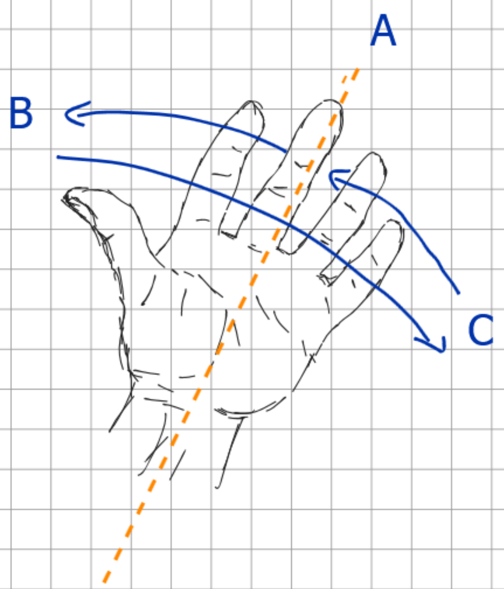
Waves Basics

7th March

ALL WAVES transfer ENERGY (or INFORMATION) from one place to another WITHOUT TRANSFERRING MATTER (stuff).
ALL WAVES feature OSCILLATIONS (vibrations). This is some form of movement or change back and forth between two positions.

Oscillations usually feature some initial rest position (equilibrium position) in this case shown at A.



One oscillation of this hand would be:

A ⟶ B ⟶ C ⟶ A

The FREQUENCY of a wave is the number of oscillations that happen PER SECOND.

The TIME PERIOD of a wave tells us how long ONE OSCILLATION takes.

$$\text{Time period} = \frac{1}{\text{Frequency}}$$

$$T = \frac{1}{f}$$

T in seconds, s

f in hertz, Hz

1 Hz = 1 oscillation per second

In TRANVERSE WAVES the OSCILLATIONS are PERPENDICULAR to the DIRECTION OF ENERGY TRANSFER.

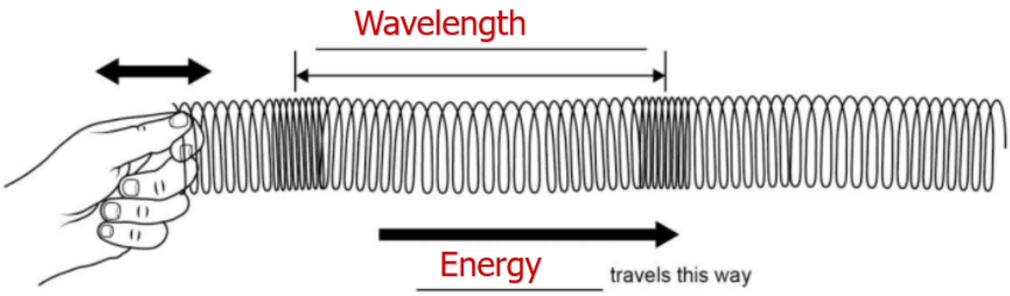
In LONGITUDINAL WAVES the OSCILLATIONS are PARALLEL to the DIRECTION OF ENERGY TRANSFER.

Transverse	Longitudinal
Seismic S	Sound
Water	Seismic P
Electromagnetic i.e. light	

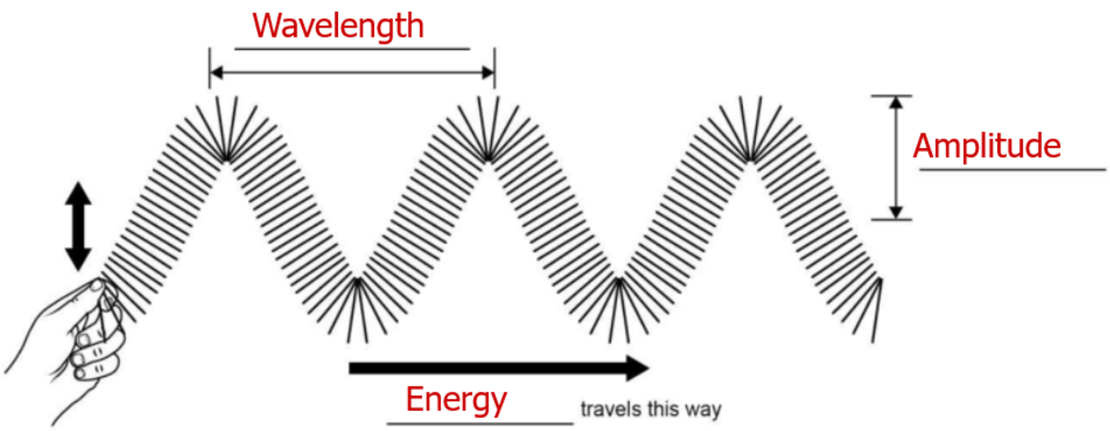
Transverse: Some can travel through a vacuum (EM waves)

