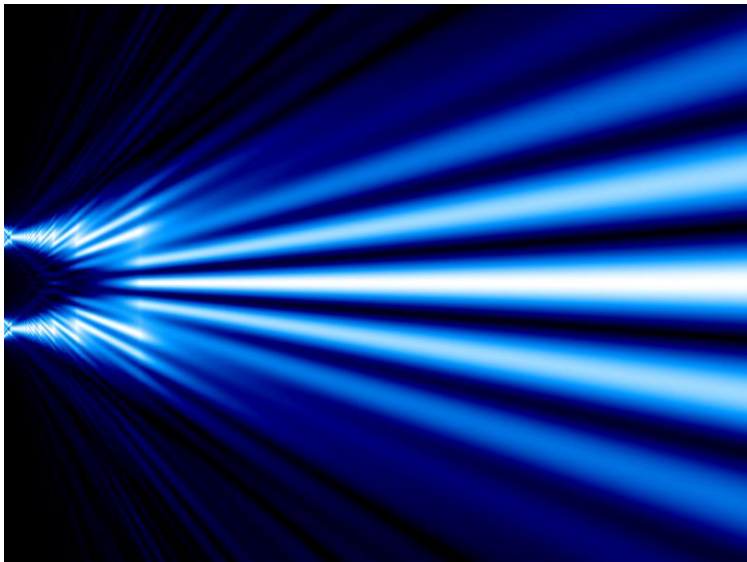
Waves & The Particle Nature of Light

2015 EdExcel A Level Physics Topic 5

Waves Introduction



Physics Tutor Online

What is a wave?

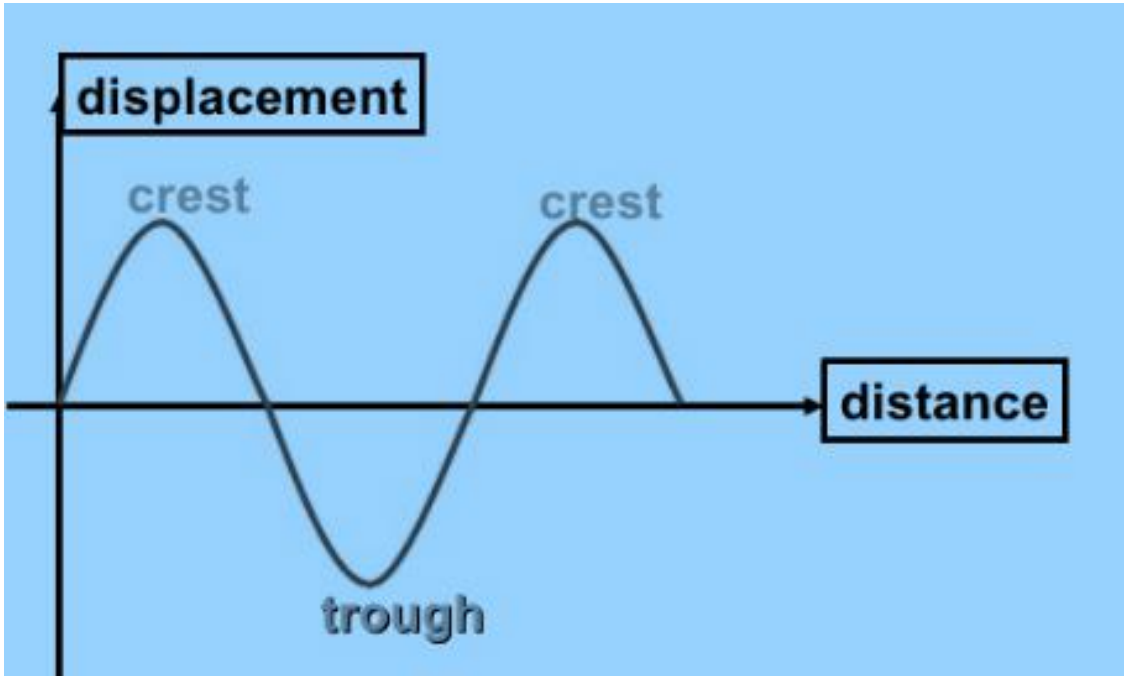
A wave is a phenomenon in which energy is transferred through vibration

