REFRACTIVE INDEX – VELOCITY OF LIGHT IN DIFFERENT MEDIA

The light changes its speed as it passes from one medium to another medium. This is called Refraction.
The frequency of light does not changes when it refracts.
The speed of light in any medium is less than the speed of light in vacuum.
If speed of light in a medium is "v" and speed of light in vacuum is "c", then v < c.
Thomas Young was the first scientist , who used "index of refraction", in 1807.
It is denoted by 'm' , 'n' , 'η' or 'μ' by different scientists.
As refractive index is a number, many of scientists used the symbol 'n' to denote Refractive Index.

Refractive Index of a medium : The ratio of speed of light in vacuum to the speed of light in certain medium is defined as Refractive Index of that medium. This is denoted by 'n'. This is also called as Absolute Refractive Index.

Absolute Refractive Index (n) = $\frac{Speed\ of\ light\ in\ vacuum}{Speed\ of\ light\ in\ medium} = \frac{c}{v}$

* Refractive index is the measurement of the medium that how hard is it for light to travel through that medium.
* Refractive Index gives us an idea that how fast or how slow the light travels in a medium.
* If Refractive index of a medium is high, the speed of light in that medium is low.
* If Refractive index of a medium is low, the speed of light in that medium is more.
* Refractive index depends upon the following factors.
  (i) Nature of the medium or material (ii) Wave length of the light used
* Refractive index has no units. Because it is a ratio of same physical quantities.

Optically denser medium : The material which is having more refractive index is called denser medium. And the material which has less refractive index is called rarer medium.

For example: Kerosene has less density than water as per mass of the substances.
Density of Kerosene = 0.81 gm/cm^3
Density of Water = 1 gm/cm^3
But Kerosene refractive index = 1.44
Water refractive index = 1.33
So Kerosene is Optically denser medium than Water. Water is rarer medium than Kerosene.

Speed of light in vacuum (c) = 3 x 10^8 m/s = 3 x 10^5 Km/s (exactly 2.99792458 x 10^8 m/s.)
Speed of light in Air = 2.997 x 10^8 m/s

Refractive Index of Air = $\frac{Speed\ of\ light\ in\ vacuum}{Speed\ of\ light\ in\ Air} = \frac{c}{v} = \frac{2.99792458\ X\ 10^8}{2.997\ X\ 10^8} = \frac{2.99792458}{2.997}$ = 1.003085 ~ 1.0003

Example-1: If the speed of light in a diamond is 1,24,000 Km/s. Find the Refractive index of diamond.

Solution: Speed of light in vacuum (c) = 3,00,000 Km/s
Speed of light in Diamond (v) = 1,24,000 Km/s

Refractive index of diamond = $\frac{Speed\ of\ light\ in\ vacuum}{Speed\ of\ light\ in\ Diamond} = \frac{c}{v} = \frac{3\ 00\ 000}{1\ 24\ 000} = \frac{300}{124}$ = 2.419 = 2.42 (approximately)

Example-1: The Refractive index of a glass material is $\frac{3}{2}$. Find the speed of light through that glass material.

Solution: Speed of light in vacuum (c) = 3 x 10^8 Km/s
Speed of light in Glass material (v) = ?

Refractive index of glass material (n) = $\frac{3}{2}$

Refractive index of Glass material = $\frac{Speed\ of\ light\ in\ vacuum}{Speed\ of\ light\ in\ glass\ material}$

