Physics

LET ALL OUR BRIGHT COLOURS SHINE

Year 11 Knowledge Organisers

Scalar and Vector Quantities

A **scalar** quantity has **magnitude** only. Examples include temperature or mass.

A **vector** quantity has both **magnitude** and **direction**. Examples include velocity.

Speed is the scalar magnitude of **velocity**.

A vector quantity can be shown using an **arrow**. The size of the arrow is relative to the magnitude of the quantity and the direction shows the associated direction.

Contact and Non-Contact Forces

Forces either **push** or **pull** on an object. This is as a result of its interaction with another object.

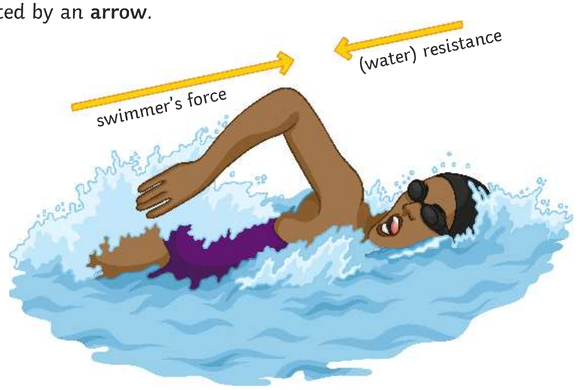
Forces are categorised into two groups:

Contact forces – the objects are touching e.g. friction, air resistance, tension and contact force.

Non-contact forces – the objects are not touching e.g. gravitational, electrostatic and magnetic forces.

Forces are calculated by the equation: **force (N) = mass (kg) × acceleration (m/s²)**

Forces are another example of a **vector quantity** and so they can also be represented by an **arrow**.



Gravity

Gravity is the natural phenomenon by which any object with mass or energy is drawn together.

- The **mass** of an object is a scalar measure of how much matter the object is made up of. Mass is measured in **kilograms (kg)**.
- The **weight** of an object is a vector measure of how gravity is acting on the mass. Weight is measured in **newtons (N)**.

weight (N) = mass (kg) × gravitational field strength (N/kg)

(The gravitational field strength will be given for any calculations. On earth, it is approximately 9.8N/kg).

An object's **centre of mass** is the point at which the weight of the object is considered to be acting. It does not necessarily occur at the centre of the object.

The **mass** of an object and its **weight** are **directly proportional.** As the mass is increased, so is the weight. Weight is measured using a **spring-balance** (or **newton metre**) and is measured in **newtons** (N).

Resultant Forces

A **resultant force** is a single force which replaces several other forces. It has the same effect acting on the object as the combination of the other forces it has replaced.

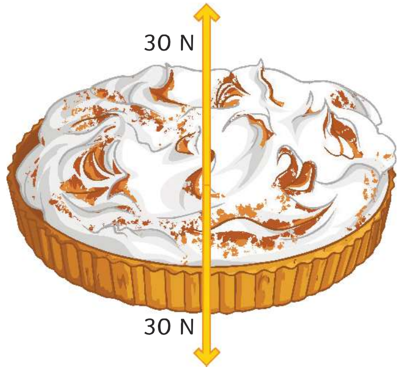
The forces acting on this object are represented in a **free body** diagram.
The arrows are relative to the magnitude and direction of the force.

The car is being pushed to the left by a force of 30N. It is also being pushed to the right by a force of 50N.

The **resultant force is 50N – 30N = 20N**

The 20N resultant force is pushing to the right, **so the car will move right.**

When a resultant force is not zero, an object will **change speed (accelerate or decelerate)** or **change direction (or both)**.



When an object is stationary, there are still forces acting upon it.

In this case, **the resultant force is 30N – 30N = 0N**.

The forces are in **equilibrium** and are **balanced**.

When forces are balanced, an object will either **remain stationary** or if it is moving, it will continue to move at a **constant speed**.

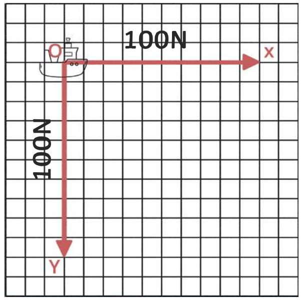
When resultant forces act along the same line, you calculate the resultant force as shown below.

Resultant Forces

A **vector diagram** can be used to determine the resultant of two forces that are not acting in a straight line.

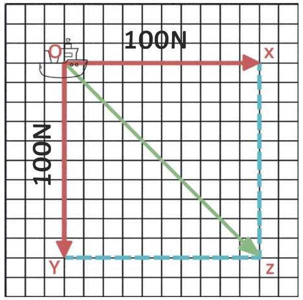
Worked example 1:

A boat is being pulled toward the harbour by two winch motors. Each motor is pulling with a force of 100N and they are working at right angles to each other. These forces are represented by lines OX and OY.



Construction lines can be added to the diagram to form rectangle OXZY. The line OZ is the diagonal of this rectangle.

OZ is the resultant force. It is the hypotenuse of the right-angle triangles OYZ and OXZ.



We can use the Pythagoras' theorem to calculate its length.

$$a^2 + b^2 = c^2$$

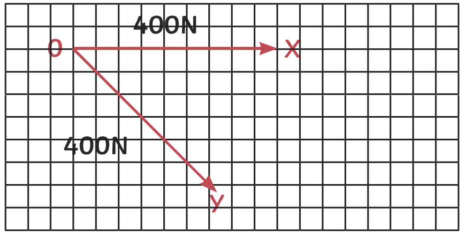
$100^2 + 100^2 = OZ^2$
$100^2 + 100^2 = 20\,000$
$\sqrt{20\,000} = 141.42$

The resultant force is 141.42N.

Alternatively, you can measure line OX and work out how many newtons are represented by each cm. Then measure the length of OZ and use your scale to calculate how many newtons the length represents.