There is no transfer of matter in a wave, just energy

Crests and Troughs

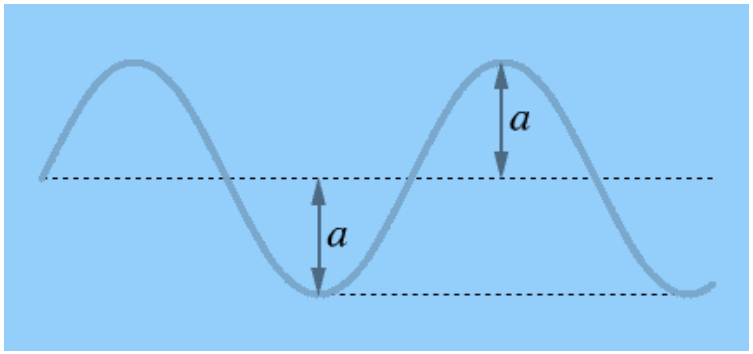
A crest is the highest point in the wave

A trough are the lowest point in the wave

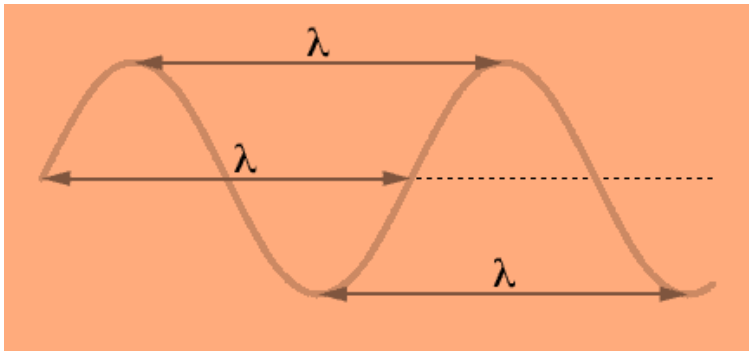


Describing Waves

The height of a crest or depth of trough is the **Amplitude** (maximum displacement measured from the equilibrium position).



Wavelength (λ) is the distance between two successive crests or troughs.



Describing Waves

Frequency is the number of vibrations or complete cycles in one second, passing a point or emitted from a source.

The SI Unit for Frequency is Hertz (Hz)

1 Hz is 1 vibration in 1 second.

50 Hz is 50 vibrations in 1 second.

Time Period is the time taken for one complete vibration (or oscillation or cycle)

The SI Unit For Period is second (s).

$$time\ period = \frac{1}{frequency} \qquad T = \frac{1}{f}$$

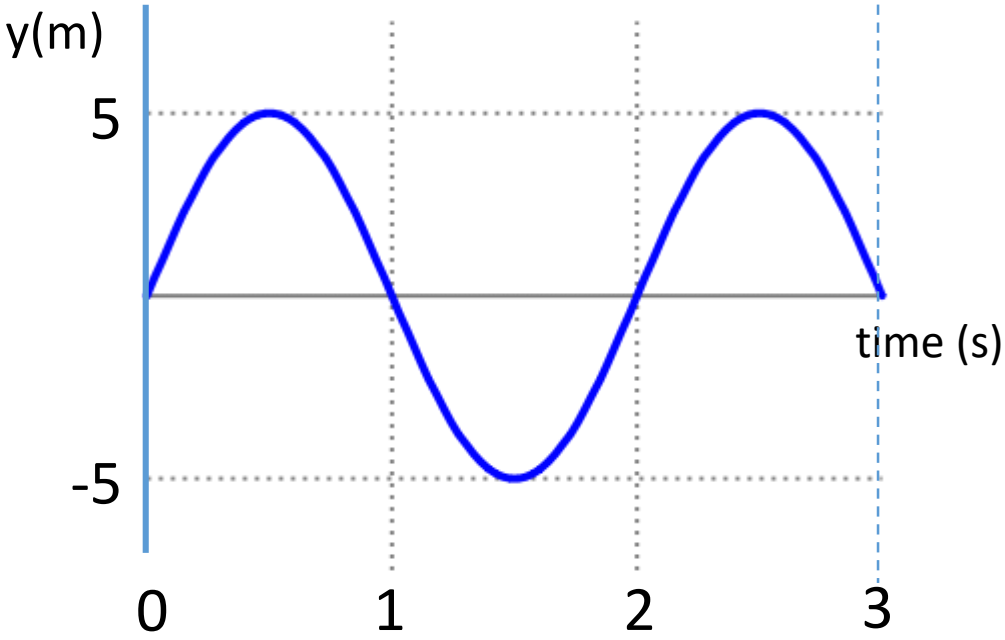
Wave speed

Wave speed is simply distance travelled per second.