Longitudinal: All need a material to travel through a Longitudinal wave

amplitude	energy	frequency	longitudinal
particles	period	transverse	wavelength



b Transverse wave



The distance from a point on one wave to the same point on the next wave is called the WAVELENGTH (often shown peak to peak or trough to trough).

The maximum displacement from the equilibrium/rest position is called the AMPLITUDE.

We can calculate the SPEED a wave travels if we know how far it travels and how long it takes.

$$\text{wave speed} = \frac{\text{distance travelled}}{\text{time taken}} \qquad v = \frac{s}{t} \qquad s = vt$$

- wave speed: in metres per second, m/s
- distance travelled: in metres, m
- time taken: in seconds, s

$$\text{wave speed} = \text{frequency} \times \text{wavelength} \qquad v = f\lambda$$

- wave speed: in metres per second, m/s
- frequency: in hertz, Hz
- wavelength: in metres, m
- λ: greek letter lambda represents wavelength

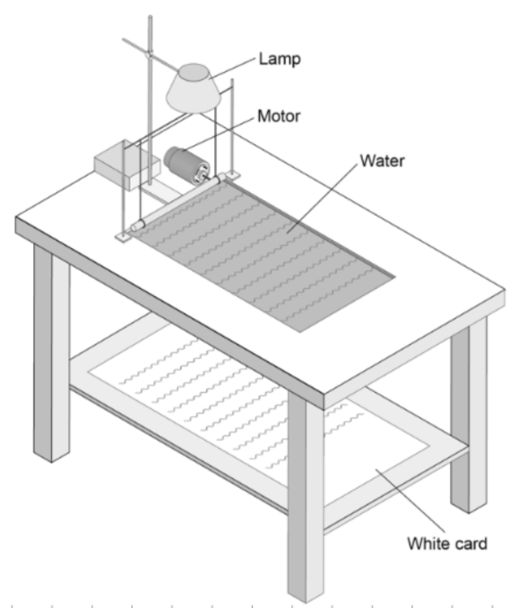
Required Practical 8: Measuring the speed of waves

18th March

Liquids

$v = f\lambda$ $\quad$ $v = s/t$

Figure 3

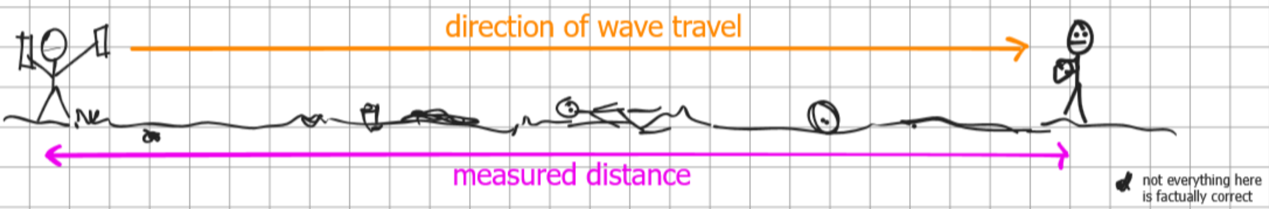


- Measure length of ripple tank with a ruler (30 cm) (s)
- Use a stopwatch to measure the time for 10 waves to travel the length of the tank.
- Divide this number by 10 to find the time for one wave to travel the length of the tank (t)
- Use $v = s/t$ to find the wave speed (v)
- Measure the time it takes for 10 waves to pass a point, and divide by 10 to find the frequency. (f) Using f = 1/T.
- Use a stopwatch to measure any times
- Now use the equation $v = f\lambda$; giving $\lambda = v/f$

Gases

To measure how quickly sound travels in air we can do the following:

- measure out a long distance with a trundle wheel/tape measure
- make a sharp and loud sound (starting pistol, clap, blocks hitting together)
- use a stopwatch to measure the time between seeing the smoke from pistol/ seeing the clap or blocks hitting, and actually hearing the sound.