Worked example 2:

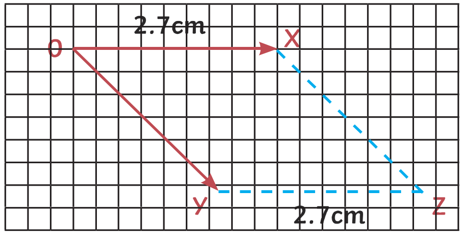
A horse drawn carriage is pulled by two horses with a force of 400N each. The horses are pulling in different directions and are not acting at an angle of 90°. OX and OY represent the force from each horse respectively, they represent the same magnitude of force so they will be the same length.



To calculate the resultant force in this situation we must use a **parallelogram of forces**.

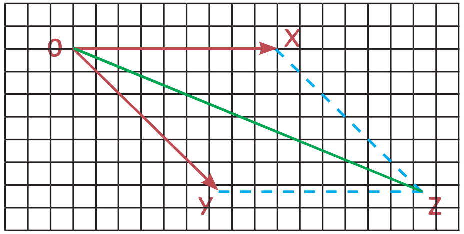
First, measure the length of OX. In this example it is 2.7cm.

Draw a line 2.7cm long from Y, parallel to OX. Connect the end of this line to X to form a parallelogram.



The line OZ is the diagonal of this parallelogram. OZ is the resultant force.

The length of OX is 2.7cm and the force is 400N.



We can work out how many newtons are represented by each cm by doing the calculation:
$400 \div 2.7 = 148.15$
1cm = 148.15N

Measure OZ. In this example it is 5cm.
$5 \times 148.15 = 740.74$
The resultant force is 740.74N.

Work Done and Energy Transfer

When an object is moved by a force, the force transfers energy to the object. The amount of energy transferred to the object is the work done.

The work done on an object depends on the size of the force and the distance moved. It can be calculated using the equation:

work done = force × distance
W = F s

One joule of work is done when a force of one newton causes a displacement of one metre.

1 joule = 1 newton metre

Worked example

A man's car has broken down and he is pushing it to the side of the road. He pushes the car with a force of 160N and the car is moved a total of 8m.

Calculate the work done.

work done = force × distance
= 160 × 8
= 1280J

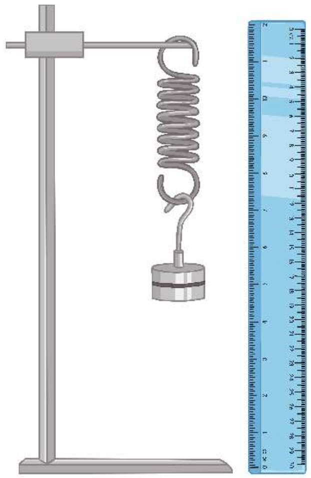
Not all of the energy transferred when work is done on an object is useful. For example, work done against the frictional forces of an object causes a rise in temperature of the object.

Required Practical Investigation Activity 6: Investigate the Relationship Between Force and Extension for a Spring

F = k × e

force applied (N) = spring constant (N/m) × extension (m)

You should be familiar with the equation above and the required practical shown to the right.

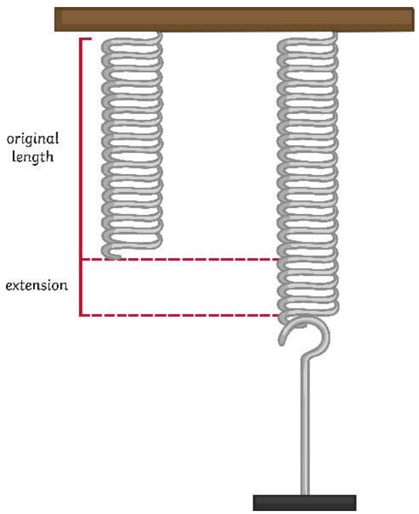


The spring constant is a value which describes the elasticity of a material. It is specific to each material. You can carry out a practical investigation and use your results to find the spring constant of a material.

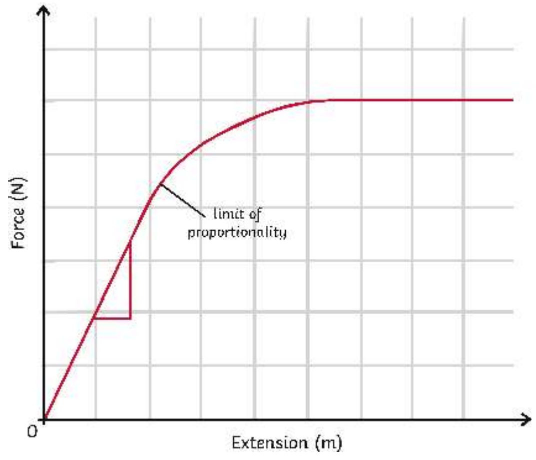
1. Set up the equipment as shown.
2. Measure the original length of the elastic object, e.g. a spring, and record this.
3. Attach a mass hanger (remember the hanger itself has a weight). Record the new length of the spring.
4. Continue to add masses to the hanger in regular intervals and record the length each time.

Once you have your results, you can find the extension for each mass using this formula: **spring length – original length**

The data collected is continuous so you would plot a **line graph** using the x-axis for extension (m) and the y-axis for force (N). As a result of Hooke's Law, you should have a **linear graph**. The **gradient of the graph is equal to the spring constant**. You can calculate it by rearranging the formula above or by calculating the gradient from your graph.



Spring Constant and Hooke's Law



Hooke's Law describes that the extension of an elastic object is **proportional** to the force applied to the object. However, there is a maximum applied force for which the extension will still increase proportionally. If the **limit of proportionality** is exceeded, then the object becomes **permanently deformed** and can no longer return to its original shape. This can be identified on a graph of extension against force when the gradient stops being linear (a straight line) and begins to **plateau**. The limit is shown on the graph above and this is the specific object's **elastic limit**.

Forces and Elasticity

When work is done on an elastic object, such as a spring, the energy is stored as elastic potential energy.

When the force is applied, the object changes shape and stretches. The energy is stored as elastic potential and when the force is no longer applied, the object returns to its original shape. The stored elastic potential energy is transferred as kinetic energy and the object recoils and goes back to its original shape.

Work Done: Elastic Objects

Work is done on elastic objects to **stretch** or compress them.

