Edexcel Physics IGCSE

Topic 3: Waves

Summary Notes

(Content in **bold** is for physics only)

General wave properties

Waves **transfer energy and information without transferring matter;** the particles oscillate about a fixed point.

- **Transverse** waves
  - Have **peaks** and **troughs**
  - Vibrations are at **right angles** to the direction of travel
  - An example is light
- **Longitudinal** waves
  - Consists of compressions (particles pushed together) and rarefactions (particles moved apart)
  - Vibrations are in the **same direction** as the direction of travel
  - An example is sound

Amplitude – the **distance** from the **equilibrium** position to the **maximum displacement**
Wavefront – a line joining points on a wave at the same point in their wave cycle at a given time
Frequency – the **number of waves** that pass a single point **per second**
Wavelength – the **distance** between a **point** on one wave and the **same point** on the next wave
Time period – the **time taken** for **one complete wave** to pass a fixed point

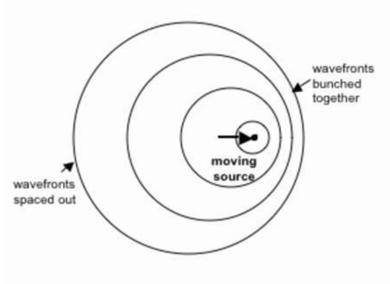
The **speed** of a wave is equal to the product of the frequency and wavelength:

- $speed = frequency \times wavelength \qquad v = f\lambda$

The frequency of a wave is equal to the reciprocal of the time period, measured in **Hertz (Hz):**

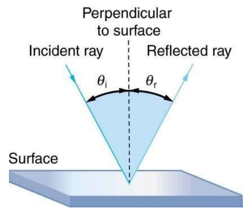
- $frequency = \frac{1}{time\ period} \qquad f = \frac{1}{T}$

The Doppler Effect:



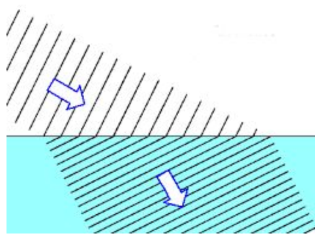
If a wave source is moving relative to an observer, there will be a change in the observed frequency and wavelength due to the Doppler effect. This is because the wavefronts either get bunched together or spaced apart. An example of this is when the siren of an ambulance is high-pitched as it approaches you, and low-pitched as it goes away.

Reflection:



- *All* waves can be **reflected** when they travel from a medium of low **optical density** (such as air) to one of much higher optical density (such as glass)
- The law of reflection states that:
  - Angle of incidence = angle of reflection
- Frequency, wavelength, and speed are all **unchanged**

Refraction:

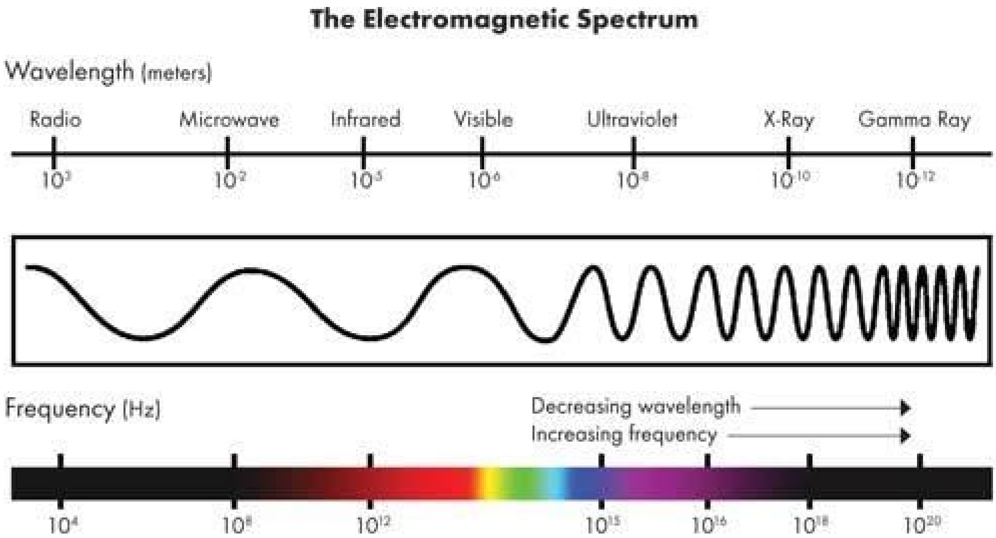


- All waves can be refracted, which is when the **speed** of a wave **changes** when it enters a new medium
- If the wave enters a **denser** medium, its speed **decreases** and it bends **towards** the normal
- If the wave enters a **less dense** medium, its speed **increases** and it bends **away from** the normal

- In all cases, the **frequency** stays the **same** but the **wavelength changes.** As a result, the velocity must change.

Electromagnetic spectrum

You need to learn the **main groups** of the electromagnetic spectrum in order of **decreasing wavelength** and **increasing frequency** including the **colours** of the visible spectrum (ROYGBIV).



All electromagnetic waves travel with the **same high speed** in a vacuum and **approximately the same** speed in air.

