Physics Knowledge Organiser
Waves (Triple Science)

Waves

Waves transfers energy. Energy is transferred through a motion called an oscillation.

An oscillation is a repeated back and fourth motion around a certain position.

There are two types of wave:

1) Transverse waves

Examples: **Light** (electromagnetic waves), ripples on water

2) Longitudinal waves

Sound, other mechanical waves involving particles

Longitudinal waves require particles to travel and transfer energy.

Therefore, in space where there are no particles (a vacuum) sound which travels as a longitudinal wave, would not be heard.

Descriptions of wave energy transfer

In a longitudinal wave, oscillations occur parallel to the direction of energy transfer/wave movement.

In a transverse wave, oscillations occur perpendicular to the direction of energy transfer/wave movement.

Wave Properties

Amplitude: The maximum displacement from the equilibrium position.

Wavelength: The distance between two equivalent points between two waves.

Peak: Top of a wave

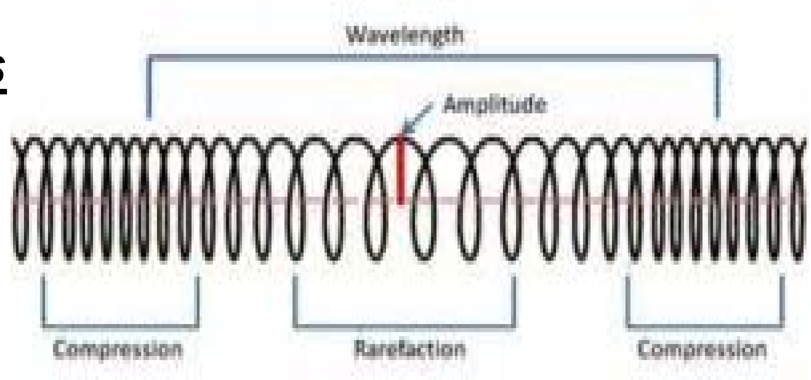
Trough: Bottom of a wave

Time period is the time to complete one wave in seconds ,s.

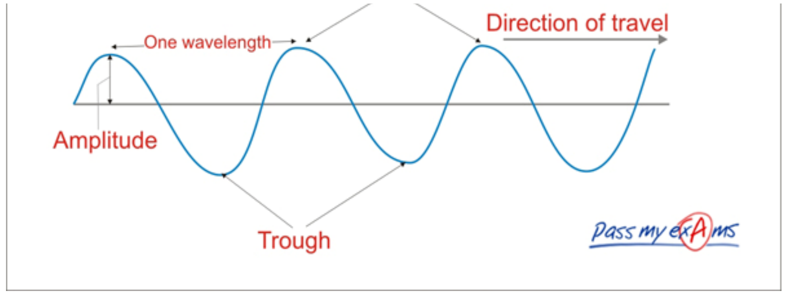
Frequency is the number of waves passing a point every second in hertz, Hz.

Diagrams for different types of waves.

Longitudinal



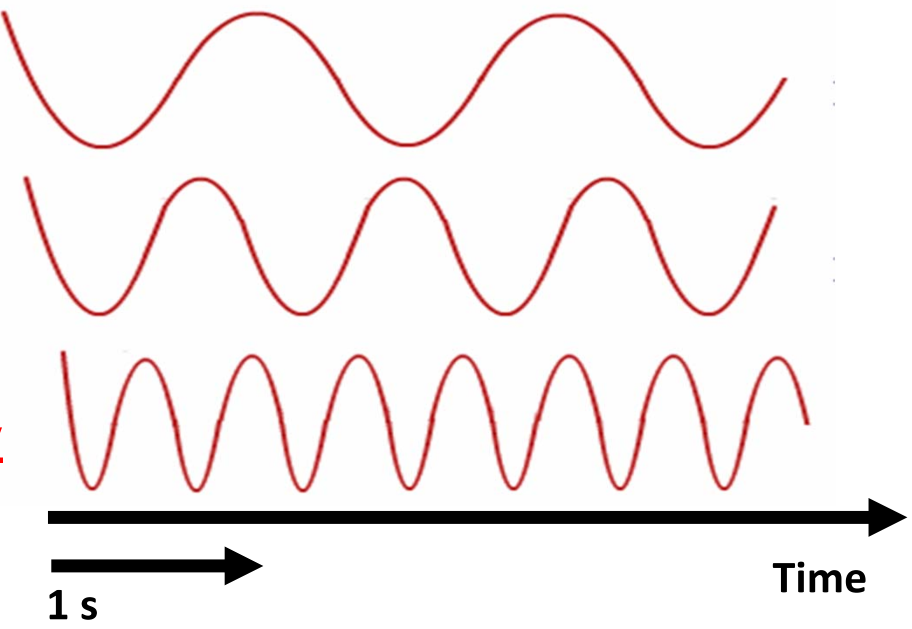
Transverse



Frequency shown on wave diagrams

Lowest frequency

Highest frequency



Time Period Equation

$$period = \frac{1}{frequency}$$

Given on equation sheet.