To calculate the work done (**elastic potential energy** transferred), use this equation:

$E\ (J) = 0.5 \times k \times e^2$

(elastic potential energy = 0.5 × spring constant × extension^2)

You might need to use this equation also: $F = k \times e$

Worked example:

A bungee jumper jumps from a bridge with a weight of 800N. The elastic cord is stretched by 25m. Calculate the work done.

Step 1: find the spring constant using $F = k \times e$

Rearrange to $k = F \div e$

$800 \div 25 = 32$N/m

Step 2: use the value for k to find the elastic potential energy (work done) using $E\ (J) = 0.5 \times k \times e^2$

$0.5 \times 32 \times 25^2$

E = 10 000J

Velocity

Velocity is a **vector** quantity. It is the **speed** of an object in a given **direction**.

Circular Motion (Higher tier only)

Objects moving in a **circular path** don't go off in a straight line because of a **centripetal** force caused by another force acting on the object.

For example, a car driving around a corner has a centripetal force caused by **friction** acting between the surface of the road and the tyres. When the Earth orbits around the Sun, it is held in orbit by **gravity** which causes the centripetal force.

When an object is moving in a circular motion, its **speed** is **constant.** Its **direction changes** constantly and because direction is related to **velocity**, this means that the velocity of the object is constantly changing too. The changes in velocity mean that the object is **accelerating**, even though it travels at a constant speed.

The acceleration occurs because there is a **resultant force** acting on the object. In this case, the resultant force is the velocity, which is greater than the centripetal force acting.

Forces and Motion: Distance vs Displacement

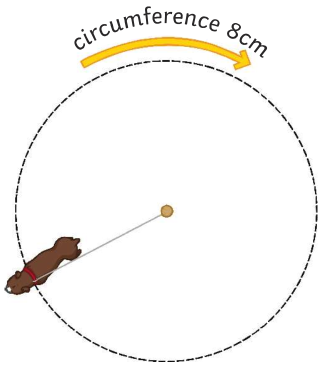
Distance is a **scalar** quantity. It measures how far something has moved and does not have any associated direction.

Displacement is a **vector** quantity. It measures how far something has moved and is measured in relation to the direction of a straight line between the starting and end points.

E.g. A dog is tethered to a post. It runs 360° around the post three times. Each 360° lap is 8m

distance = 8 × 3 = 24m

displacement = 0m (The dog is in the same position as when it started.)



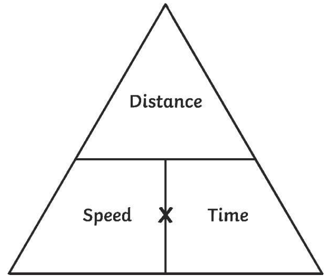
Speed

You should be able to recall the typical speed of different transportation methods.

Activity	Typical Value
walking	**1.5m/s**
running	**3m/s**
cycling	**6m/s**
driving a car	25mph (40km/h)
train travel	60mph (95km/h)
aeroplane travel	550mph (885km/h)
speed of sound	*330m/s*

These values are average only. The speed of a moving object is rarely constant and always fluctuating.

speed = distance ÷ time



You should be able to use this equation and rearrange it to find the distance or time.

Worked example:

John runs 5km. It takes him 25 minutes. Find his average speed in metres per second.

Step 1: convert the units

km → m (×1000) = 5000m

min → s (×60) = 1500s

Step 2: calculate s = d ÷ t

s = 5000 ÷ 1500

s = 3.33m/s

Worked example 2:

Zi Xin has driven along the motorway. Her average speed is 65mph. She has travelled 15 miles. How long has her journey taken? Give your answer in minutes.

Step 1: calculate t = d ÷ s

t = 15 ÷ 65

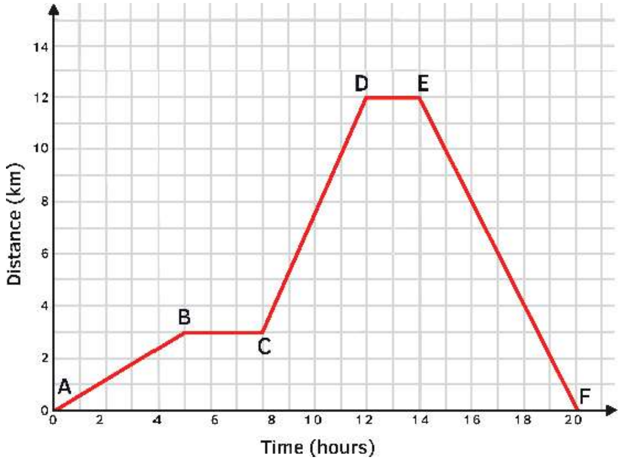
t = 0.23 (hours)

Step 2: convert units

hr → min (×60) = 13.8 minutes

Distance-Time and Velocity-Time Graphs

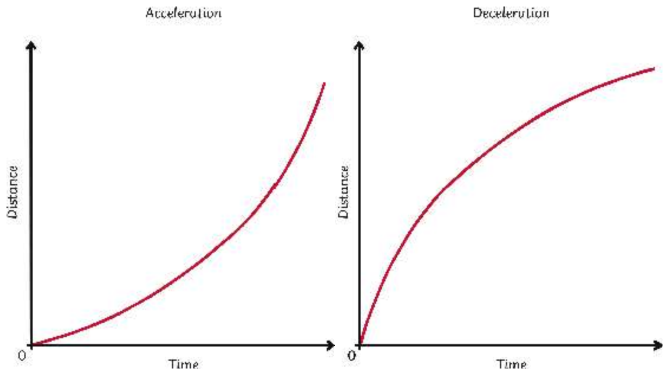
When an object travels in a **straight line**, we can show the distance which has been covered in a **distance-time graph**.



You should be able to understand what the features of the two types of graph can tell you about the motion of an object.

