Physics Knowledge Organiser
P12 - Wave properties

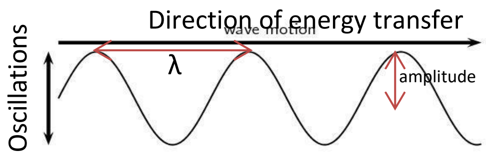
Types of Wave

You can see waves easily in the sea, or if a tap is dripping into a sink of water. However, waves are far more common than just that. Waves can be **mechanical**, which means they involve particles moving, or **oscillating**, such as waves in the sea or sound waves in the air. Or, they can be **electromagnetic**, which don't involve any particles oscillating – instead, EM waves involve vibrations or oscillations of the electromagnetic field. All waves involve the transfer of energy.

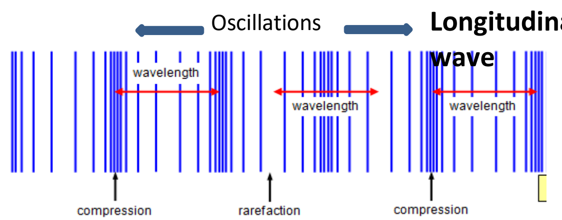
The other way of defining types of wave is whether they are **longitudinal** or **transverse**. Which one they are depends on the direction of the oscillations compared to the direction of energy transfer by the wave.

- In **transverse waves**, the oscillations are **perpendicular** to the direction of energy transfer.
- In **longitudinal waves**, the oscillations are **parallel** to the direction of energy transfer. They show areas of <u>compression</u> and <u>rarefaction</u> – see diagram.

You will need to be able to identify the amplitude, wavelength and period of a wave and describe the frequency of the wave (See diagram and definitions)



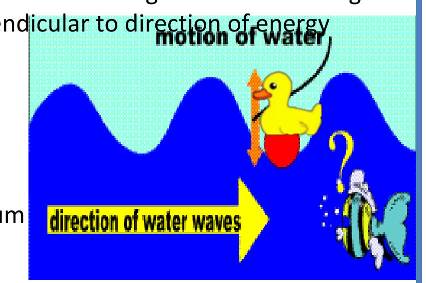
Transverse wave



Longitudinal wave

Particles Don't Travel, But The Wave Does. Particles Just Oscillate.

An easy way to see that the particles aren't travelling but the wave is (so energy is being transferred): put a rubber duck in a tank of water where waves are moving across. The duck goes up and down, just like the water particles (oscillations perpendicular to direction of energy transfer, remember), while the waves move across.



With longitudinal waves, you can tell the particles aren't flowing either – just oscillate. When you speak, you don't breathe into someone else's ear! Also, when a tuning fork is vibrating to produce a sound wave, it doesn't create a vacuum around it due to air particles travelling away.

Key Terms	Definitions
Wave	A wave transfers **energy** from one place to another, and can also carry information. All waves involve movements or **oscillations**, allowing energy to be transferred **without** particles having to flow or travel from one place to another.
Oscillations	Vibrations or movements. These movements are of particles in **mechanical** waves, or of the electromagnetic field when it comes to **electromagnetic** waves.
Perpendicular	At right angles to.
Amplitude	The amplitude of a wave is the <u>maximum displacement</u> of a point on the wave from the undisturbed position. *Translated*: the distance from a peak or trough to the 'midline' of the wave.
Wavelength	The distance from a point on one wave to the equivalent point on the next wave along. This is easiest to measure at the distance from the centre of one area of compression to the next (longitudinal waves) or the distance from peak to peak (transverse waves). Symbol: λ
Frequency	The frequency of a wave is the number of complete waves that pass a point per second. Symbol: f
Period	The period, or time period, of a wave is the time it takes to complete a full wave. Symbol: T
Wave speed	The speed at which the energy is transferred (or the wave moves) through the medium

Equation	Meanings of terms in equation
$T = \frac{1}{f}$	*T = time period (seconds, s)* *f = frequency (hertz, Hz)*
* $v = f\lambda$	*v = wave speed (m/s)* *f = frequency (Hz)* *λ = wavelength (metres, m)*

The Wave Equation

The equation is directly above. You could measure the speed of sound in air, with a long distance between you and a friend. They make a loud noise (you start your clock when you see them do it) and you time how long it takes to get to you. Just use distance/time to calculate the speed.