Units

Period = seconds (s)

Frequency = Hertz (Hz)

Example 1: Applying the Time Period equation

A string vibrates at a frequency of 20 Hz. Calculate its period.

$$period = \frac{1}{frequency}$$

$$period = \frac{1}{20}$$

$$period = 0.05s$$

Example 2 : Rearranging the Time Period equation

A Porsche engine has a period of 0.1s. Calculate the frequency.

$$period = \frac{1}{frequency}$$

$$0.1 = \frac{1}{frequency}$$

$$frequency = \frac{1}{0.1}$$

$$frequency = 10\ Hz$$

Wave Equation

$$v = f \times \lambda$$

V = Wave speed in metres per second, m/s

f = Frequency in hertz, Hz

λ = Wavelength in metres, m

You need to learn this equation.

It is not on the equation sheet.

Example 1: Applying the Wave equation

The sound wave has a frequency of 50Hz. This wave has a length of 6.6m. Calculate the speed of this wave.

$$v = f \times \lambda$$

$$v = 50 \times 6.6$$

$$v = 330\ m/s$$

Example 2 : Rearranging the Wave equation

The speed of light is $3 \times 10^8 m/s$.
The frequency of the waves is 5×10^{14} Hz.
Calculate the wavelength of these waves.

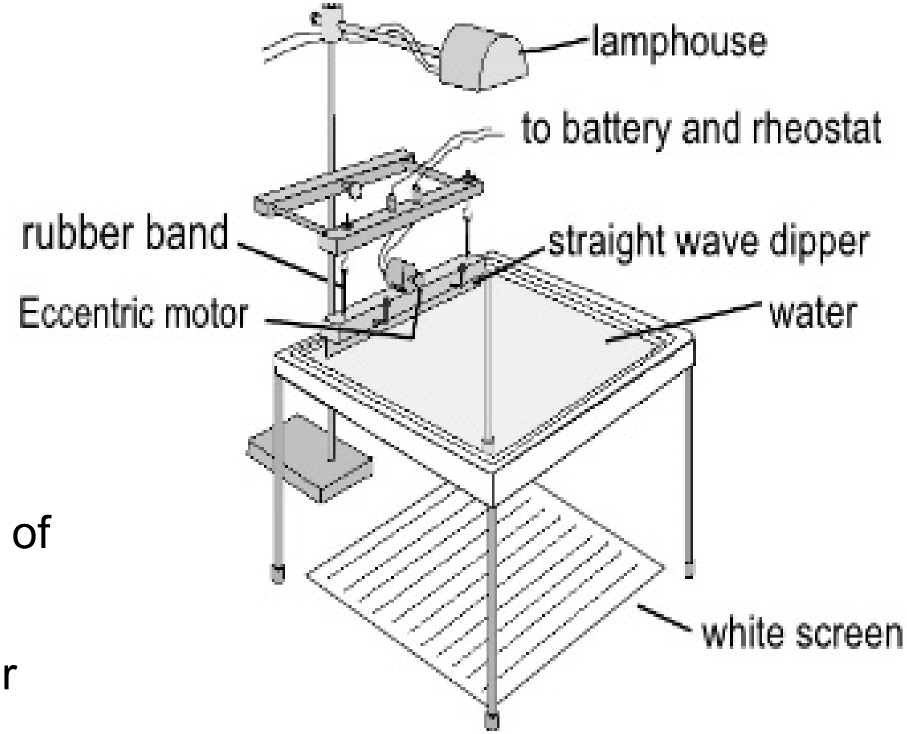
$$v = f \times \lambda$$

$$3 \times 10^8 = 5 \times 10^{14} \times \lambda$$

$$\frac{3 \times 10^8}{5 \times 10^{14}} = \lambda$$

$$\lambda = 6 \times 10^{-7}\ m$$

Measuring speed of a waves in a liquid



Method for measuring wave speed

1) Use a stop watch or stop clock to measure how many waves pass in a given time.

2) Divide the number of waves in this time to find the frequency of the waves.

3) Measure the wavelength of the 3 or more waves using a ruler placed at a right angle to the waves.