Graph Feature	Distance-Time Graph	Velocity-Time Graph
x-axis	time	time
y-axis	distance	velocity
gradient	speed	acceleration (or deceleration)
plateau	stationary (stopped)	constant speed
uphill straight line	steady speed moving away from start point	acceleration
downhill straight line	steady speed returning to the start point	deceleration
uphill curve	acceleration	increasing acceleration
downhill curve	deceleration	increasing deceleration
area below graph		distance travelled

Changing Speed on a D-T graph



When the graph is a **straight line**, it is representing a **constant speed**. A **curve** represents a changing speed, either **acceleration** or **deceleration**. The speed at any given point can be calculated by drawing a **tangent** from the curve and finding the **gradient** of the tangent.

Terminal Velocity

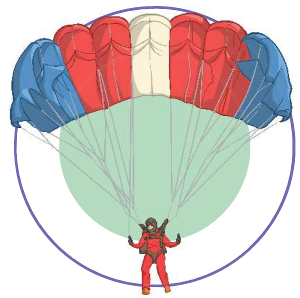
When an object begins moving, the force **accelerating** the object is much greater than the force resisting the movement. A resistant force might be **air resistance** or **friction**, for example.

As the **velocity** of the object increases, the force **resisting** the movement also increases. This causes the acceleration of the object to be reduced gradually until the forces become **equal** and are **balanced**. This doesn't cause the object to stop moving. As the object is already in motion, balanced forces mean it will continue to move at a **steady speed**. This steady speed is the maximum that the object can achieve and is called the **terminal velocity**.

The terminal velocity of an object depends on its shape and weight. The shape of the object determines the amount of resistant force which can act on it. For example, an object with a large surface area will have a greater amount of resistance acting on it.

Consider a skydiver and his parachute. When the skydiver first jumps from the aeroplane, he has a small area where the air resistance can act. He will fall until he reaches a terminal velocity of approximately 120mph.

After the skydiver releases his parachute, the shape and area has been changed and so the amount of air resistance acting is increased. This causes him to decelerate and his terminal velocity is reduced to about 15mph. This makes it a much safer speed to land on the ground.



Acceleration

Acceleration can be calculated using the equation:

$$\text{acceleration (m/s}^2\text{)} = \frac{\text{change in velocity (m/s)}}{\text{time taken (s)}}$$

Worked example:

A dog is sitting, waiting for a stick to be thrown. After the stick is thrown, the dog is running at a speed of 4m/s. It has taken the dog 16s to reach this velocity. Calculate the acceleration of the dog.

a = Δv ÷ t

a = (4-0) ÷ 16

A = 0.25m/s^2

Changes in velocity due to acceleration can be calculated using the equation below. This equation of motion can be applied to any moving object which is travelling in a **straight line** with a **uniform acceleration**.

Final velocity^2 (m/s) – initial velocity^2 (m/s) = 2 × acceleration (m/s^2) × displacement (m)

or

$$v^2 - u^2 = 2as$$

Worked example:

A bus has an initial velocity of 2m/s and accelerates at 1.5m/s^2 over a distance of 50m. Calculate the final velocity of the bus.

Step 1: rearrange the equation: $v^2 - u^2 = 2as$

$v^2 = 2as + u^2$

Step 2: insert known values and solve

$v^2 = (2 \times 1.5 \times 50) + 2^2$

$v^2 = (150) + 4$

$v^2 = 154$

$v = \sqrt{154}$

v = 12.41m/s

Braking Distance

The **braking distance** is the distance travelled by a vehicle once the **brakes are applied** and until it reaches a full stop.

Braking distance is affected by:

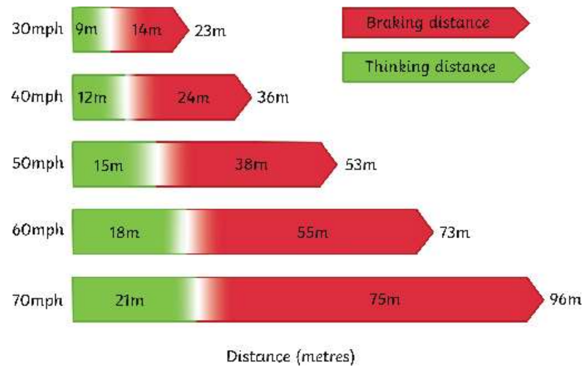
- **adverse weather conditions** (wet or icy)
- **poor vehicle condition** (brakes or tyres)

When **force** is applied to the brakes, **work is done** by the **friction** between the car wheels and the brakes.

The work done reduces the **kinetic energy** and it is transferred as **heat** energy, increasing the **temperature** of the brakes.

increased speed = increased force required to stop the vehicle

increased braking force = increased deceleration

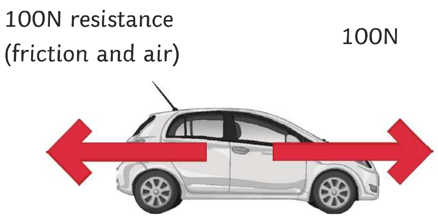


Large decelerations can cause a huge increase in **temperature** and may lead to the **brakes overheating** and the driver **losing control** over the vehicle

Newton's Laws of Motion: Newton's First Law

If the resultant force acting on an object is zero...

- **a stationary object will remain stationary.**
- **a moving object will continue at a steady speed and in the same direction.**



Inertia – the tendency of an object to continue in a state of rest or uniform motion (same speed and direction).

Newton's Laws of Motion: Newton's Second Law

The acceleration of an object is proportional to the resultant force acting on it and inversely proportional to the mass of the object

resultant force (N) = mass (kg) × acceleration (m/s^2)

Inertial mass – how difficult it is to change an objects velocity. It is defined as the ratio of force over acceleration.

Newton's Laws of Motion: Newton's Third Law

When two objects interact, the forces acting on one another are always equal and opposite.

For example, when a book is laid on the table, it experiences a reaction force from the table. The table pushes up on the book. The book also pushes down on the table. These two forces are equal and opposite.

Stopping Distance

The **stopping distance** of a vehicle is calculated by:

stopping distance = thinking distance + braking distance

Reaction time is the time taken for the driver to respond to a hazard. It varies from 0.2s to 0.9s between most people.