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Measuring the frequency, wavelength and speed of waves in a ripple tank

Method:

1. Set up the ripple tank as shown in the diagram with about 5cm depth of water
2. Adjust the height of the wooden rod so that it just touches the surface of the water
3. Switch the lamp and motor on and adjust until low frequency waves can be clearly observed.
4. Measure the length of a number of waves then divide by the number of waves to find the wavelength. It can be easier to take a photograph of the card with the ruler and take a measurement of the still picture
5. Count the number of waves passing through a point in ten seconds then divide by 10 to get the frequency.
6. Calculate the speed of the wave using: Wave speed = frequency x wavelength

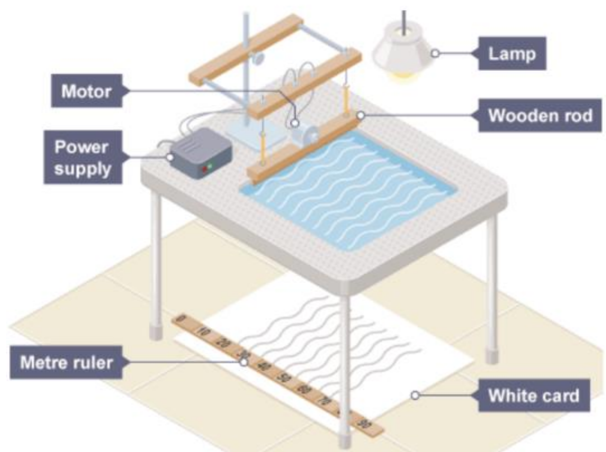
Measuring the frequency, wavelength and speed of waves in a solid

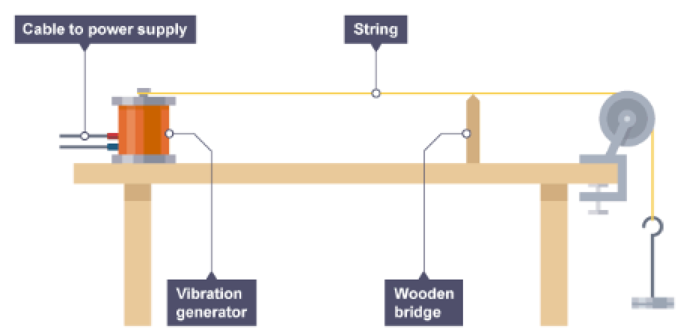
Method:

1. Attach a string or cord to a vibration generator and use a 200 g hanging mass and pulley to pull the string taught as shown in the diagram. Place a wooden bridge under the string near the pulley.
2. Switch on the vibration generator and adjust the wooden bridge until stationary waves can be clearly observed.
3. Measure the length of as many half wavelengths (loops) as possible, divide by the number of half wavelengths. This is half the wavelength, doubling this gives the wavelength.
4. The frequency is the frequency of the power supply
5. Calculate the speed of the waves using: wave speed= frequency x wavelength

Hazard	Consequence	Control measures
Electrical components near water	Shock and damage to components	Secure electrical components before adding water taking care not to splash

Hazard	Consequence	Control measures
Cord snapping	Damage to eyes	Eye protection / safety screen





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P12 - Wave properties – Physics only (HT)