The SI unit of speed is m/s

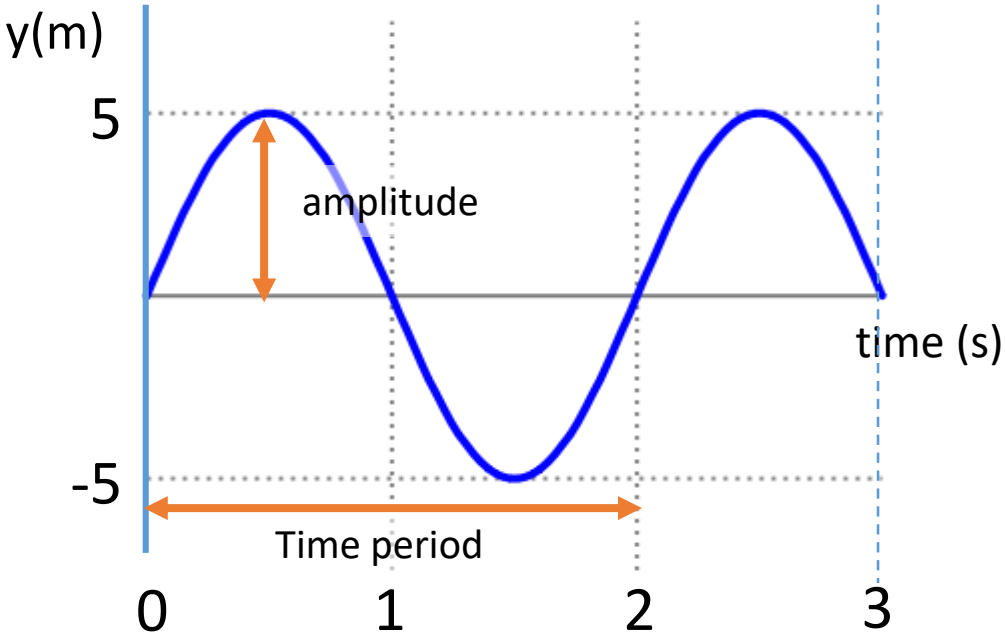
Examples of wavespeeds:
Light (vacuum) 3×10^8 m/s
Sound (air) 330m/s

Labelling a wave



Amplitude=?
Time period=?
Frequency=?

Labelling a wave

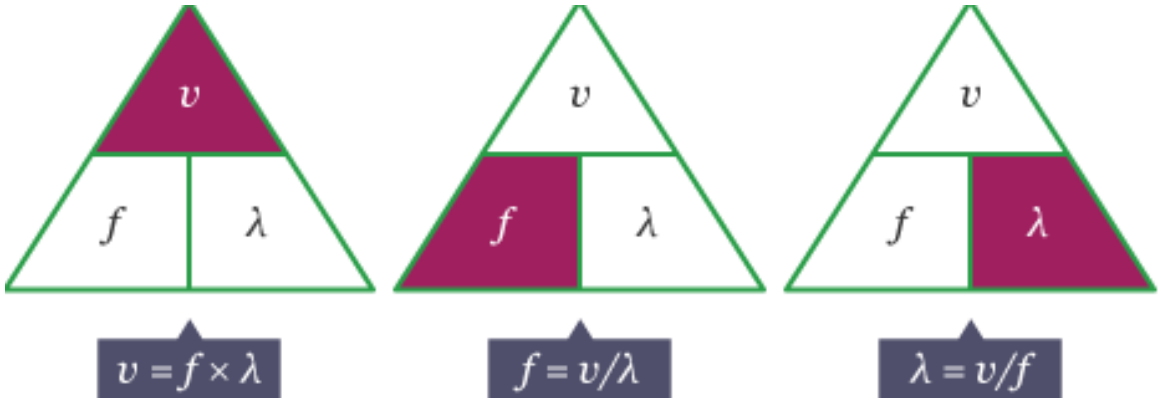


Amplitude=5m
Time period=2s
Frequency=0.5Hz

The Wave Equation

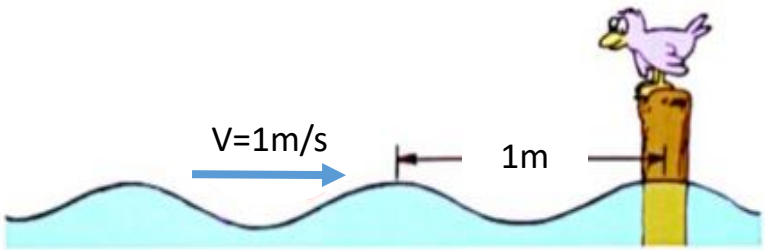
The wave equation relates the speed of the wave to its frequency and wavelength:

Wave speed (v) =	frequency (f) x	wavelength (λ)
in ms^{-1}	in Hz	in m



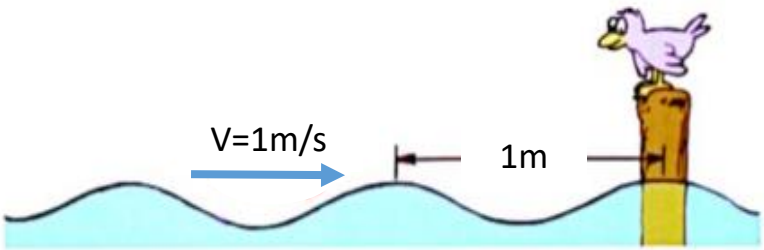
Example

Question: Calculate the frequency from the data shown



Example

Question: Calculate the frequency from the data shown



Solution:

$v = 1ms^{-1}$

$\lambda = 1m$

According to equation

$v = f\,\lambda$

$$f = \frac{v}{\lambda} = \frac{1}{1}$$

$f = 1\ Hz$

Wave equation practice questions

1) A water wave has a frequency of 3Hz and a wavelength of 0.6m. How fast is it moving?

2) A water wave travels through a pond with a speed of $2ms^{-1}$ and a frequency of 10Hz. What is the wavelength of the waves?

3) The speed of sound is $330ms^{-1}$ (in air). When Tom hears this sound his ear vibrates 440 times a second. What was the wavelength of the sound?

4) Violet light has a wavelength of around $6x10^{-7}m$. What is the frequency of violet light?

Wave equation practice questions

1) A water wave has a frequency of 3Hz and a wavelength of 0.6m. How fast is it moving?

1.8m/s

2) A water wave travels through a pond with a speed of $2ms^{-1}$ and a frequency of 10Hz. What is the wavelength of the waves?

0.2m

3) The speed of sound is $330ms^{-1}$ (in air). When Tom hears a sound his ear vibrates 440 times a second. What was the wavelength of the sound?

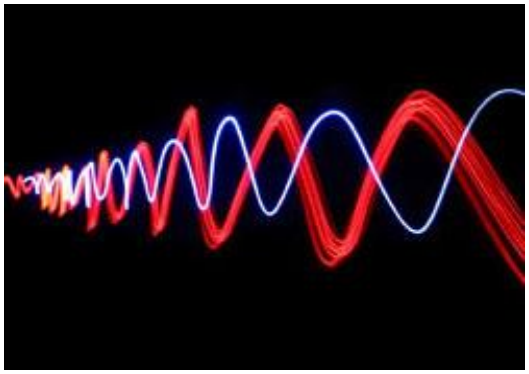
0.75m

4) Violet light has a wavelength of around $6x10^{-7}m$. What is the frequency of violet light?

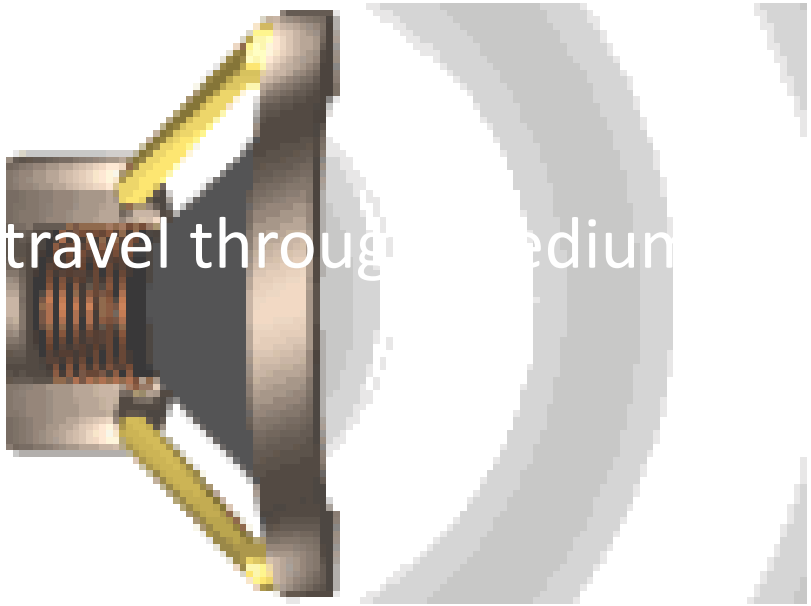
$5x10^{14}Hz$

Types of Waves

1) Mechanical Waves need matter (medium) to travel through
2) Electromagnetic Waves can travel through empty space.