Reaction time is affected by:

- **tiredness**
- **drugs**
- **alcohol**
- **distractions**

You can measure human reaction time in the lab using simple equipment: a metre ruler and stopwatch can be used to see how quickly a person reacts and catches the metre ruler. The data collected is quantitative and you should collect repeat readings and calculate an average result.

Momentum

momentum (N) = mass (kg) × velocity (m/s)

The law of conservation of mass (in a closed system) states that the total momentum **before** an event is equal to the total momentum **after** an event.

Worked example:

Calculate the momentum of a 85kg cyclist travelling at 7m/s.

$p = m \times v$

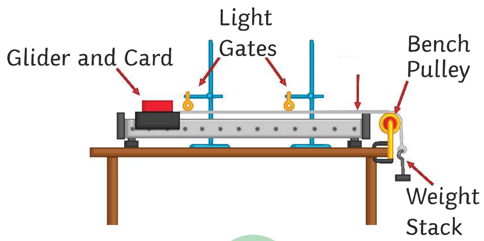
$p = 85kg \times 7m/s$

$p = 595kg\ m/s$

Required Practical Investigation 7

Aim: investigate the effect of varying the force on the acceleration of an object of constant mass, and the effect of varying the mass of an object on the acceleration produced by a constant force.

You may be given any of the following apparatus set-ups to conduct these investigations:



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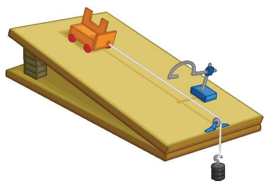

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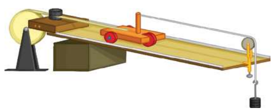


Something is a **fair test** when **only** the independent variable has been allowed to affect the dependent variable.

The independent variable was **force**.

The dependent variable was **acceleration**.

The control variables were:

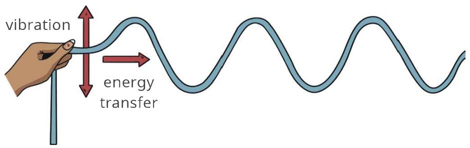
- **same total mass**
- **same surface/glider/string/pulley (friction)**
- **same gradient if you used a ramp**

AQA GCSE Combined Science Waves **Knowledge Organiser**

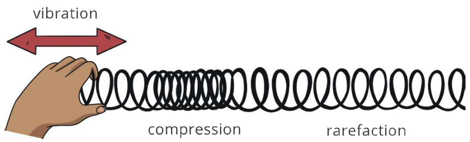
Transverse and Longitudinal Waves

Waves can be either **transverse** or **longitudinal**.

In a **transverse** wave, the vibrations of the particles are **perpendicular** (at right angles) to the direction of energy transfer. The wave has **peaks** (or crests) and **troughs**. Examples of transverse waves include **water waves** and **electromagnetic waves**.

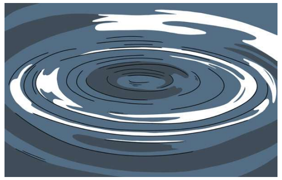


In a **longitudinal** wave, the vibrations of the particles are **parallel** to (in the same direction as) the direction of energy transfer. A longitudinal wave has areas of **compression** and **rarefaction. Sound waves** travelling through air are an example of this type of wave.

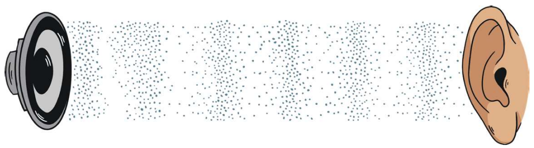


When a wave travels through a medium, energy is transferred by the particles but the matter itself does not move.

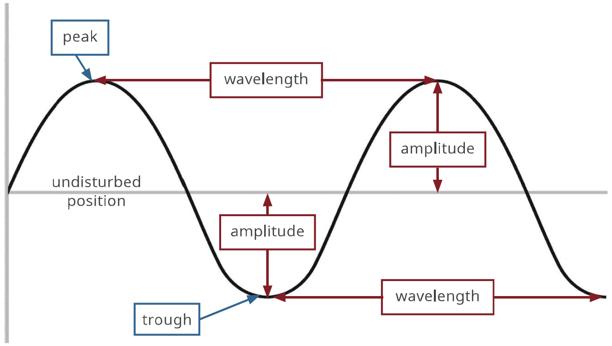
This can be shown by placing a cork in a tank of water and generating ripples across the surface. The cork will move up and down on the oscillations of the wave, but it will not travel across the tank.



Similarly, when sound waves move from a speaker towards the ear, the air particles next to the speaker do not move towards the ear; they vibrate around their original position.



Wave Properties



The **amplitude** of a wave is the distance from the undisturbed position to the peak or trough of the wave.

The **wavelength** is the distance from a point on one wave to the same point on the next wave, measured in **metres** (m).

The **frequency** of a wave is the number of waves that pass a given point every second, measured in **hertz** (Hz).

The **period** of a wave is the time taken for a full wave to pass a given point, measured in **seconds** (s).

$$\textbf{period} = \frac{\textbf{1}}{\textbf{frequency}} \quad \text{or} \quad T = \frac{1}{f}$$

Wave speed is how quickly energy is transferred through a medium (or how quickly the wave travels), measured in **metres per second** (m/s).

$$\textbf{wave speed = frequency × wavelength} \quad \text{or} \quad v = f\lambda$$

The speed of a **sound wave** travelling through the air can be measured using a simple method. A person stands a measured distance from a large flat wall, e.g. 100m. The person then claps their hands and the time taken to hear the echo is measured. The speed of sound can be calculated using the equation:

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

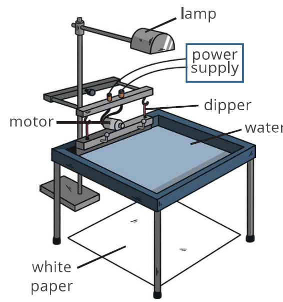
Remember, the distance that the sound wave has travelled will be double the distance between the person and the wall because the wave has travelled to the wall and back again. It is important to take several measurements and calculate the mean to reduce the effect of human error in your measurements.

Required Practical: Observing Waves

Make observations to identify the suitability of apparatus to measure the frequency, wavelength and speed of waves.