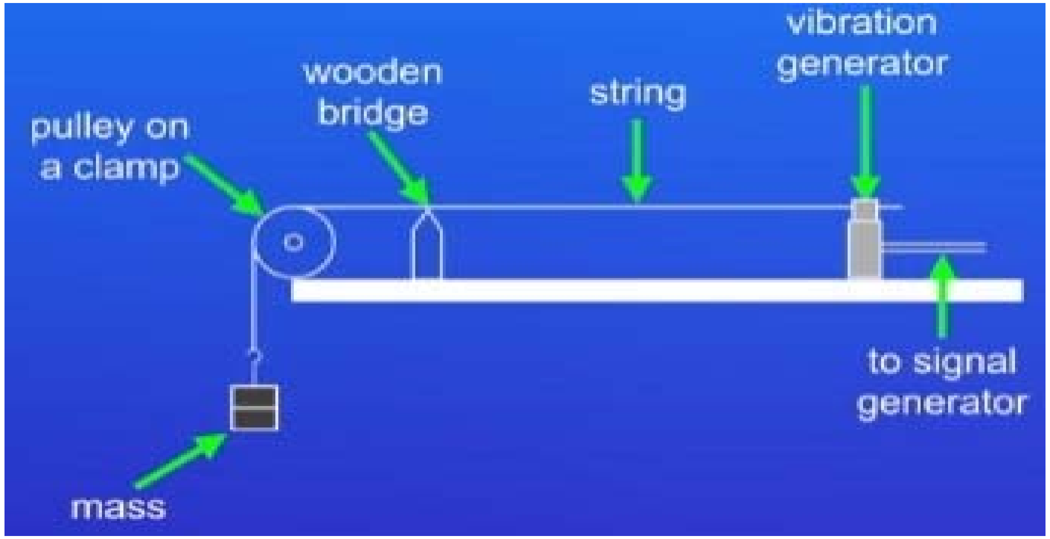
4) Divide by the number of waves to get the wavelength of 1 wave.

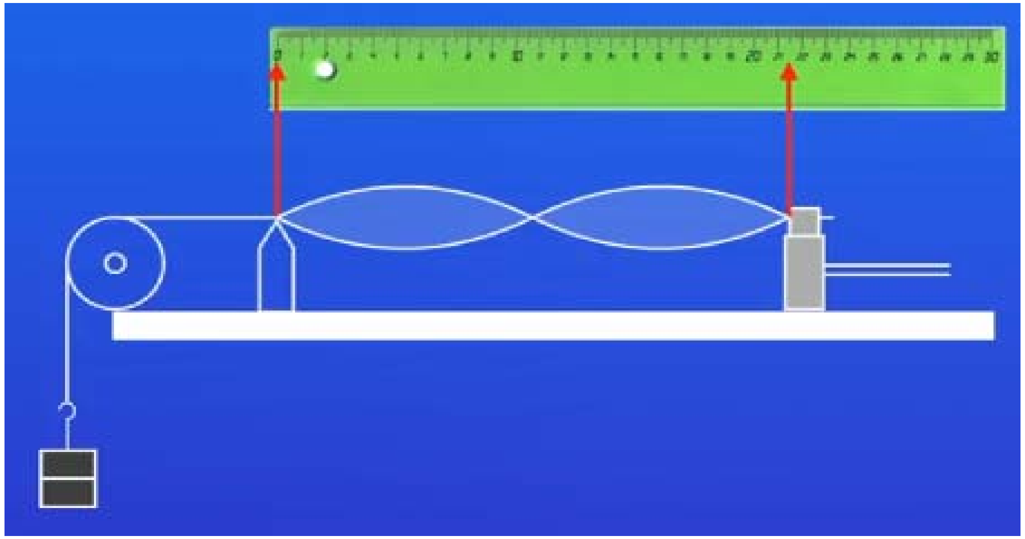
5) Use the wave equation

$wave\ speed = frequency \times wavelength$ **to calculate the wave speed.**

Measuring speed of a waves in solids

Diagram of set up for practical





Method

1) Get a 1m piece of string and attach to one end to a **vibration generator** which is connected to a **signal generator.** Hang the other end over the pulley with a mass on the end of it.

2) Adjust the frequency of the signal generator to produce a **standing wave.**

3) Measure the **wavelength** from the wooden bridge to the vibration generator using a 30cmor metre ruler.

4) The **frequency** is taken by reading it from the signal generator.

5) Use the wave equation $\boldsymbol{wave\ speed = frequency \times wavelength}$ **to calculate the wave speed.**

Refraction

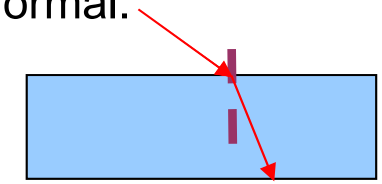
When light passes from a less optically dense material to a more optically dense material, the speed of the light decreases.

However, for light rays that are not incident at 90° to the material (along the normal line), the light ray will also change direction. This is called **Refraction** of light.