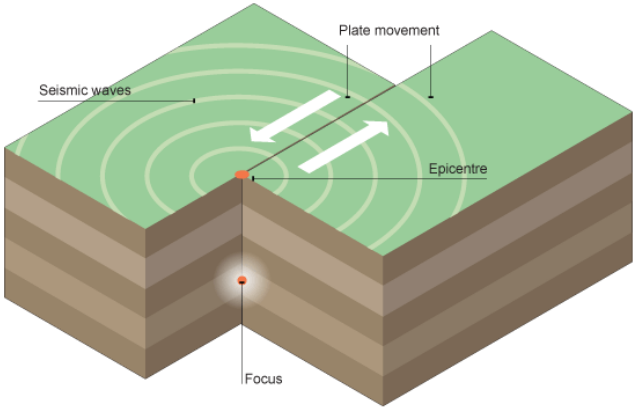


1) Mechanical Waves



air

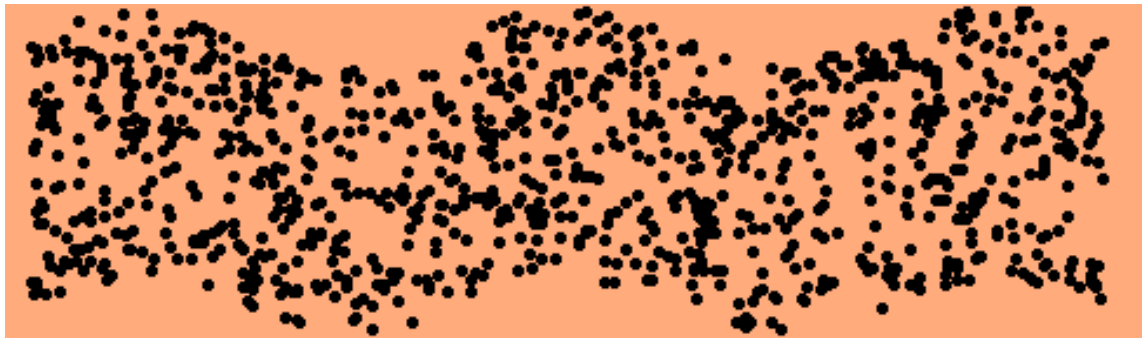
water



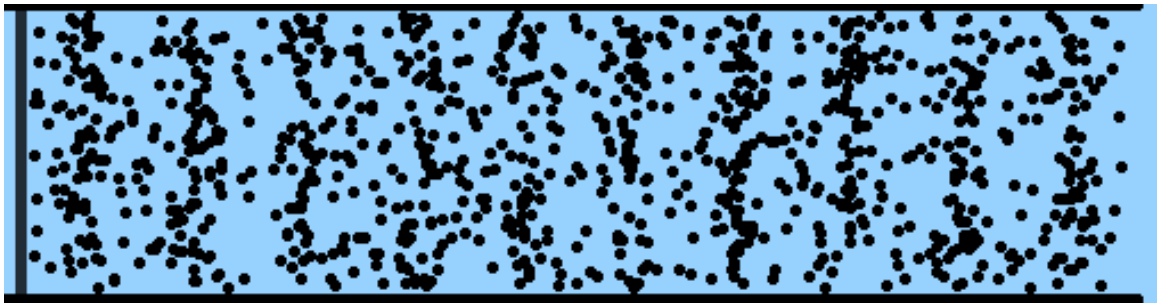
solids