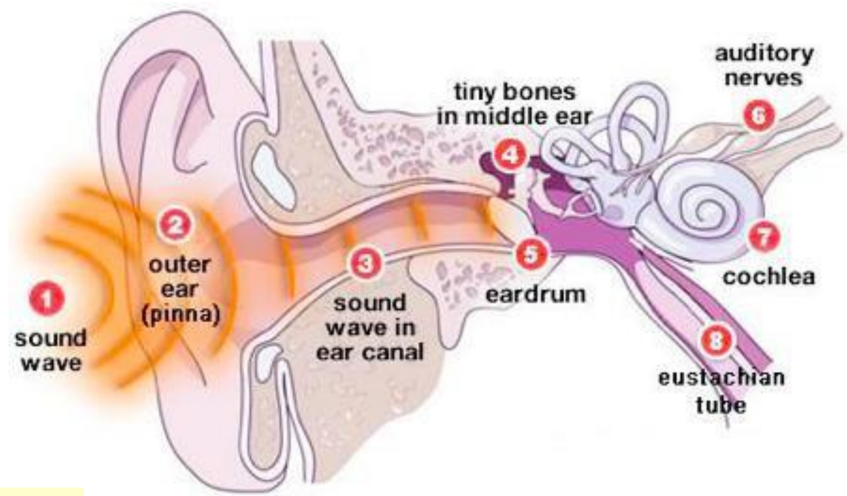
Sound waves

Sound waves a longitudinal waves caused by **vibrations** in matter. Sound waves can travel through solid, liquid or gas media, but not in vacuum because there is no matter (no particles) to actually vibrate.

We **hear** sound waves because the vibrations travel in the air into our ears, and cause the eardrum to vibrate. In turn, this transmits the vibrations to the inner ear where the vibrations cause electrical impulses, which travel along the auditory nerves to the brain. However, this conversion of vibrations in the air to vibrations in the solid of our eardrum only happens over a certain range of frequencies of vibration. As a result, some sounds are too low pitched for us to hear and some are too high pitched.

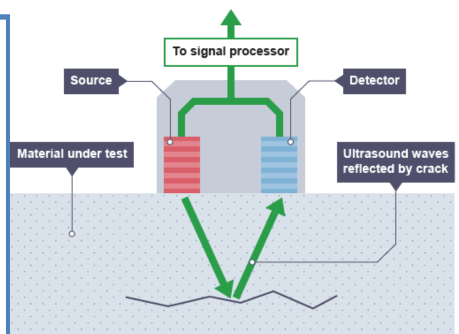
The human auditory range is 20 – 20 000 Hz. Sounds with a higher frequency than 20 000 Hz (20 kHz) are called ultrasound.

Key Terms	Definitions
Medium	Material a wave is travelling through (or being **transmitted** through). Plural = media.
Auditory	Anything relating to hearing or parts of the ear.
Ultrasound	Sounds too high in pitch to be heard (higher frequency than 20 kHz)
Seismic waves	Vibrations caused by earthquakes that travel through the Earth
P – waves	Longitudinal seismic waves
S – waves	Transverse seismic waves
Echo	Reflection of a sound (including ultrasound)



Using waves for detection and exploration...

Ultrasound is useful for <u>detection</u> – finding things that you can't directly see. It can be used for medical diagnosis (such as scans of a foetus), for finding things in a medium – e.g. cracks in a solid block, or shoals of fish in the sea, or where the bottom of the sea is. This works because ultrasound is **partially reflected** when there is a change in medium (some ultrasound waves continue through). By detecting the waves reflected – or echoed – back, you can work out how far away the boundary between the two media is. This can be calculated if you know the speed of the ultrasound and the time it takes to reflect back – use $s = vt$. See diagram.



Seismic waves are produced by earthquakes, and they can be detected. There are two kinds: S-waves and P-waves, with different properties, as shown on diagram. This is very helpful, because they provide evidence that there is a liquid outer core to the Earth, and evidence that the mantle is solid – fantastic news, because no-one can dig down to find these structures. So waves help us <u>explore</u> the deep structure of the Earth.