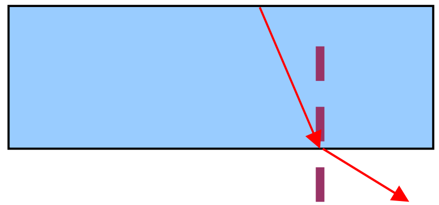
Ray Diagrams

F AST
A WAY
S LOW
T OWARDS

Light travels **f**aster (water to air) it bends **a**way from the normal.



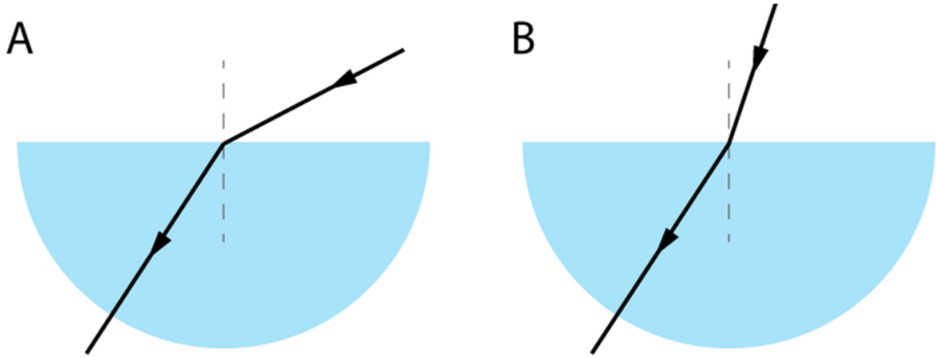
Light moves **s**lower (air to water) it bends **t**owards the normal.



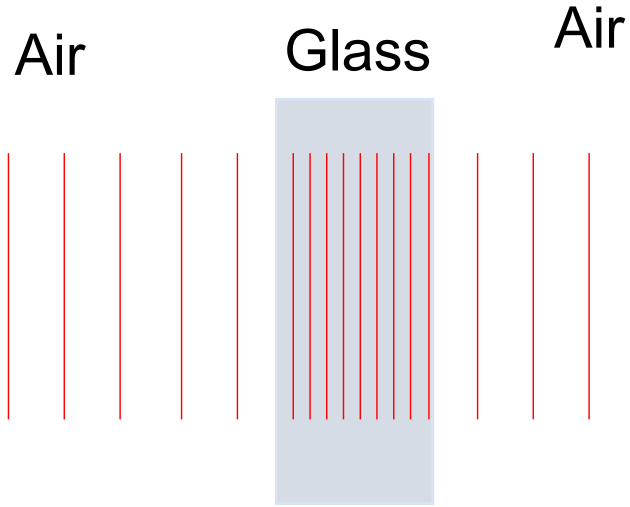
Ray diagram of Refraction for a curved surface

Refraction through a curved surface will take place at 90° to the surface.

Therefore, the light will change speed but not direction. This is because the light ray is travelling along the normal.



Refraction with Wave front diagrams

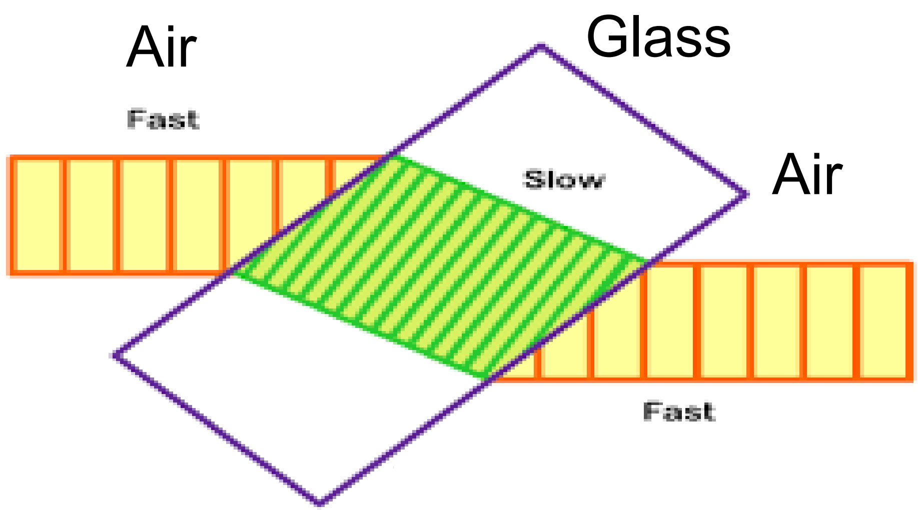


The diagram shows how the wave is travelling at a constant speed in the air.

When the wave meets the glass, the whole wavefront will meet the glass at the same time. The **speed of the wave decreases** as glass is **more optically dense**. This is shown by the **wavefronts getting closer together**.