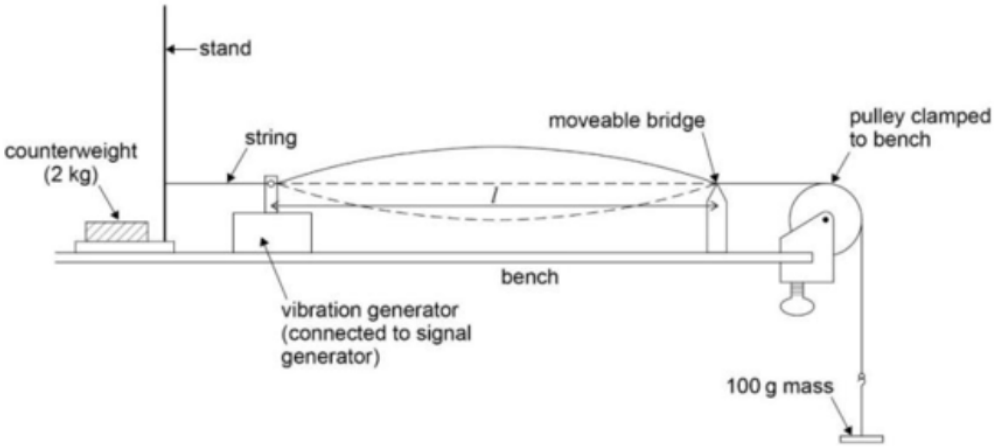
distance / m	time 1 /s	time 2 /s	time 3 /s	mean time /s	speed m/s
185	0.68	0.72	0.69	0.70	264

We could increase the accuracy of our experiment by using a LONGER DISTANCE. This would increase the time values, making it easier to start and stop the stopwatch correctly.

We could also reflect the sound wave from surface and measure the time for the wave to travel there and back. We measure the time between hearing the sound and its echo.

Solids

You are going to calculate the speed of a wave on a string, by measuring the frequency of the wave and the wavelength produced.



Method

1. Set up the apparatus as shown in the diagram.

2. Adjust the length of the string, L, so that it is 0.80 m measured using the metre ruler.

3. Increase the frequency of the signal generator from zero until the string resonates and produces a 'half wave' as shown in the diagram.

4. To find the wavelength: Divide the distance between the vibration generator and the moveable bridge by the number of half waves. Then multiply this by two.

5. Read the frequency, f, on the signal generator dial, this gives us the frequency of the wave.

6. Calculate the speed of the wave each time using $v = f\lambda$.

Waves at a boundary

3rd April

When a wave hits the surface of a new substance (a boundary) it will do one or more of the following things:

- TRANSMISSION - it may travel into the new substance and through it. If the speed of the wave changes we may get REFRACTION.
- REFLECTION - the wave may bounce away from the surface
- ABSORPTION - the energy from the wave is absorbed by the new substance

Reflection

Mirror:

angle of incidence /°	angle of reflection /°
10	10
20	20
30	30

	width of incoming ray	width of reflected ray
Mirror		
Wood		

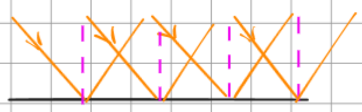
The LAW of REFLECTION states that:

the angle of incidence = angle of reflection

Note: we ALWAYS measure angles between the wave and the NORMAL

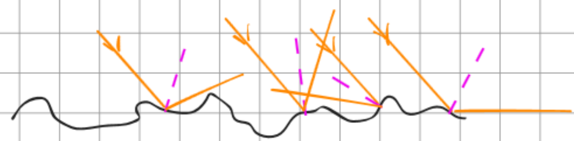
This dashed line is the 'NORMAL' line. We draw it at 90 degrees to the surface where the wave hits the surface.

