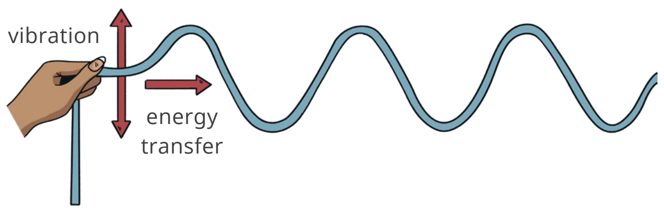
AQA GCSE Combined Science Waves **Knowledge Organiser**

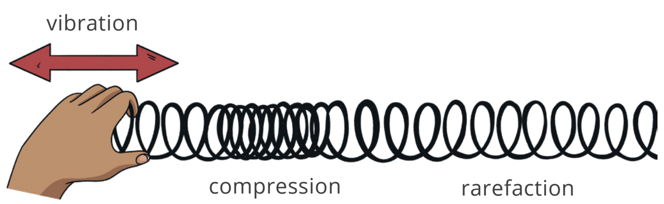
Transverse and Longitudinal Waves

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**.

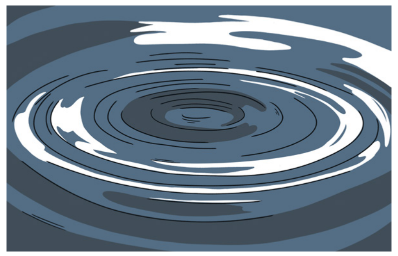


In a **longitudinal** wave, the vibrations of the particles are **parallel** to (in the same direction as) the direction of energy transfer. A longitudinal wave has areas of **compression** and **rarefaction. Sound waves** travelling through air are an example of this type of wave.

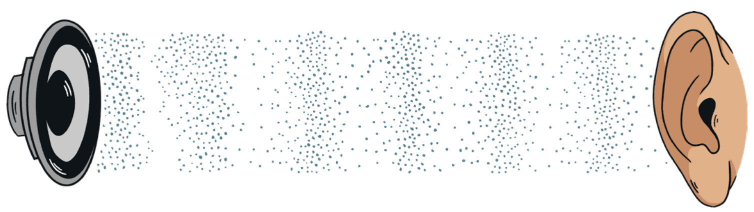


When a wave travels through a medium, energy is transferred by the particles but the matter itself does not move.

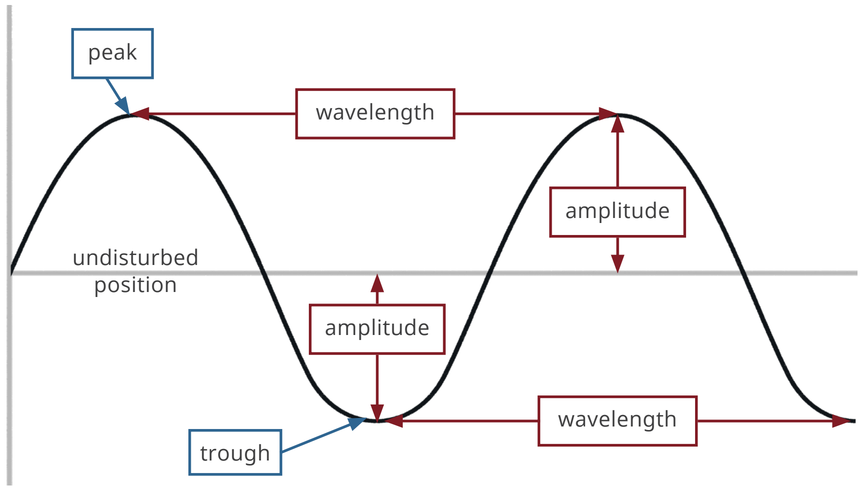
This can be shown by placing a cork in a tank of water and generating ripples across the surface. The cork will move up and down on the oscillations of the wave, but it will not travel across the tank.



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).

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

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:

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

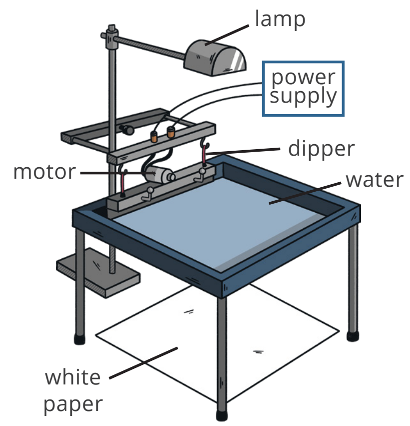
Remember, the distance that the sound wave has travelled will be double the distance between the person and the wall because the wave has travelled to the wall and back again. It is important to take several measurements and calculate the mean to reduce the effect of human error in your measurements.

