KNOWLEDGE — Physics Topic P12 Waves, electromagnetism & space – Wave properties — ORGANISER

Section 1: Key terms

Amplitude	The **maximum displacement** of a point on a wave away from its **undisturbed** (rest) **position**.
Wavelength	The **distance** from a point on one wave to the **equivalent point** on the **next wave**. E.g. crest to crest. Measured in **metres**.
Frequency	The **number of waves** passing a certain **point each second**. Measured in **hertz (Hz)**
Longitudinal	**Oscillations** are along **the same direction as the direction of travel** e.g. **sound** waves.
Transverse	**Oscillations are at right angles** to the **direction of travel** e.g. **water** waves, all **electromagnetic** waves.
Period	The **time needed** for **one wave** to **pass a given point**.
Compression	Stretched out region of a **longitudinal** wave where the **particles are closest together**.
Rarefaction	Region in a **longitudinal** wave where the particles are **furthest apart**. (The stretched out section.)
Oscillate	**Swing back** and **forth** in a regular rhythm.
Absorb	When the **energy** of an **EM wave** is **taken up by an object**.
Transmit	When a wave is able to **pass through** a material.
Reflect (HT)	The wave **bounces off a surface**; the **angle of incidence** is **equal** to the **angle of reflection**.
Refract (HT)	The wave **changes direction** when it enters a **medium of different density** where it has a **different speed**.
Medium	The **substance** that **carries a wave** (or disturbance) from one location to another.
Vacuum	A **space** entirely **devoid of matter**.

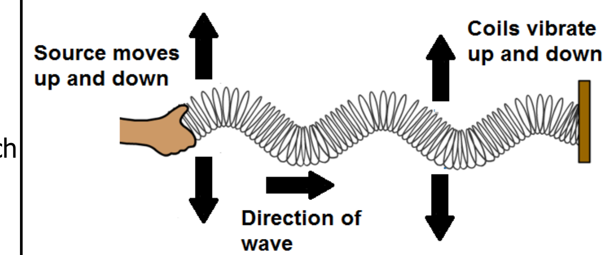
Section 2: The nature of waves

Waves **transfer energy** not matter. Waves can be used to transfer energy and information. **Mechanical waves** travel through a medium, for example light waves and radio waves, they can be **transverse** or **longitudinal**. **Electromagnetic waves** can travel through a vacuum and are **transverse**.

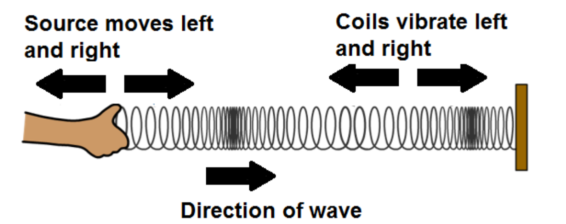
Transverse waves	Longitudinal waves
All electromagnetic waves (visible light, IR, Ultraviolet etc.) S waves. Ripples on the surface of water.	Sound waves. P waves.

Section 2: The nature of waves (continued)

Transverse waves have **oscillations** that are **perpendicular** to the direction in which the waves transfer energy.

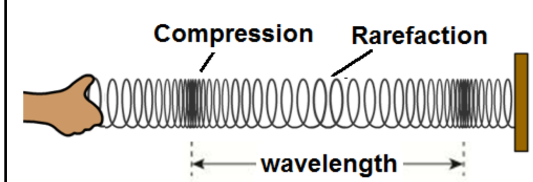


Longitudinal waves have **oscillations** that are **parallel** to the direction in which the waves transfer energy.

