

Refraction

Refractive Index

The refractive index of a material is a measure of how easy it is for light to travel through it. The refractive index of material s can be calculated using:

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

where n is the refractive index, c is the speed of light in a vacuum and c_s is the speed of light in material s .

Refractive Index, n , has no units

If light can travel at c in material x then the refractive index is: $n = \frac{c}{c_x} \rightarrow n = \frac{c}{c} \rightarrow n = 1$

If light can travel at $c/2$ in material y then the refractive index is: $n = \frac{c}{c_y} \rightarrow n = \frac{c}{c/2} \rightarrow n = 2$

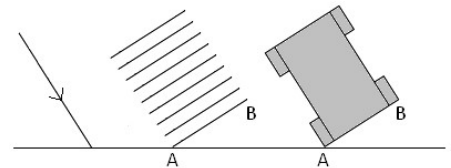
The higher the refractive index the slower light can travel through it
The higher the refractive index the denser the material

Explaining refraction

When light passes from one material to another it is not only the speed of the light that changes, the direction can change too.

If the ray of light is incident at 90° to the material then there is no change in direction, only speed.

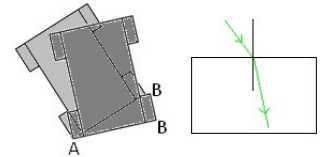
It may help to imagine the wavefront of the light waves as the front of a car to determine the direction the light will bend. Imagine a lower refractive index as grass and a higher refractive index as mud.



• Entering a Denser Material

The car travels on grass until tyre A reaches the mud. It is harder to move through mud so A slows down but B can keep moving at the same speed as before. The car now points in a new direction.

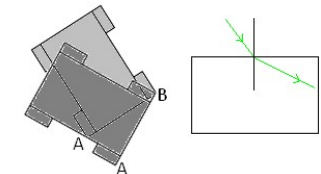
Denser material – higher refractive index – bends towards the Normal



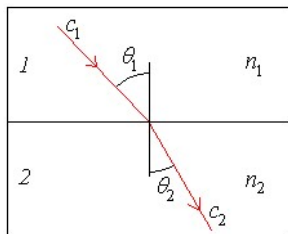
• Entering a Less Dense Material

The car travels in mud until tyre A reaches the grass. It is easier to move across grass so A can speed up, but B keeps moving at the same speed as before. The car now points in a new direction.

Less dense material – lower refractive index – bends away from the Normal



Relative Refractive Index



Whenever two materials touch the boundary between them will have a refractive index dependent on the refractive indices of the two materials. We call this the relative refractive index.

When light travels from material 1 to material 2 we can calculate the relative refractive index of the boundary using any of the following:

$${}_1n_2 = \frac{n_2}{n_1} = \frac{c_1}{c_2} = \frac{\sin \theta_1}{\sin \theta_2}$$

Relative Refractive Index, ${}_1n_2$, has no units

Some questions may involve light travelling through several layers of materials. Tackle one boundary at a time.

$${}_wn_g = \frac{n_g}{n_w} = \frac{c_w}{c_g} = \frac{\sin \theta_w}{\sin \theta_g}$$

$${}_gn_a = \frac{n_a}{n_g} = \frac{c_g}{c_a} = \frac{\sin \theta_g}{\sin \theta_a}$$