Waves in a Ripple Tank

The diagram shows the apparatus most commonly used for this investigation.



Method:

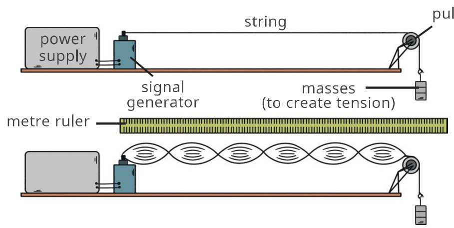
1. Set up the apparatus as shown in the diagram.
2. Turn on the power supply and observe the waves produced in the water. Make any necessary adjustments to the equipment, for example altering the potential difference of the power supply, so that the waves are clear to observe.
   The lower the frequency of the waves, the easier it will be for measurements to be made.
3. To measure the **wavelength**, use a metre ruler to measure the length of 10 waves and divide this value by 10 to find one wavelength. Repeat this several times and calculate the mean wavelength. A **stroboscope** can be used to freeze the wave pattern to make it easier to measure the waves.
4. To measure the **frequency**, mark a point on the white paper and count the number of waves that pass this point in 10 seconds. Divide the number of waves by 10 to find the number of waves that pass per second. Repeat this several times and calculate the mean frequency.
5. To calculate **wave speed**, use the equation:

wave speed = frequency × wavelength

Waves in a Solid

Waves in a solid can be observed using the apparatus shown in the diagram.

When the signal generator is switched on, the string begins to vibrate.



The frequency of the signal generator, the length of the string or the tension in the string is adjusted until a clear wave pattern can be seen. The wave should not look like it is moving.

To find the **wavelength**, count the number of half wavelengths (single loops) in 1 metre, then divide the length by the number of half wavelengths and multiply by two.

The **frequency** of the wave is the frequency of the signal generator.

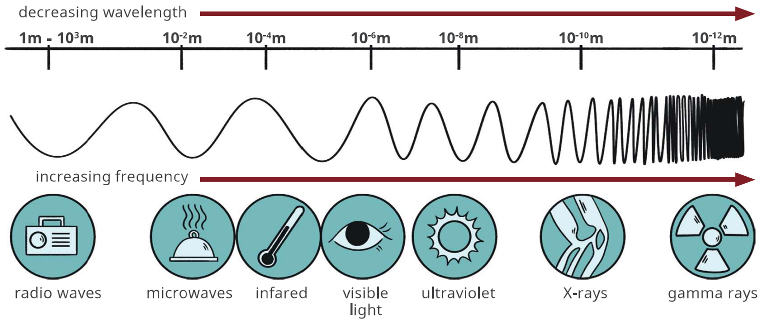
Wave speed can be calculated using the equation:

wave speed = frequency × wavelength

AQA GCSE Combined Science Waves **Knowledge Organiser**

The Electromagnetic Spectrum

Electromagnetic waves are transverse waves. They transfer energy from a source to an absorber. All electromagnetic waves travel at the same speed through a vacuum or air. They are grouped by their wavelength and frequency to form a continuous spectrum.



Remember: **R**oman **M**en **I**nvented **V**ery **U**nusual **X**-ray **G**uns

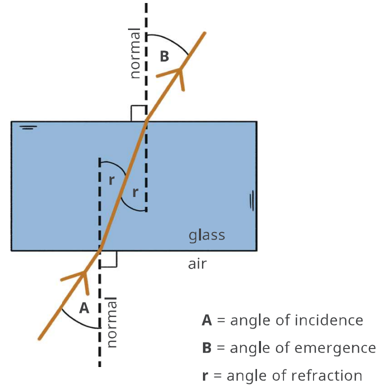
Properties of Electromagnetic Waves

When a wave moves into a medium with a different density (e.g. from air into glass), the wave changes direction. This is called **refraction**. This can be represented by a ray diagram.

When a wave enters the glass block at an angle to the normal, it bends towards the normal. The angle of refraction is smaller than the angle of incidence. The angle at which the wave leaves the glass block (angle of emergence) is equal to the angle at which it enters the glass block (angle of incidence).

If a wave enters a different medium at 90° (perpendicular) to the boundary, it will not change direction but instead carry on in a straight line.

(HT only) Refraction occurs due to the difference in density of the two materials. When a wave moves from a less dense medium to a more dense medium (e.g. from a gas to a solid), it slows down and bends towards the normal. When a wave moves from a more dense medium to a less dense medium (e.g. from a solid to a gas), it speeds up and bends away from the normal.



Electromagnetic Wave	Uses and Applications	Explanation (HT only)	Extra Information
radio waves	terrestrial television and radio communications	Radio waves can be transmitted over long distances by reflecting them off a layer of the Earth's atmosphere called the ionosphere.	**(HT Only)** Oscillations in electrical circuits can produce radio waves. **(HT Only)** An alternating current can be produced when radio waves are absorbed.
microwaves	satellite communication, satellite television, heating food	Microwaves can penetrate the Earth's atmosphere to communicate with satellites. When water molecules absorb microwaves, it causes their internal energy store, and therefore their temperature, to increase.	Microwaves are used in mobile phone communications as well as satellite television.
infrared	cooking, thermal imaging camera, electric heaters, short-range communications (remote controls)	Infrared waves cause heating as they are absorbed by matter. Infrared cameras can detect infrared radiation to produce thermal images.	Infrared radiation can cause burns to skin.
visible light	vision, fibre optic communication	In fibre-optic cables, pulses of visible light are used to send coded signals over large distances.	The human eye can only detect visible light waves.
ultraviolet	energy efficient lamps, sun tanning, detecting forged bank notes, sterilising water	Some chemicals absorb energy from ultraviolet waves and then emit this energy as visible light. This is known as fluorescence.	Absorption of ultraviolet waves by the skin can increase the risk of skin cancer and lead to premature ageing of the skin.
X-rays	medical imaging, airport security	X-rays can penetrate soft tissue, such as muscles and skin, but are absorbed by hard structures like bones.	X-ray absorption by human tissues can lead to gene mutation and cancer.
gamma rays	sterilising medical equipment, sterilising food, radiotherapy for cancer treatment	Gamma rays are highly penetrating and can easily pass through body tissues. The ionising ability of gamma rays means that they can damage cancerous cells (as well as healthy ones).	Gamma rays are produced by changes in the nucleus of an atom. Gamma ray absorption by human tissues can lead to gene mutation and cancer.