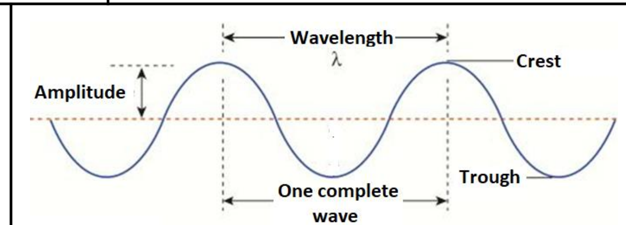


Section 3: The properties of waves

Longitudinal waves are made up of **compressions** and **rarefactions**. The **wavelength** is the **distance** from the **middle** of **one compression** to the **middle** of the **next compression**.



Distance from one crest to the next crest is the **wavelength**. The **amplitude** is the height of the wave crest.



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Section 3: The properties of waves (continued)

Period of a wave	period of a wave = $\frac{1}{\text{frequency}}$	
Calculating wave **speed**	Wave speed = frequency x wavelength $V = f\lambda$	Wave speed - m/s Frequency – hertz, Hz Wavelength – metres, m

Section 4: Investigating waves

Measuring the Speed of Sound

- **Measure** the **distance** to a **building.**
- **Fire a starting pistol** and **start a timer.**
- **Stop the timer** when the **echo** is heard.
- **Half** your value for **time.**
- Work out the **speed** using **distance divided by time**.

Measuring the Speed of ripples in a water tank

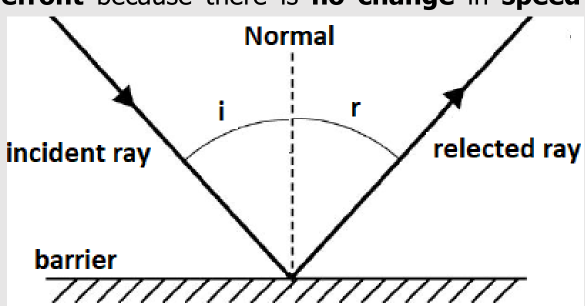
- Use a **ruler** to create **plane waves.**
- **Measure time** taken for a **wave** to travel from one end of tank to the other.
- **Measure distance** travelled.
- Work out the **speed** using **distance divided by time**.

Section 5: Reflection and refraction (HT)

The behaviour of waves can be investigated with water waves in a ripple tank. Waves travelling towards a barrier of a boundary are called **incident** waves.

Reflection

Takes place at the barrier in a tank. The **Reflected wavefront** moves away from barrier at **same angle** to the barrier as the **incident wavefront** because there is **no change** in **speed** or **wavelength**.

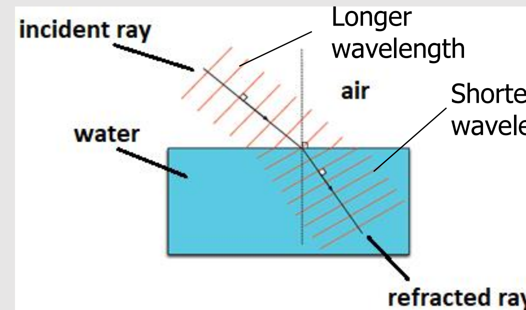


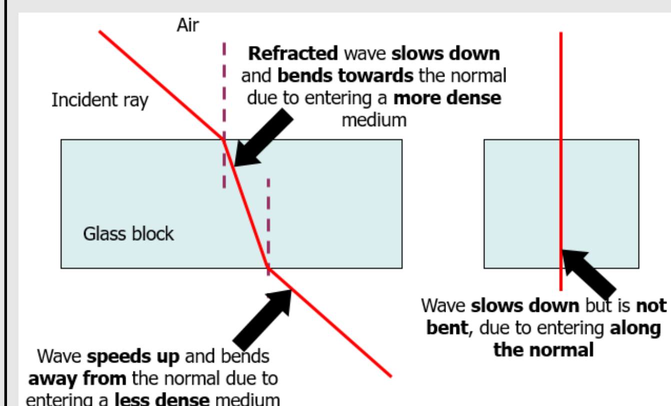
Angle of incidence (i) = angle of reflection (r)

Section 5: Reflection and refraction continued (HT)

Refraction

Waves **change speed** and **wavelength** when they **cross** a **boundary** between **different substances**. This can be seen in a ripple tank at the boundary between deep and shallow water. Unless the waves meet the boundary at right angles, the **change in speed causes** a **change in direction**. This effect is called **refraction**.





