the area of the weight and used along with the weight measurement to calculate the pressure applied to the syringe plunger. The **volume** of air trapped in the syringe can be measured using the **scale on the syringe**.

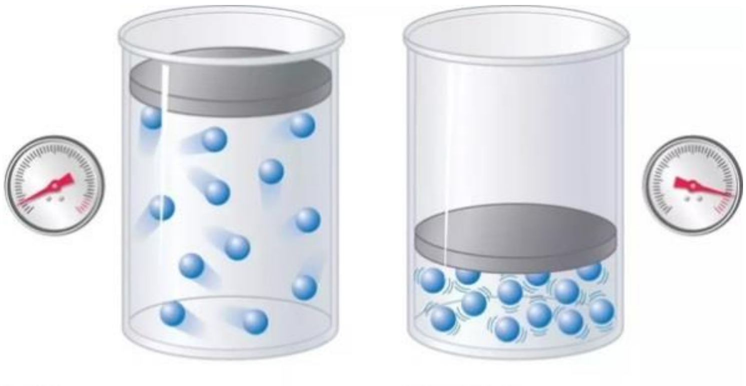




The pressure of the gas inside the container increases because as the container becomes smaller the particles of the gas will hit the walls of the container more often. This will produce a larger average force on the container walls increasing the pressure of the gas. Since the area of the container walls will also be reduce with reduced volume this also increases the pressure of the gas.

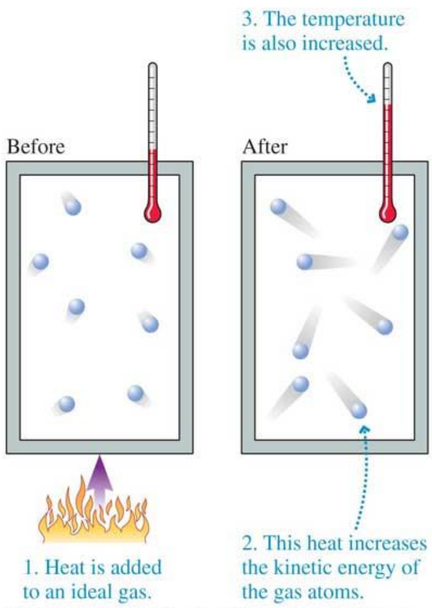
Pressure - Volume (constant mass and temperature)

- As pressure on the container increases, volume of the container decreases.
- As container volume decreases the gas pressure increases.
- As container volume increases the gas pressure decreases.



Temperature of a gas

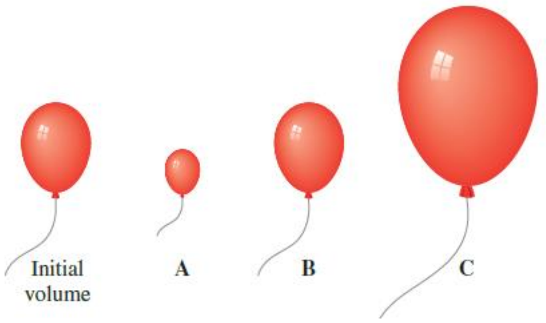
Temperature: The temperature of a gas depends on the kinetic energy of the gas particles. The faster the particles move, the greater their kinetic energy and the higher the temperature.

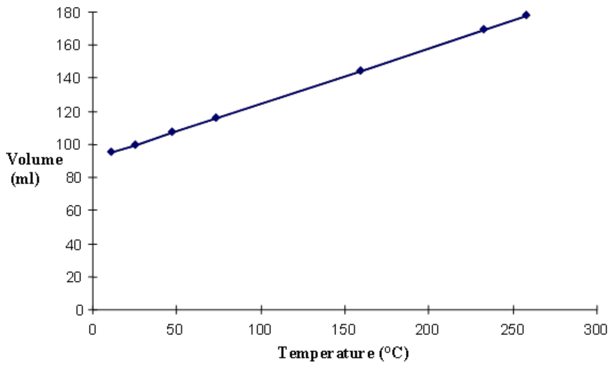


Volume and temperature of a gas

Consider a volume V of gas at a temperature T. If the **temperature of the gas is increased**, the kinetic energy and hence speed of the particles of the gas increases. The particles collide with the container walls more violently and more often. This will produce a larger force on the container walls. If the container is able to expand then the container walls will be pushed outwards and the **volume of the gas will increase**.