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:

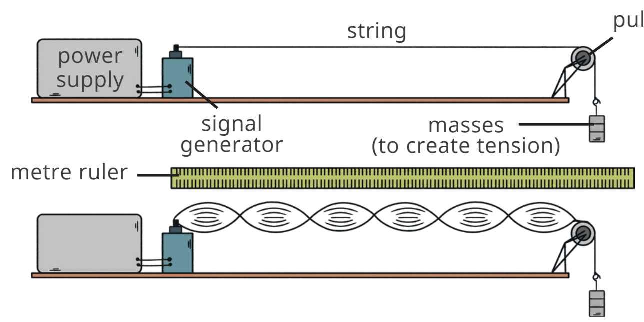
1. Set up the apparatus as shown in the diagram.
2. Turn on the power supply and observe the waves produced in the water. Make any necessary adjustments to the equipment, for example altering the potential difference of the power supply, so that the waves are clear to observe.
   The lower the frequency 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

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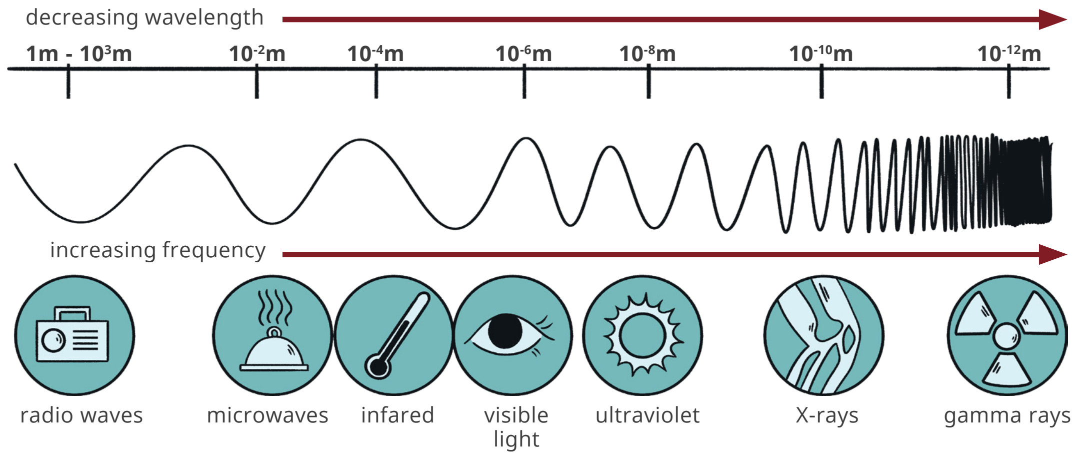
The Electromagnetic Spectrum

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: Roman **M**en **I**nvented **V**ery **U**nusual **X**-ray **G**uns

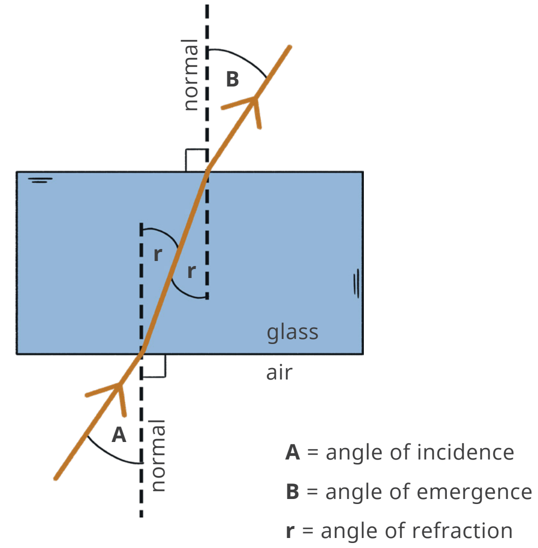
Properties of Electromagnetic Waves

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.

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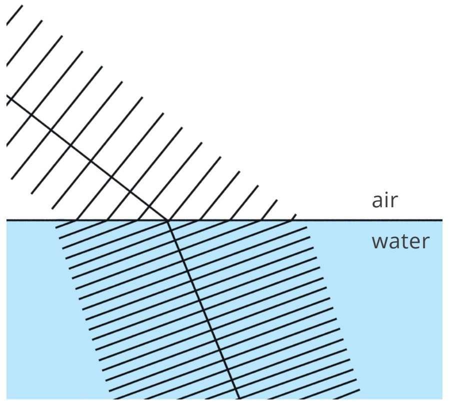
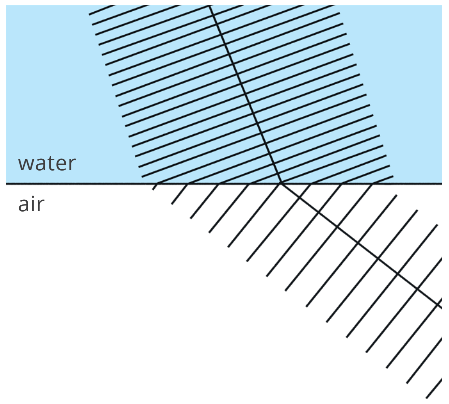
Properties of Electromagnetic Waves

(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.



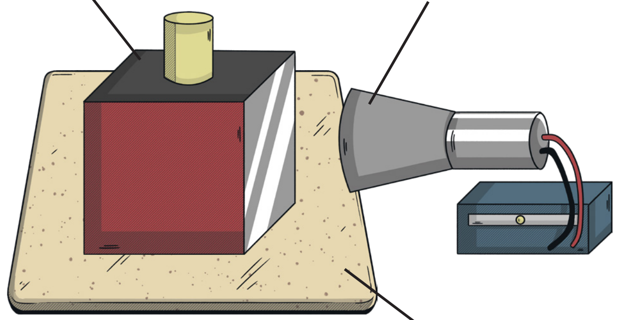


Required Practical: Radiation and Absorption

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.