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

$\frac{3}{2} = \frac{3\ X\ 10^8}{v}$ ➔ v = 2 x 10^8 m/s

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REFRACTIVE INDICES OF SOME MATERIAL MEDIA

Material Medium	Refractive Index	Speed of light in that medium
Air	1.0003	$V = \frac{c}{n} = \frac{3\ X\ 10^8}{1.0003} = 2.99 \times 10^8$ m/s
Ice	1.31	$V = \frac{c}{n} = \frac{3\ X\ 10^8}{1.31} = 2.29 \times 10^8$ m/s
Water	1.33	$V = \frac{c}{n} = \frac{3\ X\ 10^8}{1.33} = 2.26 \times 10^8$ m/s
Kerosene	1.44	$V = \frac{c}{n} = \frac{3\ X\ 10^8}{1.44} = 2.08 \times 10^8$ m/s
Fused quartz	1.46	$V = \frac{c}{n} = \frac{3\ X\ 10^8}{1.46} = 2.05 \times 10^8$ m/s
Turpentine Oil	1.47	$V = \frac{c}{n} = \frac{3\ X\ 10^8}{1.47} = 2.04 \times 10^8$ m/s
Crown Glass	1.52	$V = \frac{c}{n} = \frac{3\ X\ 10^8}{1.52} = 1.97 \times 10^8$ m/s
Benzene	1.50	$V = \frac{c}{n} = \frac{3\ X\ 10^8}{1.50} = 2.00 \times 10^8$ m/s
Canada balsam	1.53	$V = \frac{c}{n} = \frac{3\ X\ 10^8}{1.53} = 1.96 \times 10^8$ m/s
Rock salt	1.54	$V = \frac{c}{n} = \frac{3\ X\ 10^8}{1.54} = 1.95 \times 10^8$ m/s
Carbon Disulphide	1.63	$V = \frac{c}{n} = \frac{3\ X\ 10^8}{1.63} = 1.84 \times 10^8$ m/s
Dense flint Glass	1.65	$V = \frac{c}{n} = \frac{3\ X\ 10^8}{1.65} = 1.82 \times 10^8$ m/s
Ruby	1.71	$V = \frac{c}{n} = \frac{3\ X\ 10^8}{1.71} = 1.75 \times 10^8$ m/s
Sapphire	1.77	$V = \frac{c}{n} = \frac{3\ X\ 10^8}{1.77} = 1.69 \times 10^8$ m/s
Diamond	2.42	$V = \frac{c}{n} = \frac{3\ X\ 10^8}{2.42} = 1.24 \times 10^8$ m/s
Coconut Oil	1.445	$V = \frac{c}{n} = \frac{3\ X\ 10^8}{1.445} = 2.08 \times 10^8$ m/s
Palm Oil	1.455	$V = \frac{c}{n} = \frac{3\ X\ 10^8}{1.455} = 2.06 \times 10^8$ m/s
Olive Oil	1.458	$V = \frac{c}{n} = \frac{3\ X\ 10^8}{1.458} = 2.06 \times 10^8$ m/s
Hydrogen Gas	1.00032	$V = \frac{c}{n} = \frac{3\ X\ 10^8}{1.00032} = 2.99 \times 10^8$ m/s
Carbon Dioxide	1.00045	$V = \frac{c}{n} = \frac{3\ X\ 10^8}{1.00045} = 2.99 \times 10^8$ m/s

Relative Refractive Index : The ratio of speed of light in the first medium to the speed of light in the second medium is known as relative refractive index of second medium with respect to the first medium. It is denoted by n_{21}.

The speed of light in first medium = v_1 The speed of light in second medium = v_2

$$n_{21} = \frac{Speed\ of\ light\ in\ first\ medium}{Speed\ of\ light\ in\ second\ medium} = \frac{v_1}{v_2}$$

But $v = \frac{c}{n} \rightarrow v_1 = \frac{c}{n_1}$ and $v_2 = \frac{c}{n_2}$ $\therefore$ $n_{21} = \frac{\left(\frac{c}{n_1}\right)}{\left(\frac{c}{n_2}\right)} = \frac{\left(\frac{1}{n_1}\right)}{\left(\frac{1}{n_2}\right)} = \frac{n_2}{n_1} \rightarrow n_{21} = \frac{n_2}{n_1}$

Relative refractive index of second medium with respect to first medium = $\frac{Refractive\ index\ of\ second\ medium}{Refractive\ index\ of\ first\ medium}$

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