Specular Reflection



- Smooth surface
- Light rays enter and leave parallel to each other
- May see a reflection of an image

Diffuse Reflection



- Rough surface
- Light rays scattered in different directions
- No clear reflection seen

Refraction

Entering the block

angle of incidence / °	angle of refraction / °
15	10
41	26
63	35

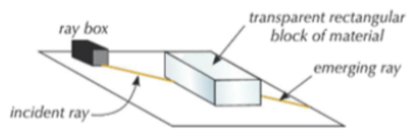
The angle of refraction is always LESS than the angle of incidence when a wave crossing a boundary SLOWS DOWN.

The angle of refraction is always GREATER than the angle of incidence when a wave crossing a boundary SPEEDS UP.

GCSE Physics Required Practical 9: Investigating Refraction

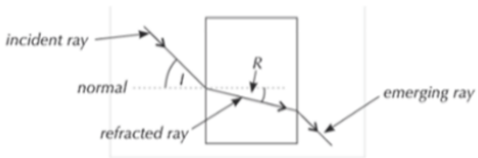
You are going to measure and record the incident and refracted angles when light travels from air to a more optically dense medium.

Equipment: Plain paper, ray box, Perspex block, pencil, protractor, ruler



Method: Place a rectangular Perspex box on a sheet of plain paper and draw around it

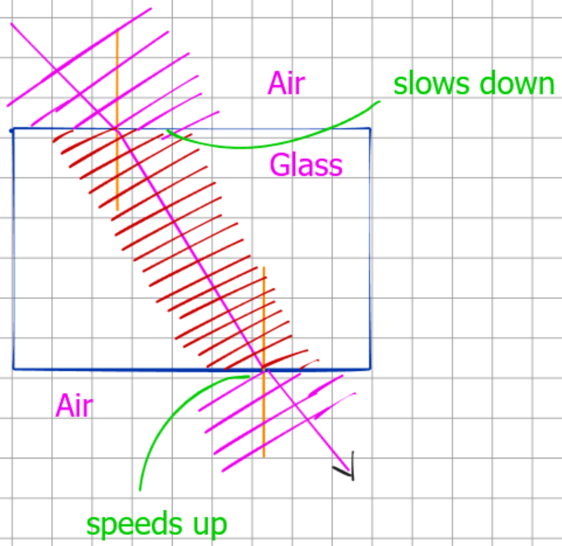
1. Mark a point on the middle on one of the long sides of the block, and draw a dashed line perpendicular to the surface (the normal).
2. Replace the block on the sheet and shine the light from the single slit on the ray box so it is incident where you have marked your normal, and such that the light ray forms an angle to the normal
3. Trace this light ray
4. Mark where the ray exits the block and trace this too.
5. Remove the block, and with a straight line, join up the lines for the incident ray and the emerging ray
6. Draw a normal where the light ray exited the block
7. Measure the angles of incidence and refraction for the incident ray, and again for the emerging ray
8. Repeat for 3 more angles of incidence



Explaining Refraction

25th April

Refraction is caused when a wave travels across a boundary and changes speed.



When a wave hits a boundary at angle one part of the wave front changes speed before the other.

If one part of a wavefront SLOWS DOWN before the other, the wave will bend TOWARDS THE NORMAL.

If one part of a wavefront SPEEDS UP before the other, the wave will bend AWAY FROM THE NORMAL.

During refraction the SPEED of the wave changes and so does the WAVELENGTH.

The FREQUENCY of the wave DOES NOT CHANGE.

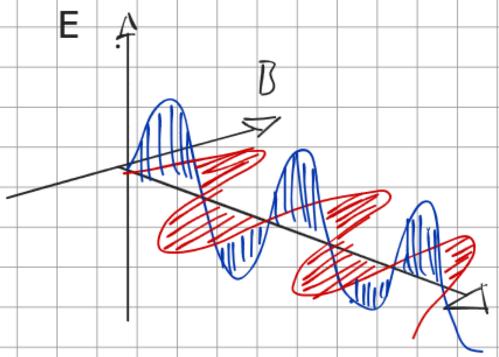
$v = f\lambda$ so $v \propto \lambda$ (the wave speed is proportional to wavelength)

An INCREASE in speed means an INCREASE in wavelength and vice versa.