Hazards and Risks of Electromagnetic Waves

Ultraviolet waves, X-rays and gamma rays have some risks associated with them.

How dangerous electromagnetic radiation is depends on the type of wave and the dosage.

Radiation dosage is measured in sieverts (Sv) or millisieverts (mSv).

Safe limits of exposure of each type of radiation are known and can be referred to when assessing the risk of using electromagnetic radiation.

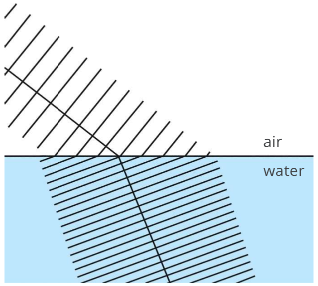
AQA GCSE Combined Science Waves **Knowledge Organiser**

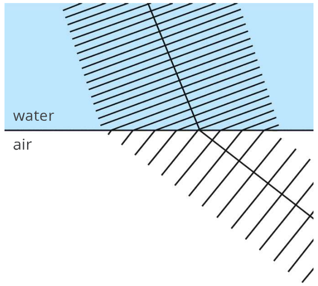
Properties of Electromagnetic Waves

(HT Only) Different substances absorb, reflect, refract or transmit electromagnetic waves in different ways. This may change depending on the wavelength of the electromagnetic wave.

A wave front diagram shows that as a wave moves from a less dense to a more dense medium (e.g. from air into water), at an angle to the normal, it slows down and its wavelength decreases. One side of the wave reaches the more dense medium first, causing the wave to change direction. Although the wavelength decreases, the frequency of the wave remains the same due to its change in speed.

When a wave moves from a more dense medium into a less dense medium, the reverse happens. The wave speeds up and its wavelength increases. The frequency of the wave remains the same.





Required Practical: Radiation and Absorption

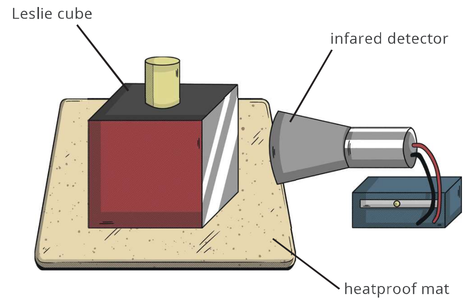
Investigate how the nature of a surface affects the amount of infrared radiation absorbed or radiated by that surface.

In this investigation, you are finding out which type of surface emits the most **infrared** radiation:

- **dark and matt**
- **dark and shiny**
- **light and matt**
- **light and shiny**

Method:

1. Place the **Leslie cube** on a heatproof mat.
2. Boil some water in a kettle, fill the Leslie cube with hot water and put the lid on.
3. Use a thermometer or an **infrared detector** to measure the amount of infrared radiation emitted from one of the surfaces of the Leslie cube.
4. Repeat the experiment for each surface of the Leslie cube, ensuring that the infrared detector is an equal distance from each surface.

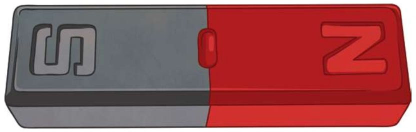


You should find that a dark, matt surface emits much more infrared radiation than a light, shiny surface.

AQA Combined Science: **Physics Topic 7 Magnetism and Electromagnetism**

Poles of a Magnet

A magnet has two ends called **poles**: the **north pole** and the **south pole**. The magnetic forces of the magnet are strongest at the poles.



When two magnets are brought close together, they will **attract** or **repel**, depending on which poles are brought together:

- **Like poles** will **repel** one another e.g. N-N or S-S.
- **Opposite poles** will **attract** e.g. N-S.

The forces exerted between the poles of two magnets are a type of **non-contact force**: the magnets do not have to be touching for the effect to be observed.

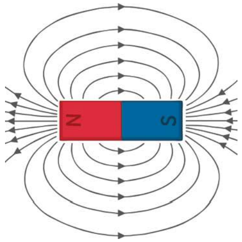
Remember that only **iron**, **cobalt** and **nickel** (or alloys containing these metals) are magnetic.

A **permanent magnet** is one with its own magnetic field. The magnetism cannot be turned on or off e.g. a bar magnet or a horseshoe magnet.

An **induced magnet** is a material which becomes magnetic only when placed within a magnetic field. Induced magnets only attract other materials and lose most (if not all) of their magnetism when removed from the magnetic field e.g. iron filings.

Magnetic Fields

The **magnetic field** is the area surrounding a magnet where the force is acting on another magnet or magnetic material. It can be observed using a compass placed at different points around a bar magnet. The field lines can be drawn by using the compass to mark the direction at a range of points.



A magnet always causes a magnetic material to be **attracted**. The strength of the magnetic field is determined by the proximity to the magnet.

When looking at a diagram of magnetic field lines, the force is strongest where the lines are closest together. The magnetic field of the magnet is strongest at the poles. The direction of the magnetic field shows the direction the force would act on another north pole.
As a result, magnetic field lines always come away from the north pole (like poles repel) and towards the south pole (unlike poles attract).

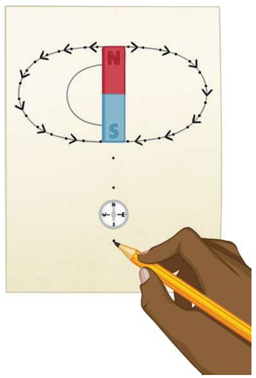
The earth produces a magnetic field and a magnetic compass uses this to help aid navigation. The core of the earth is made of iron (a magnetic material). A compass contains a small bar magnet shaped as a needle, which points in the direction of the earth's magnetic field.