The wave then increases in speed as it leaves the glass shown by an increasing distance between wavefronts.

Higher Tier Only



The diagram shows how the wave is travelling at a constant speed in the air.

The **edge of the wavefront** that meets the glass first will **decrease in speed** as **glass is more optically dense**. This causes **this part of the wavefront to change speed before the rest of it.**

This can also be seen for when the wave is leaving the glass block as the edge of the wavefront that meets this boundary first will increase in speed.

Electromagnetic (Em) Waves

Source – the original place a wave travels from.

Absorber – An object which takes in the energy from a wave.

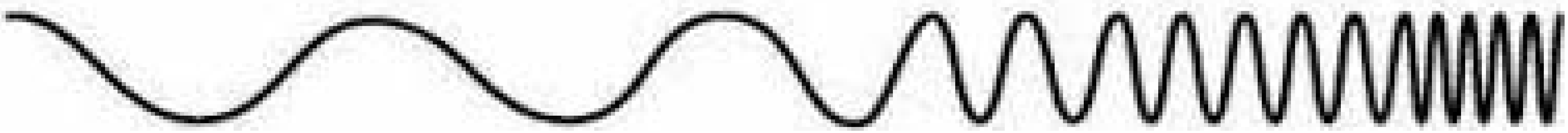
Detector – A device which measure the presence of a wave or a substance.

All em waves are transverse waves and they all travel at the same speed through a vacuum (in space).

EM Spectrum

Highest wavelength

Smallest wavelength



Smallest frequency

Highest frequency

Generation of Electromagnetic (Em) Waves

Changes in atoms or their nuclei can generate electromagnetic waves at different frequencies.

Gamma rays are caused by changes in the nucleus of an atom.

Producing Radio Waves (HT only)

1. Radio waves are produced by vibrating long wires in a circuit.
2. When the radio waves reach a receiver, the energy from the wave is absorbed.
3. This causes electrons in the wire to vibrate back and forth producing an alternating current.
4. The frequency of the current is the same as the original radio wave.

Uses of em waves

EM Wave	Uses
Radio	Radio and television
Microwave	Cooking food and satellite communication
Infrared	Electrical heaters, cooking food and infra-red cameras, controllers
Visible light	Lighting and fibre optic communication
Ultraviolet	Energy efficient lamps and sun tanning, detect forgery
X-rays	X-rays in medical imaging
Gamma rays	Food sterilisation and medical imaging

Dangers of em waves

UV, x-rays and gamma rays are ionising radiation due to their high frequency. Exposure to them can increase your risk of these effects.

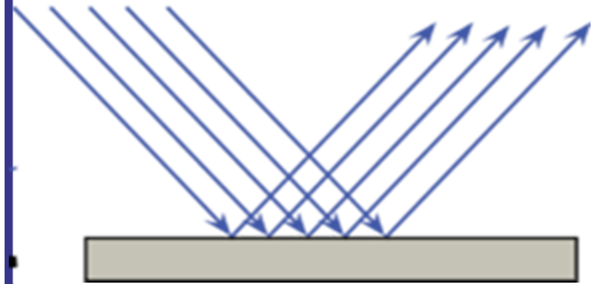
Electromagnetic wave	Dangers
Ultraviolet	Premature aging and skin cancer
X-rays	Mutations of genes in cell and cancer
Gamma rays	Mutations of genes in cell and cancer

Radiation dose is the measure of the risk of harm resulting from an exposure of the body to radiation.

Visible Light

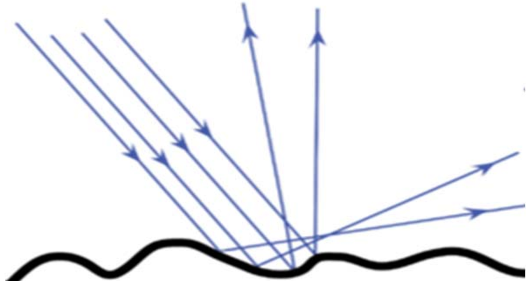
Types of reflection

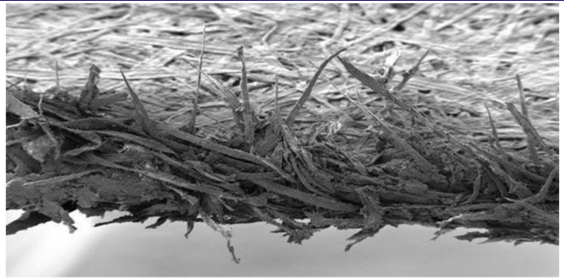
Specular Reflection



Smooth surfaces reflect light in the same direction.

Diffuse Reflection





Rough surfaces reflect light in different directions.