Waves and substances (HT)

When waves meet a boundary with a different substance they may be:

- Totally or partially **reflected**
- **Transmitted** through the substance
- **Absorbed** by the substance.

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Section 6: Key terms (Triple)

Ultrasound	Frequencies of sound above 20kHz (20000 Hz.)
Sonar	A system for the detection of objects under water by emitting sound pulses and detecting or measuring their return after being reflected.
Seismic waves	Produced by earthquakes. P waves are longitudinal and S waves are transverse (cannot travel through a liquid.)
Epicentre	The point where an earthquake occurs is called its focus. The nearest point on the Earth's surface to the focus is the epicentre.

Section 6: Sound waves (Triple)

Sound waves are caused by vibrating objects. Sound can travel through media like solids, liquids or gases but it can't travel through a vacuum (there are no particles.)

Investigating sound waves	To investigate sound waves use a **signal generator** and a **loudspeaker**. The loudspeaker produces sound waves as it pushes the surrounding air backwards and forwards. Sound waves **cannot pass** through a **vacuum**, this can be investigated using a electric bell in a bell jar. As the **air is pumped out** of the bell jar, the **ringing sound fades** away.
Amplitude	The **loudness** of a note **increases if** the **amplitude** of the sound waves **increases**.
Frequency	The **pitch** of a note **increases** if the **frequency** of the sound wave **increases.**
The ear	When sound reaches your ear, air particles in your **ear canal** vibrate against your **ear drum**, which vibrates against **three tiny bones**. These set **inner-ear fluid** moving which moves thousands of **delicate cells** which send **signals** to the **brain** causing the sensation of sound. The **conversion of sound waves to vibrations** of solids works over a **limited frequency range**, restricting the range of human hearing from 20Hz to about 20 kHz.
Echo sounding (Sonar)	Uses pulses of high-frequency sound waves to: • detect objects in deep water and • to measure water depth below a ship

Section 7: The uses of ultrasound (Triple HT)

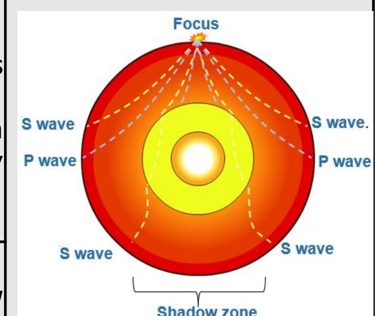
Ultrasound waves have a **frequency higher** than the **upper limit of hearing** for **humans**.
Ultrasound waves are **partially reflected** when they **meet a boundary** between two different media (e.g. two different types of body tissue.)
The **time taken** for the **reflections to reach** a **detector** can be used to **determine how far** away such a boundary is.

Ultrasound scanners	Used for prenatal scans of a baby in the womb. Also used to obtain images of organs in the body (e.g. kidney). It is non-ionising so is harmless.
Industrial imaging	Detecting flaws in metal casting (e.g. internal cracking) as they are partially reflected by cracks.

Section 8: Seismic waves (Triple HT)

Seismic waves are waves produced in an earthquake (sudden release of energy caused by the movement of tectonic plates) and travel through the Earth. They spread out from an **epicentre.**

P-waves	• **P**rimary waves. • Travel through both solids and liquids • Longitudinal waves that push and pull on material as they move through the Earth.
S-Waves	• **S**econdary waves • Slower; they arrive a few minutes after P-waves. • Cannot travel through liquids. • Transverse waves shake the material they pass through from side to side.



The paths of these seismic waves are curved because the density is gradually changing.

The study of seismic waves have provided new evidence that led to discoveries about parts of the Earth which are not directly observable (e.g. the structure and size of the Earth's core.)