Plotting Magnetic Field Lines

A magnetic compass can be used to plot and draw the magnetic field lines around a magnet.

You should be able to describe this method for a bar magnet.

1. Place the bar magnet in the centre of a sheet of plain paper.
2. Using a magnetic compass, position it on the paper somewhere around the magnet.
3. Observe the direction of the needle and carefully draw a dot at the circumference of the magnet, in line with each end of the needle. Make sure you include an arrow to indicate the direction of north.
4. Repeat steps 2 and 3 for several positions around the magnet.
5. Join the arrows to complete the magnetic field lines and whole pattern.



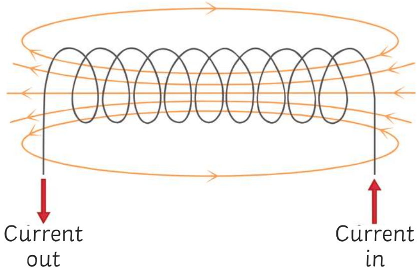
Electromagnetism

A circular **magnetic field** is produced when a current is passed through a conducting wire. This produces an **induced magnet**.

Switching off the current causes the magnetism to be lost.

The strength of the magnetic field can be increased by increasing the current flowing through the wire. The strength of the magnetic field is stronger closer to the wire.

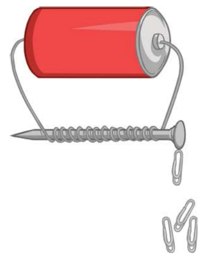
Coiling the wire to form a **solenoid** will also increase the strength of the magnetic field. The strength of the magnetic field created by a solenoid is strong and uniform throughout.



To increase the strength of the magnetic field around a solenoid you can…

- add an iron core;
- increase the number of turns in the coil;
- increase the current passing through the wire.

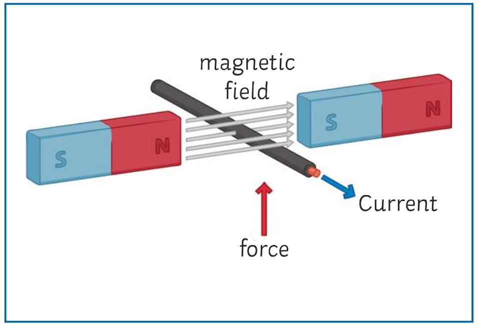
An **electromagnet** is a solenoid with an iron core. Electromagnets are **induced magnets** and can be turned on and off.



Electric motors, loudspeakers, electric bells and remotely controlled door locks all use **electromagnets**.

The Motor Effect and Flemings Left-Hand Rule

When a wire carrying a current is exposed to the magnetic field of another magnet, then a **force** is produced on the wire at a **right angle** to the direction of the magnetic field produced.



This is called the **motor effect**.

The force produced by the motor effect can be calculated using this equation:

force (N) = magnetic flux density (T) × current (A) × length (m)

For example:
A current of 8A is flowing through a wire that is 75cm long. The magnetic field acting at a right angle on the wire is 0.5T. Calculate the force.

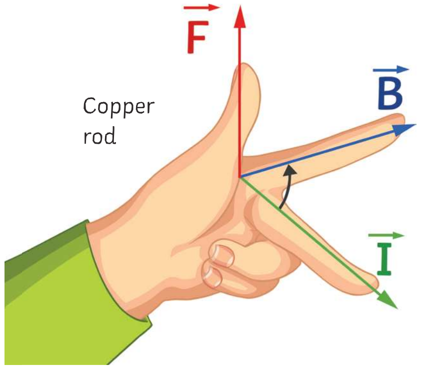
$F = B \times I \times l$

Remember: the equation uses length measured in m. The question gives you the length in cm so you need to convert it before you calculate your answer.

$F = 0.5 \times 8 \times 0.75$

$F = 3N$

From the equation we can see that the force acting on a given length of wire (e.g. 1m) will be increased if the current increases or the magnetic flux density increases. If the current flowing through a wire is **parallel** to the magnetic field, then **no force** is produced – there is no motor effect.



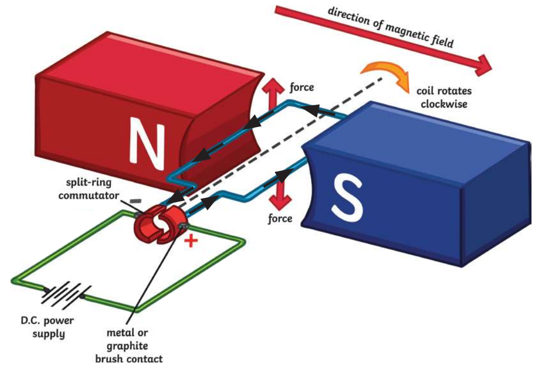
You might be shown a diagram and asked to indicate the direction of the force produced. **Fleming's left-hand rule** can help you do this because it represents the **relative orientation** of the force produced by the motor effect.

Remember:

- Use your **left hand**!
- The angle between your index finger and middle finger should be a **right angle** on the horizontal plane.
- The angle between your index finger and thumb should be a **right angle** on the vertical plane.
- Your **thumb** represents the direction of the **force**.
- Your **index finger** represents the direction of the **magnetic field**.
- Your **middle finger** represents the direction of the **current** flowing through the wire.

Electric Motors

When the wire carrying the current is **coiled**, the motor effect acting on it causes the wire to **rotate**. This is how an **electric motor** works.



As the **current** flows (from negative to positive), the force produced in each side of the coil acts in **opposite directions**, causing the coil to **rotate** overall.

When the coil reaches a **vertical position**, the force produced is now **parallel** to the magnetic field line and so would be **zero**. This would cause the motor to stop rotating.

To maintain the rotation of the coiled wire, a **split ring commutator** is used to supply the current to the wire. The DC supply reaches the split ring via graphite or metal **brushes** which maintain the connection while allowing it to rotate freely on the **axle**.

The two halves of the split ring commutator ensure that the **current supplied** to the wire **changes direction** each half-turn (or that the current supplied is the same direction on each side of the motor) and as a result, the force produced maintains a **constant rotation** in one direction overall.