Interactions with light

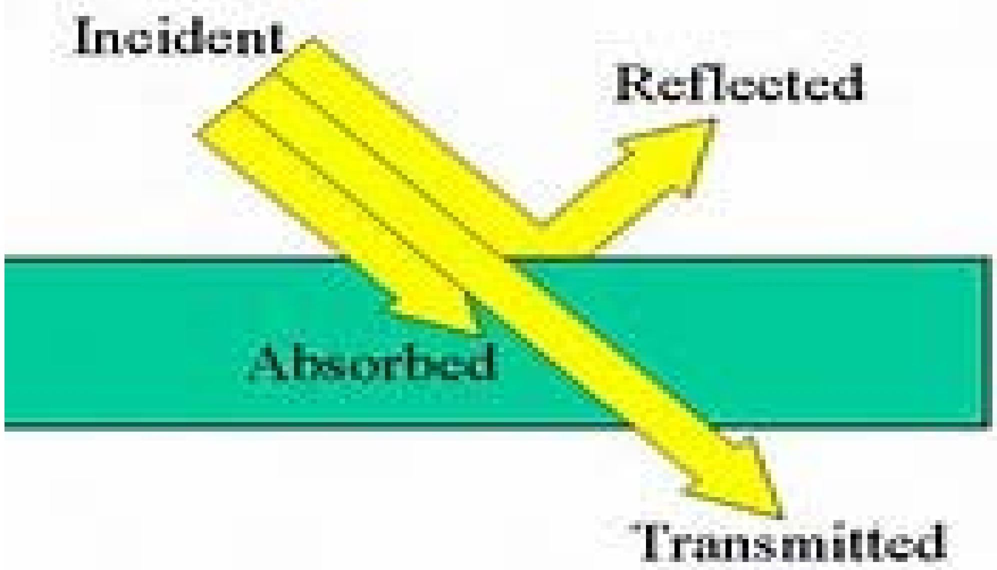
When light is incident on (hits) an object,

3 different effects can happen:

1) Absorption

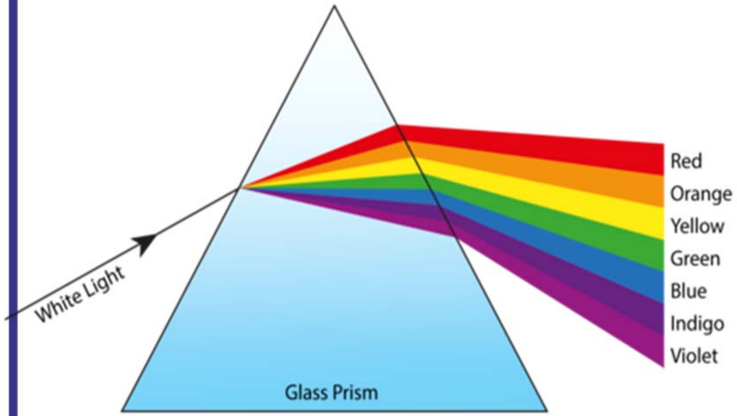
2) Reflection

3) Transmission



Visible Light

White Light



White light consists of all the colours of the visible spectrum. Each colour of light has its own unique wavelength.

Opaque, translucent and transparent objects

Opaque

No visible light transmitted

It reflects its own colour is reflected.

All other wavelengths absorbed.

Translucent

Transmit some wavelengths of visible light and reflect others.

Transparent

Transmit all wavelengths of visible light.

Coloured objects

Coloured objects reflect their own colour of visible light and absorb all other colours.

Examples

Red objects reflect red light and absorb all other colours.

White objects reflect all wavelengths of visible light.

Black objects absorb all wavelengths of the visible light.

If a coloured object is under a light of a different colour, it is unable to reflect the light. It will absorb the light and appear black.

Examples

Red objects appear black under blue light

Blue objects appear black under red light

White objects appear red under red light.