1) Mechanical Waves

i) transverse



ii) longitudinal

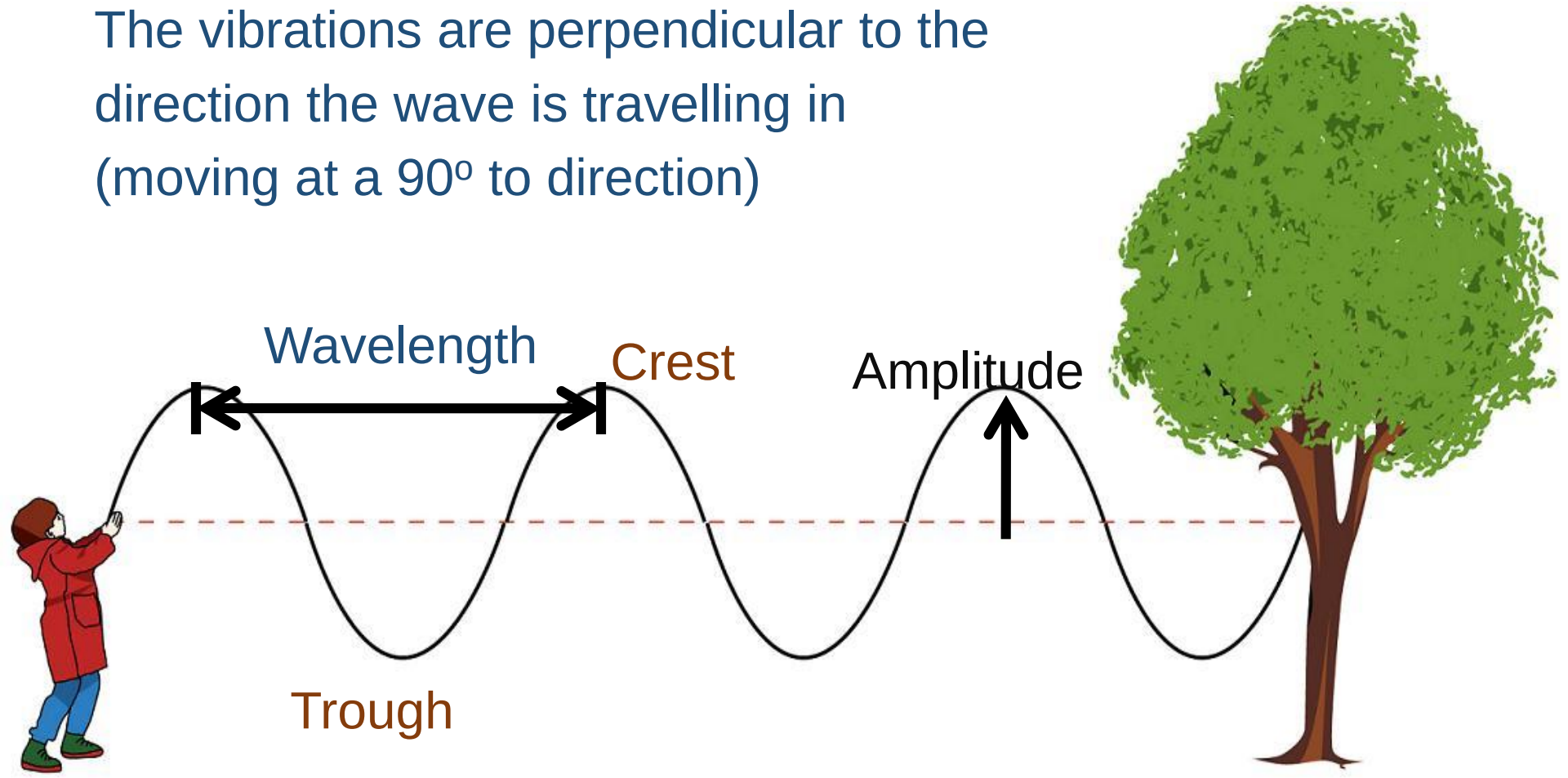


i) Transverse

Most waves are transverse

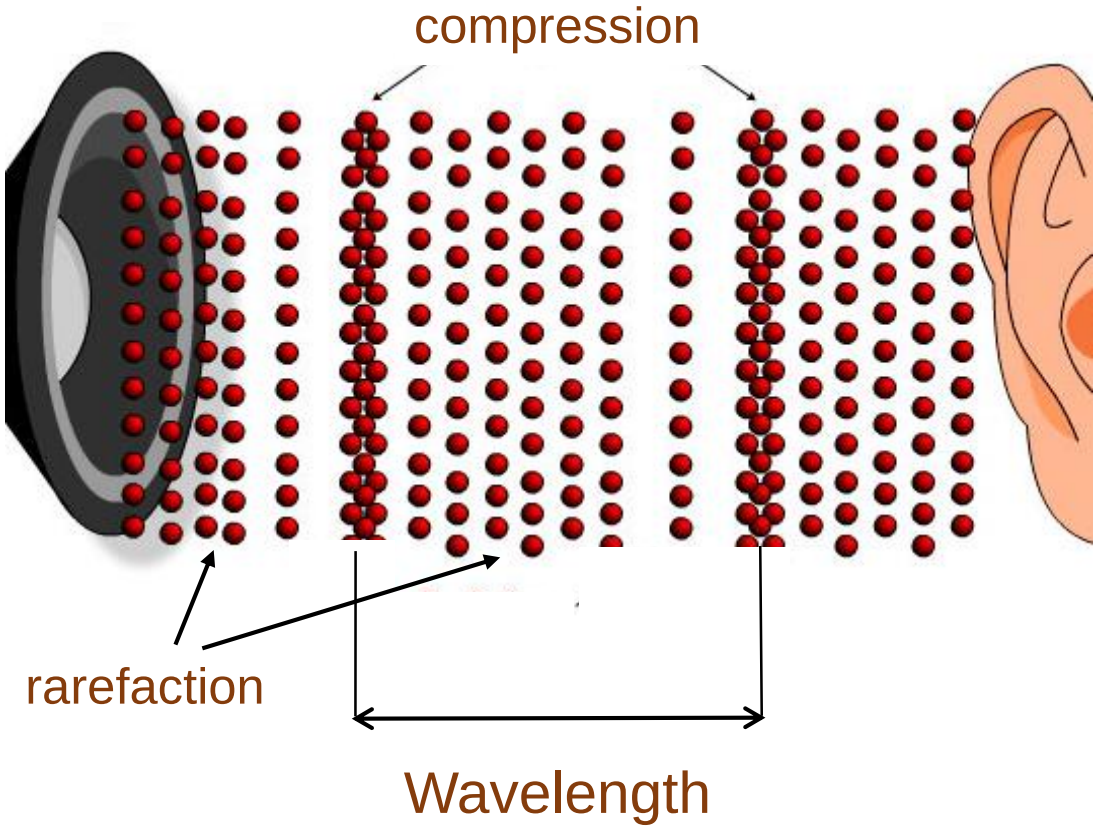
The vibrations in transverse waves go from side to side.

The vibrations are perpendicular to the direction the wave is travelling in (moving at a 90º to direction)

