Name: Key

Notes - 25.3-25.4 Refraction and Total Internal Reflection

1. The changing of a light ray's direction (loosely called bending) when it passes through variations in matter is called refraction.

2. In Einstein's theory of relativity, the speed of light c was found not to depend on the velocity of the source or the observer.

3. The speed of light is so important that its value in a vacuum is one of the most fundamental constants in nature. However, the speed of light does vary in a precise manner with the material it passes through.

4. The first real evidence that light traveled at a finite speed came from the Danish astronomer Ole Roemer in the late 17th century. Roemer had noted that the average orbital period of one of Jupiter's moons, as measured from Earth, varied depending on whether Earth was closer to or farther from Jupiter as they orbited the Sun. He correctly concluded that the apparent change in period was due to the change in distance between Earth and Jupiter and the time it took light to travel this distance.

5. $c = 2.997\,924\,58 \times 10^8 \frac{m}{s} \approx 3.00 \times 10^8 \frac{m}{s}$

6. The speed of light through matter is less than it is in a vacuum, because light interacts with the atoms in a material. The speed of light depends strongly on the type of material, since its interaction with different atoms, crystal lattices, and other substructures varies. The speed of light through a material is equal to:

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

where n = index of refraction. Since the speed of light is always less than c in matter and equals c only in a vacuum, the index of refraction is always greater than or equal to one.

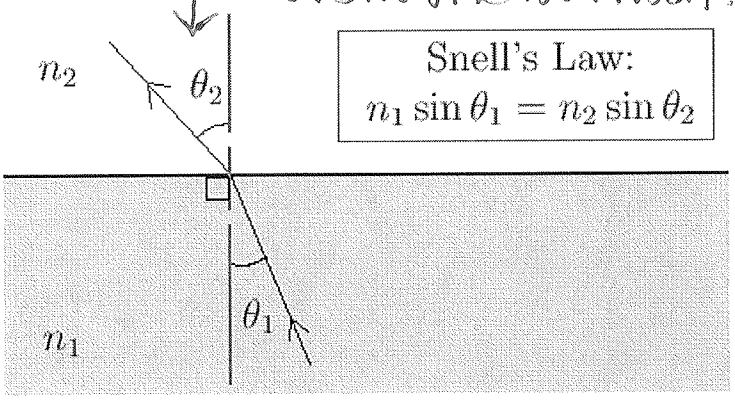
Table 25.1 Index of Refraction in Various Media

Medium	n
Gases at 0°C, 1 atm	
Air	1.000293
Carbon dioxide	1.00045
Hydrogen	1.000139
Oxygen	1.000271
Liquids at 20°C	
Benzene	1.501
Carbon disulfide	1.628
Carbon tetrachloride	1.461
Ethanol	1.361
Glycerine	1.473
Water, fresh	1.333
Solids at 20°C	
Diamond	2.419
Fluorite	1.434
Glass, crown	1.52
Glass, flint	1.66
Ice at 20°C	1.309
Polystyrene	1.49
Plexiglas	1.51
Quartz, crystalline	1.544
Quartz, fused	1.458
Sodium chloride	1.544
Zircon	1.923

7. The change in direction of a light ray depends on how the speed of light changes when it crosses from one medium to another. No change in the speed of light means no bending.

8. Snell's Law:

angles are always measured from the normal.



Snell's Law:
$n_1 \sin\theta_1 = n_2 \sin\theta_2$

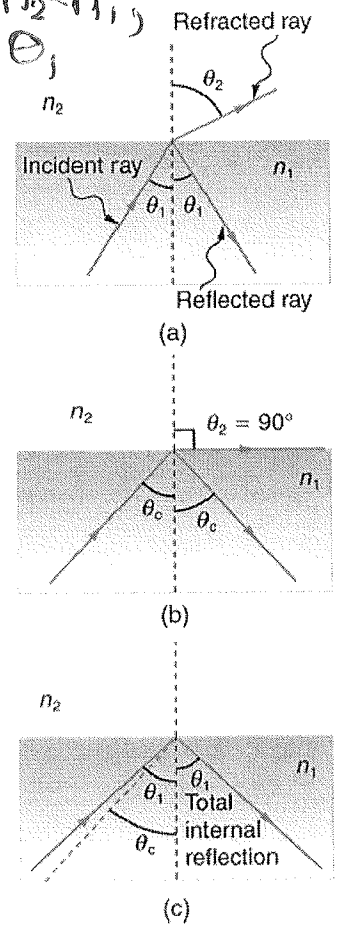
9. Total Internal Reflection

A. When the second medium has an index of refraction less than the first, you can get total internal reflection where all of the light is reflected back into the medium.

When $n_2 < n_1$, $\theta_2 > \theta_1$

critical angle

B. $\theta_C = \sin^{-1}\left(\frac{n_2}{n_1}\right)$



C. Examples:

i. fiber optics

ii. looking from under water

iii. mirages on a hot highway