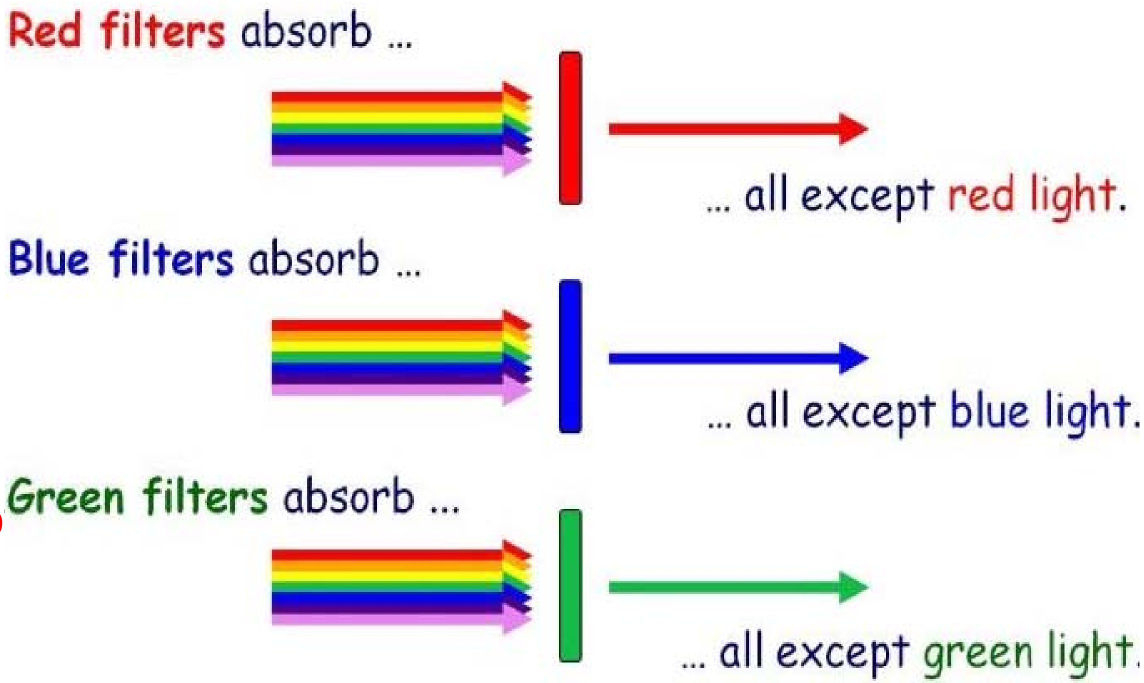
Black objects appear black under green light.

Visible Light

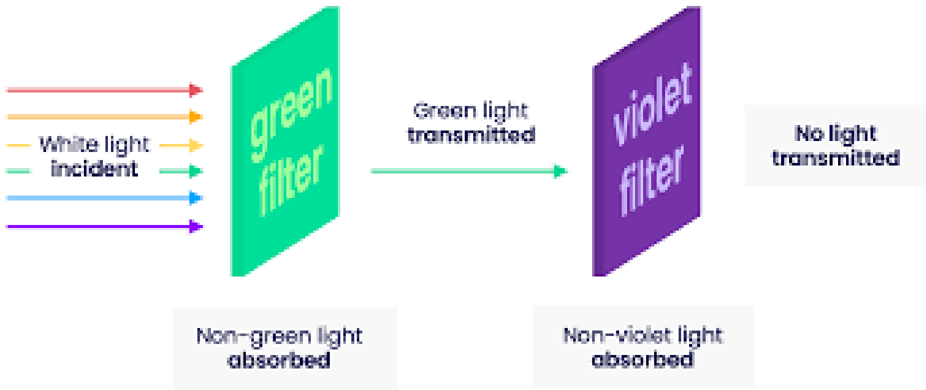
Coloured Filters

Coloured filters transmit their own colour of visible light travelling through them and absorb all others.

Example
Red light is transmitted from a red filter and absorbs all other wavelengths (colours) of light.
Blue light is transmitted from a blue filter and absorbs all other wavelengths (colours) of light.
Green light is transmitted from a green filter and absorbs all other wavelengths (colours) o light.



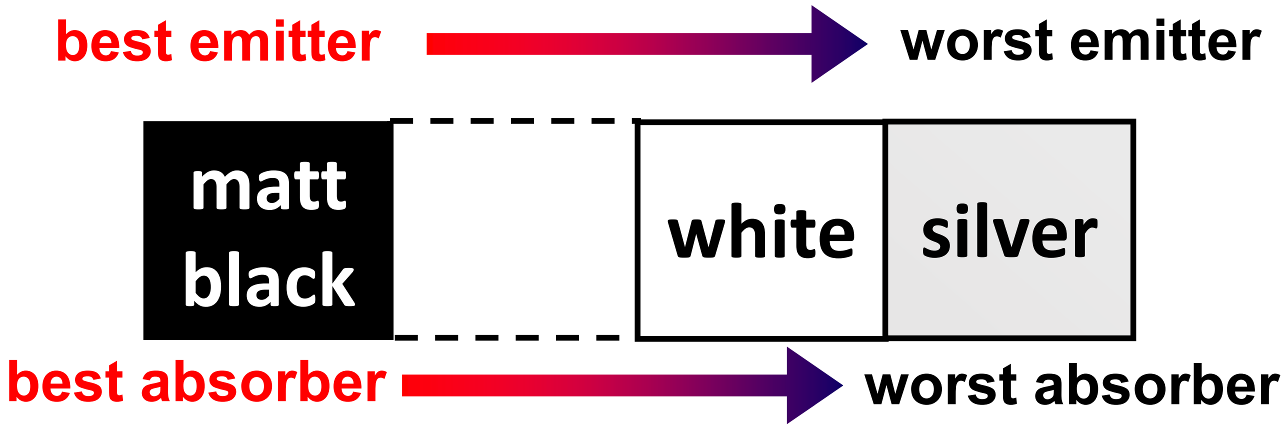
Light cannot travel through filters of two different colours. This is because it is transmitted through the first filter but then will be blocked by the second filter.