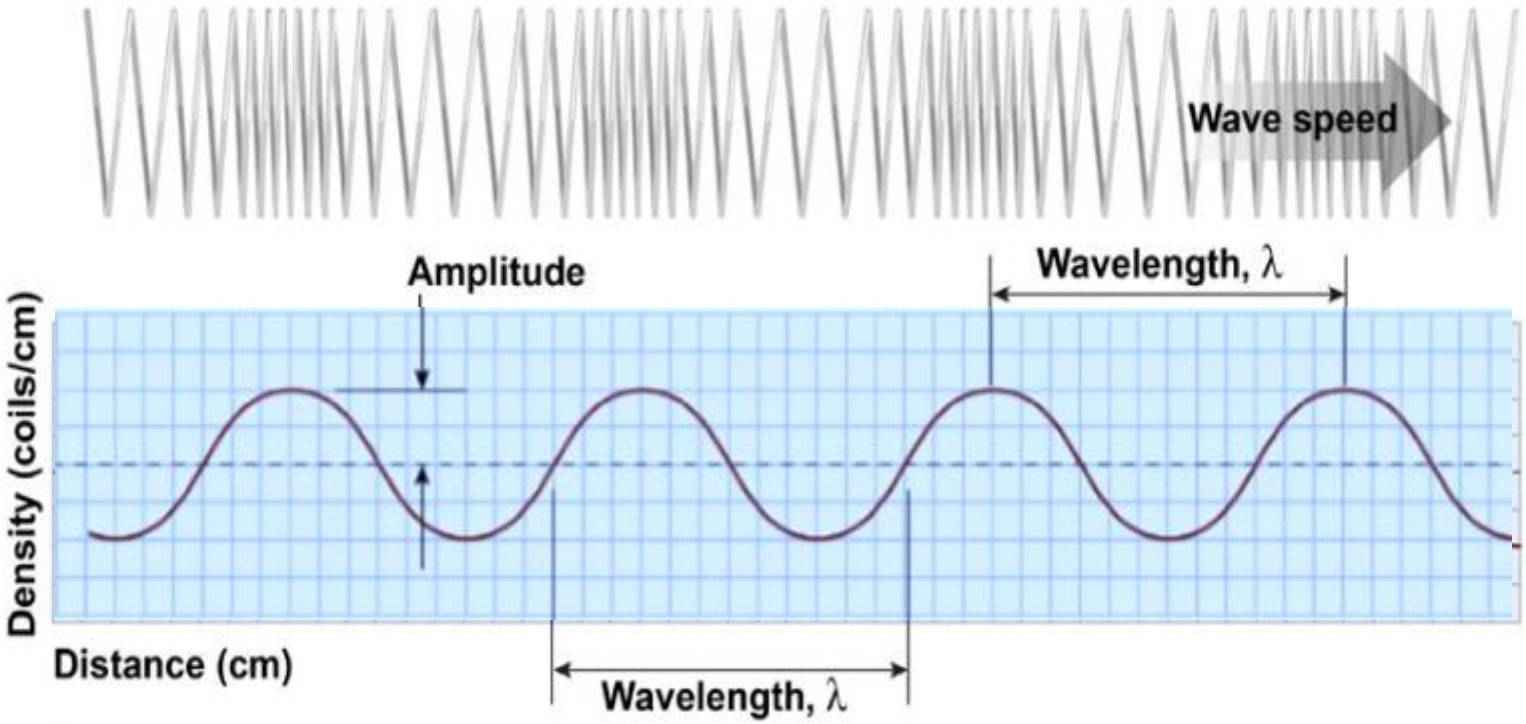


ii) Longitudinal

In longitudinal (compression) waves, energy moves along the medium whilst travelling forwards.



Graph of a longitudinal wave

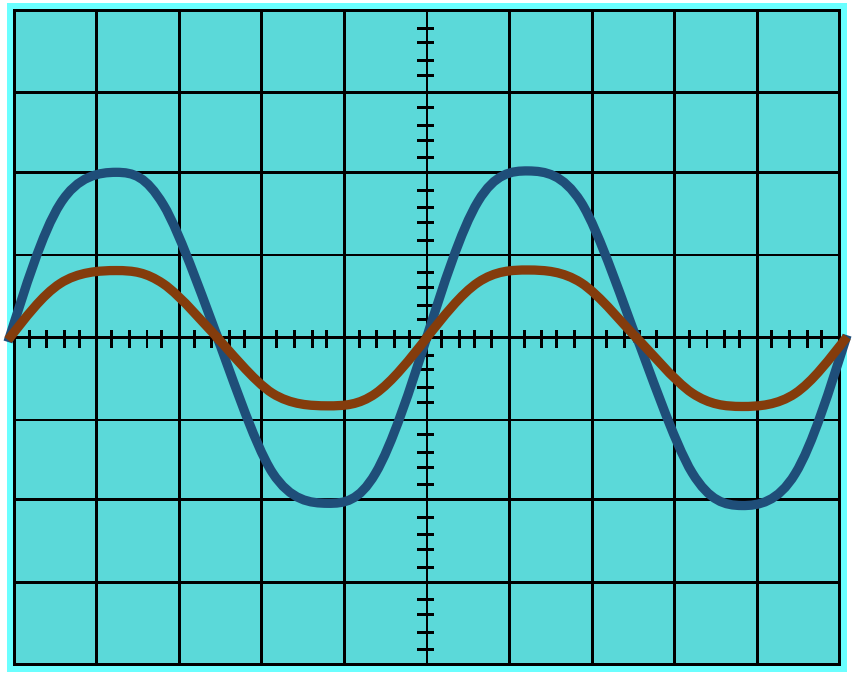


Core Practical 6 – Speed of sound in air

Oscilloscope

Determining the speed of sound in air using a 2 beam oscilloscope, signal generator, speaker and microphone

A pulse is sent directly to the oscilloscope and a second pulse from the microphone, detecting the sound wave from the loudspeaker.



Core Practical 6 – Speed of sound in air

Oscilloscope

As the microphone is moved away from the loudspeaker speaker the phase difference changes

The distance moved from in phase position to the next in phase position is measured. This distance is equal to the wavelength.

The frequency is found using the timebase (time per division) and f=1/t