The Electromagnetic Spectrum

29th April

All types of light are in the form of ELECTROMAGNETIC WAVES.

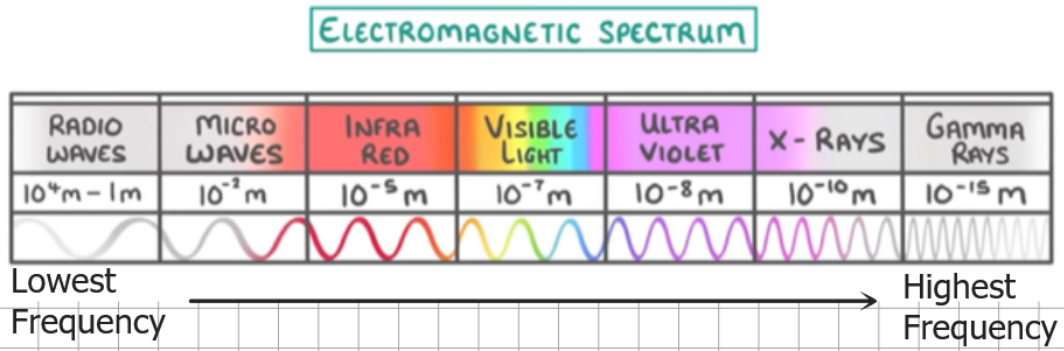


ALL electromagnetic waves can travel through a vacuum.

ALL electromagnetic waves are transverse.

ALL electromagnetic waves travel at the speed of light (300,000,000 m/s).

However, EM waves have a RANGE OF FREQUENCIES and WAVELENGTHS.



Possible mnemonics: Red Monkeys In Venus Use X-box Games
Red Monkeys In Vienna Usually X-ray Goats
Rapid Men In Velcro Underwear X-rays Gorillas

General Information	Radio Waves	Microwaves	Infrared
	Uses: communication, radio & TV Can refract from the Earth's atmosphere around the Earth, and they can reflect from certain layers of the atmosphere (ionosphere) Produced by oscillating electrons in wires.	Uses: cooking food, satellite communications Some wavelengths of microwaves can be absorbed by water, which causes heating. Could cause burns if absorbed by the water in your body. Some wavelengths can pass straight through the atmosphere so can be sent to satellites in space.	Uses: thermal imaging, electrical heating, cooking food All objects emit infrared. The hotter the object, the greater the amount of infrared it emits. Can cause burns if absorbed by the skin/body.
Visible Light 400nm Blue — 700nm Red Uses: fibreoptics, seeing the environment Different wavelengths of light correspond to different colours. Can be produced by electrons moving to lower energy levels in atoms. Can cause blindness/damage eyesight if very intense	**Ultraviolet** Uses: sun tanning, energy efficient lighting, security markings Can cause damage to the skin; premature aging of skin, skin cancers, can damage eyes Can cause fluorescence: when a material absorbs UV and emits the energy back out as visible light.	**X-Rays** Uses: medical imaging X-rays are absorbed by bone, but can pass through soft tissue (skin, fat, muscle etc) Dangers: can cause mutations, damage DNA, increase cancer risk	**Gamma Rays** Uses: tracers, medical imaging (see atomic structure topic) Ionising radiation (just like x-rays), so have the same dangers Produced by changes in atomic nuclei

Radio Waves 9th May

Alternating current in a transmitter causes ELECTRONS to OSCILLATE.

This oscillation creates RADIO WAVES with the SAME FREQUENCY.

The energy from these waves can be ABSORBED by ELECTRONS in a receiver.

This causes the ELECTRONS in the receiver to OSCILLATE at the SAME FREQUENCY as the radio wave. An ALTERNATING CURRENT has been INDUCED in the receiver.