Infrared Radiation

Black surfaces are the best absorbers and emitters of infrared radiation.

Silver (shiny) surfaces are the worst absorbers and emitters of infrared radiation.



Infrared Practical Setup and results

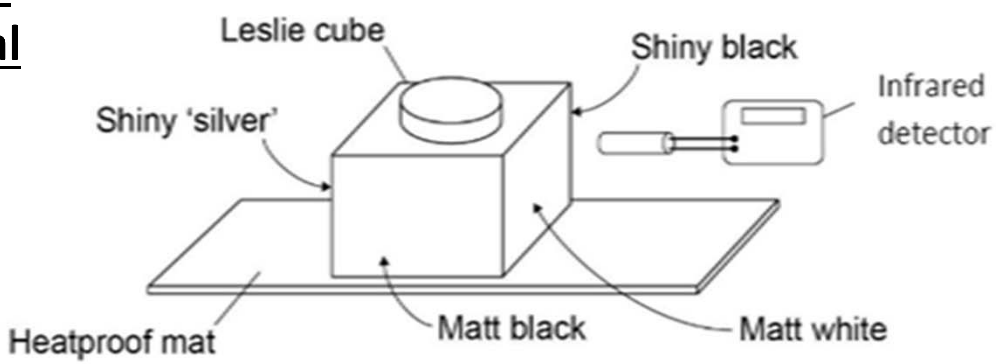


Figure 1: Practical Setup

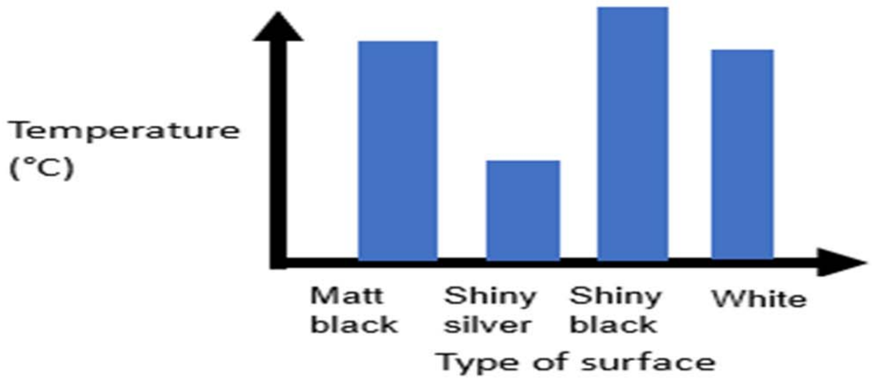


Figure 2: Experimental results

Infrared Practical Method

Method

1) Place the Leslie cube on to a heat proof mat.
2) Fill the cube with very hot water and replace the lid of the cube.
3) Mark a distance of 5cm using a ruler from each surface where measurements will be taken.
4) Use an infrared detector to measure the temperature of each surface.
5) Draw a bar chart to show the temperature of the surface against the type of surface.

The black surface should show the most infrared radiated and the shiny silver surface should show the least.

Infrared Radiation (Triple only)

1) All objects can emit and absorb infrared radiation.
2) The higher an object's temperature, the more infrared radiation it emits.
3) Objects at a constant temperature absorb and emit infrared radiation at the same rate.
4) The more infrared radiation an object absorbs, the greater its temperature and the more infra radiation it emits.

Topic Key Terms

Oscillations
Perpendicular
Parallel
Transverse
Longitudinal
Energy
Transfer
Amplitude
Wavelength
Time period
Frequency
Wave speed
Vibration

Incident ray
Reflected ray
Angle of incidence
Angle of reflection
Normal
Refracted ray
Angle of refraction
Optical dense

Electrons
Premature aging
Skin cancer
Mutations
Cancer

Transmission
Absorption
Reflection
Opaque
Translucent
Transparent
Filter

Required practicals equipment

Measuring speed of waves in liquids

Ripple Tank
Stopwatch
30cm ruler

Measuring speed of waves in liquids

Ripple Tank
Stopwatch
30cm ruler

Infrared Radiation

Leslie cube
Kettle
Ruler
Infrared detector
Heatproof mat