WJEC (Wales) Physics GCSE

1.6: The Total Internal Reflection of Waves

Detailed Notes

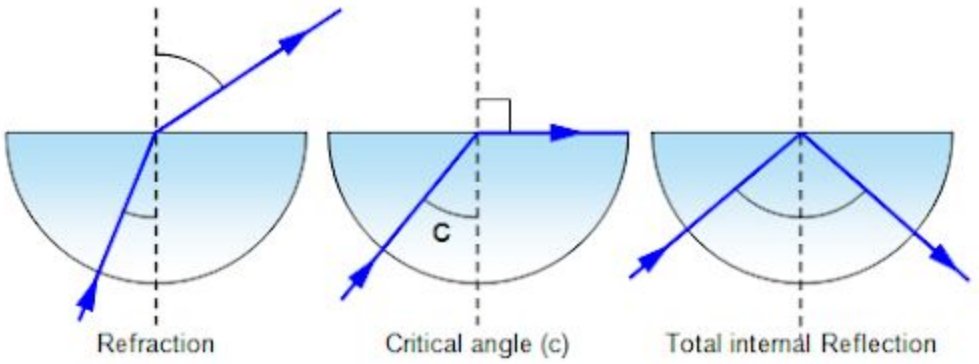
(Content in **bold** is for higher tier **only**)

Total Internal Reflection

When light crosses into a **less dense** medium, it **speeds up** and its wavelength **increases**. The ray of light appears to **bend away** from the normal. This is refraction.

As the angle of incidence of the ray is increased, the **angle of refraction** also **increases** until it reaches a **critical angle** (c). At this point, the ray will be refracted at **90º**, travelling along the medium boundary. The value of the critical angle is different for different materials but the critical angle of **glass to air is ~42º**.

If the angle of incidence increases further so that it **exceeds** the critical angle, the ray will not be refracted and will instead undergo **total internal reflection.**

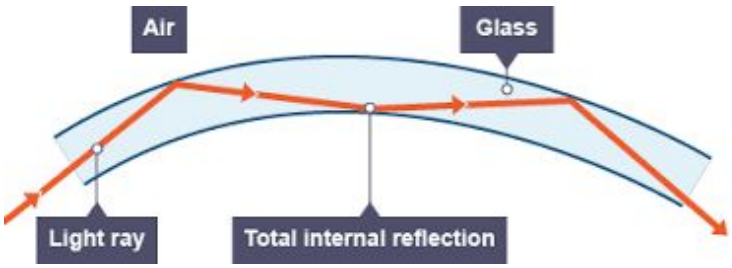


Refraction and total internal reflection (getrevising.co.uk).

Therefore for total internal reflection to occur, the ray must be traveling from a **more to a less dense** medium and the angle of incidence must **exceed the** relevant **critical angle** for optic media boundary under study. For example, for a ray of light to be totally internally reflected at a glass-air boundary, glass must be denser than air and the incident angle must be >42º.

Optical Fibres

Optical fibres are **thin glass cables** used in communications. Their operation relies on total internal reflection. Each optical fibre is a thin strand of very **high-grade glass** that transfers **light or infrared** signals via total internal reflection. Therefore the signal moves down the fibre until it reaches the other end.



Transmission of signals using optical fibres (bbc.co.uk).

These fibres are so thin, they can **bend** and still operate. Multiple fibres can be bundled together and wrapped in insulation to enhance signal transmission and reduce the amount of light lost through small levels of refraction.

Long Distance Communication

Optical fibres can be used in long distance communication systems instead of satellites. Each method of communication has pros and cons for transmitting signals over greater distances.

Optical Fibres

- Pros
  - Signals **aren't interrupted** by atmospheric interference (eg. storms).
  - Communication is considered to be **safer** as it is more difficult to tap into or intercept the signals.
- Cons
  - Require **point-to-point** connection between the transmitter and receiver.

Satellites

- Pros
  - Microwaves **travel faster** in air than infrared or light signals do, in glass.
- Cons
  - More **difficult to protect** from interference and interception.
  - **Signal strength** can be severely limited by the orbit of the satellite.
  - Building and launching satellites is **very expensive**.

Medical Uses of Optical Fibres

The relatively small size of optical fibres means they can be very useful for **remote imaging**, especially in medicine as they can be used to **image inside the body** without being too invasive.

Endoscopes

These are **small bundles** of optical fibres that form a camera for inside the body. **Reflected light** from organs or tissues is transmitted back along the fibres to a computer where the doctor can view a **live image** of inside the body. Recently this has allowed for great medical advancements in cancer diagnosis and **keyhole surgery**.

The images produced can be **unclear** and take a lot of experience to learn how to interpret. However as technology advances, imaging is becoming clearer and as a result such procedures are becoming easier to carry out.

CT Scans

These are another method of imaging inside the body however they use multiple **X-rays** to build up a **2D image**. Multiple 2D scans can be built up into **3D models** of internal organs.

CT scans give a **very detailed** insight into the body's internal structure, however they tend not to be as useful for more specific areas. They use **strongly ionising X-Rays** which after excessive exposure could **damage cells** and even increase likelihood of developing **cancer**. These risks have to be considered. If such a CT scan is to be carried out on a patient, the benefits of taking the scan must outweigh the risks.