GCE Physics Unit 2.6 Refraction of Light

Refractive index:

When waves travel from one medium to another its speed changes. The speed in one medium compared to the speed in a vacuum can be calculated using the **refractive index, n**.

$$n = \frac{c}{v}$$

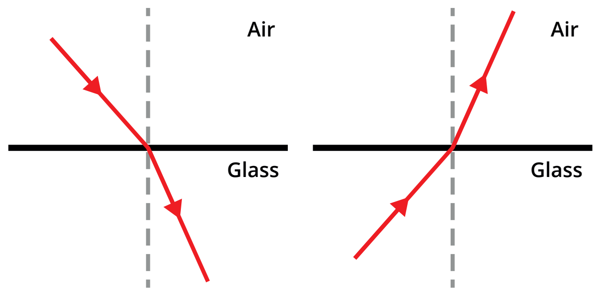
As c, is constant we can compare one medium with another to calculate the speed when light travels across a boundary.

$$n_1 v_1 = n_2 v_2$$

Remember, the refractive index of the initial medium n_1 and the n_2 is the medium it travels into.

Snell's law:

If the wave hits the boundary at an angle, this change in speed will cause a change in direction of the wave.

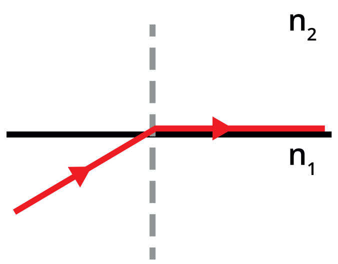


The angle of refraction can be calculated using **Snell's law**;

$$n_1 sin\theta_1 = n_2 sin\theta_2$$

Critical angle:

When light travels **towards a medium with a lower refractive index** the ray bends away from the normal.



If the angle of incidence is increased to the point that the ray bends along the boundary, **angle of refraction = 90°**, it is known as the critical angle.

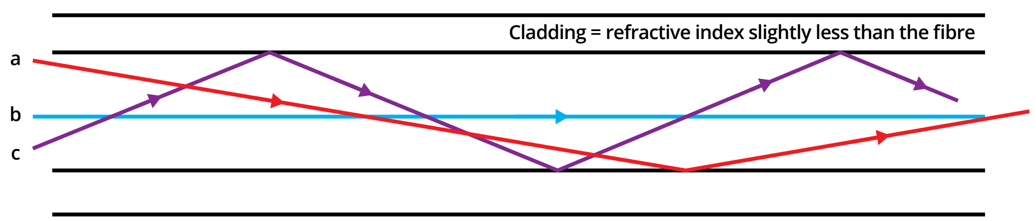
It can be calculated using this equation;

$$n_1 sin\theta_C = n_2$$

Optical fibre:

If light hits a boundary at larger than the critical angle, total internal reflection will occur. This is used to send signals through optical fibres.

Total internal reflection will only occur if the **angle of incidence is larger than the critical angle** and if the ray travels **towards a material with a lower refractive index**. This means that the cladding must have a lower refractive index than the core.

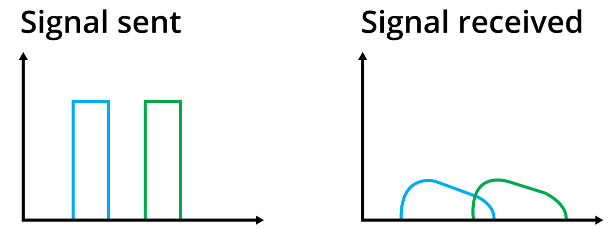


Both ray a and c hit the boundary at an angle larger than the critical angle therefore will reflect. This ensures that the signal will travel along the fibre to be received at the end.

Multimode dispersal:

As the rays a, b and c in the optical fibre diagram travel through the fibre at **different angles**, they will travel **different distances** through the fibre. Ray b will have the shortest distance to travel in a straight line, ray c has the longest distance to travel. This means the **time they take to travel will also be different**.

As signals are sent as coded pulses, this will cause a problem if there is too much of a range of distances within a fibre. **A pulse will become spread** and, if the pulses are too close, they will **overlap**, making the signal unclear.



This can be avoided by using **monomode fibres**, which have very thin cores, which ensures that there are **no zig-zag paths** and therefore no variation in time to travel through the fibre.

n = refractive index

v = speed of light in the medium in ms^{-1}

c = speed of light in a vacuum in ms^{-1}

θ_C = critical angle