Uses of electromagnetic waves:

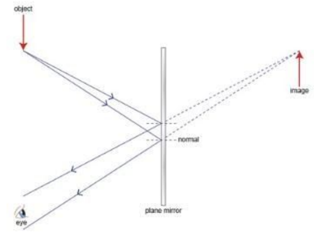
- **Radio waves** are used for **radio and television communications.** They have a long wavelength and are reflected by a layer of the atmosphere called the **ionosphere**.
- **Microwaves** are used for **satellite transmissions** and in **cooking.** As they have a greater frequency (shorter wavelength) they are more penetrating so can pass through the ionosphere and penetrate deep into food.
- **Infrared radiation** is used in **heaters** and **night vision equipment.**
- **Visible light** is used in **fibre optics** and **photography.**
- **Ultraviolet** light is used in **fluorescent lamps.**
- **X-rays** are used in **medical imaging** and in **security** as (because they have a very short wavelength and high frequency) they can penetrate material easily.
- **Gamma radiation** is used in **sterilising food and medical equipment** due to its high energy.

Hazards:

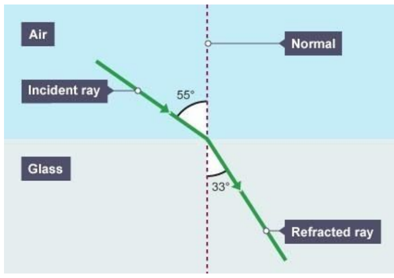
- Microwaves can cause **internal heating** of body tissues.
- Infrared radiation can cause **skin burns.**
- Ultraviolet light exposure increases the risk of **skin cancer** and **blindness.**
  - **Sun cream** and **sun glasses** prevent over-exposure in summer.
- X-rays and Gamma rays are **ionising** radiation that can cause **mutations** leading to **cancer.**
  - **Exposure** to these kinds of radiation should be **minimised** (for example, by using protective shielding made of very dense materials such as lead).

Light and sound

Light waves are **transverse** waves and can be **reflected** and **refracted.**



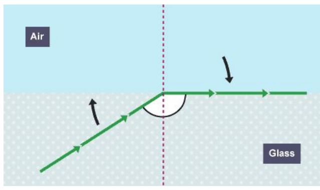
- **Reflection** of light can be shown when light reflects at a plane mirror and forms an image.
  - This can be represented by a **ray diagram** like the first one shown on the right.
- **Refraction** of light can be shown when light is passed through a glass slab at an angle to its normal.
  - When light enters a more optically dense medium, the **angle of incidence** (the angle between the incident ray and the normal) is **greater** than the **angle of refraction** (the angle between the refracted ray and the normal). This can be represented by a ray diagram like the second one shown on the right.
  - The **opposite** is true when light enters a less optically dense medium.

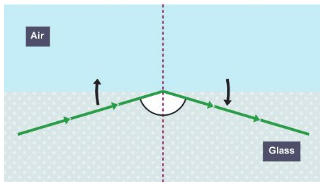


Snell's law relates the angle of incidence and the angle of refraction to the refractive index of a medium by $n1 sin i = n2 sin r$ where n is the optical density & i is the angle of incidence and r is the angle of refraction.

Total internal reflection:

- At a certain angle of incidence called the **critical angle**, the light will travel along the boundary between the two media.
- **Total internal reflection** occurs when the angle of incidence is **greater** than the critical angle and the light **reflects** back into the medium.
- For total internal reflection to occur, the light must also be travelling from a **more optically dense medium** into a **less optically dense medium** (most common example is glass to air).
- The critical angle c can be related to the refractive index by:

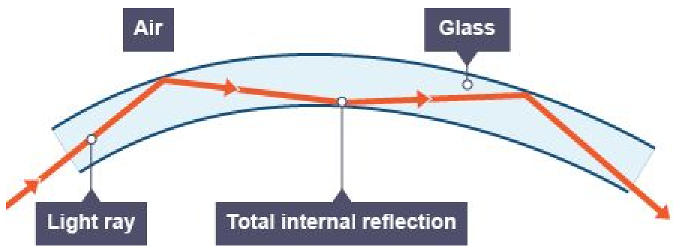




$$n = \frac{1}{\sin sin\ c}$$

Optical fibres:

- An **optical fibre** is a long thin rod of **glass** surrounded by cladding which uses total internal reflection to transfer information by light, even when bent.



- They are used extensively in **medicine** (endoscopes, inside-body flexible cameras) and **communications** (high speed data transfer).

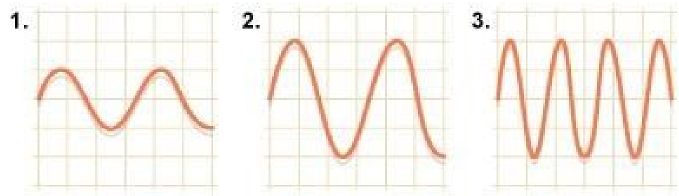
Sound waves are **longitudinal** waves and can be **reflected** and **refracted.**

The range of audible frequencies for a healthy human ear is 20 Hz to 20000 Hz.

To measure the speed of sound in air, you can make a noise at a known, large distance from a solid wall and record the time for the echo (reflected sound) to be heard, then use speed = distance/time, where distance is 2 x length - taking into account the fact that the sound had to go there and back.

An oscilloscope connected to a microphone can be used to display a sound wave and find its frequency and amplitude.

- **The greater the amplitude of a sound wave, the louder it is.**
- **The greater the frequency of a sound wave, the higher its pitch.**



- **The first sound wave shown is quiet and low pitched.**
- **The second sound wave shown is loud and low pitched.**
- **The third sound wave shown is loud and high pitched.**