An experiment can be carried out to show this by placing balloons of the same size into different temperature locations such as a freezer (balloon A), refrigerator (balloon B) or a warm oven (balloon C). The **volume** of the balloon can be estimated by using a piece of **string** and a **ruler** to measure the **circumference** of the balloon in each location. The **temperature** of each location can be measured using a **thermometer**.

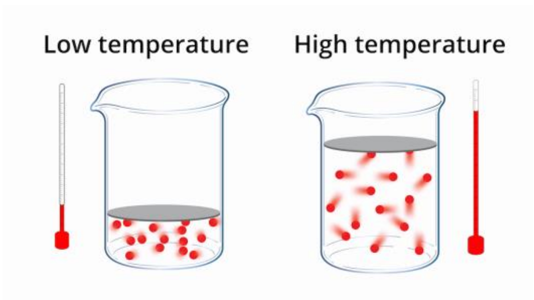




As the gas heats up and the container expands the **pressure** of the gas **remains constant**. Although the particles are moving faster and the average force is increased the area of the collisions becomes larger as the container expands.

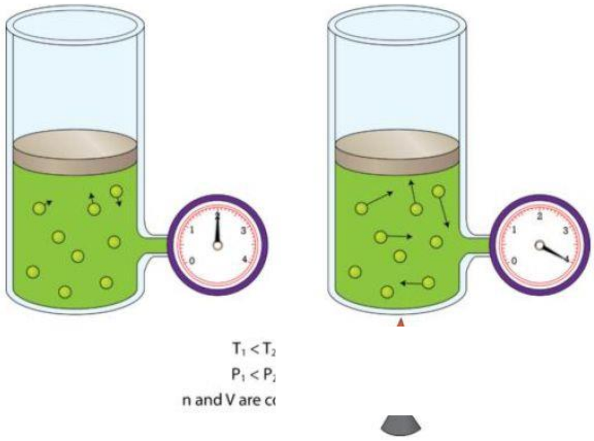
Volume - Temperature (constant mass and pressure)

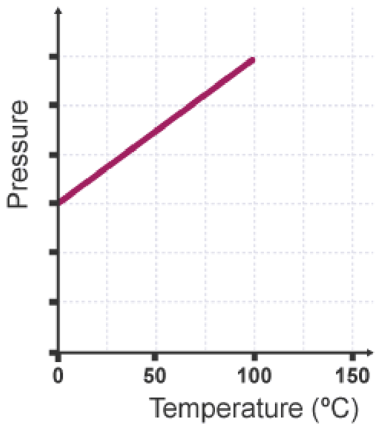
- As temperature decreases volume decreases.
- As temperature increases volume increases.



Pressure and temperature of a gas

Consider a gas at a pressure p and temperature T. If the temperature of the gas is increased, the kinetic energy and hence speed of the particles of the gas increases. The particles collide with the container walls more violently and more often. This will produce a larger force on the container walls. If the container can't expand then the area inside the container does not change. As **temperature increases**, then the force increases resulting in an **increase in pressure**.





Pressure - Temperature (constant mass and volume)

- As temperature increases pressure increases.
- As temperature decreases pressure decreases.

Applications of pressure and the kinetic model of gases

Car Tyres: As cars are driven the friction between the tyres and the road causes the air inside the tyres to heat up. This means that the particles of air are moving more quickly and hitting the insides of the tyre with more force and more often. Since the volume of the inside of the tyre does not change the pressure of the air inside the tyre rises.

Tanks of air: A diver uses tanks of air to breathe under water. When the tanks are filled, the air is transferred from the large volume of the outside air into the restricted, small volume of an oxygen tank. This means that as the volume decreases, the pressure inside the tanks increases as the particles are forced into a small space. The tank has to be very strong to withstand the force that the air particles inside the tank apply to it.

Aircraft cabins: When an aircraft flies at a high altitude, the atmospheric pressure outside the cabin is very low. In fact, the pressure is so low that if the pressure inside was the same as outside it would lead to altitude sickness in all of the passengers and crew. To avoid this happening, extra air is pumped from outside into the cabin, increasing the pressure inside and simulating the pressure we experience at ground level.