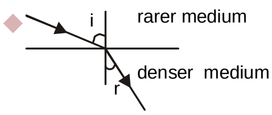
Refraction

1. When a light ray travels from one medium to another, it suffers a change of direction at the surface of separation of the two media. This is known as **refraction**.

2. **Laws of refraction**

i. The incident ray, the refracted ray and the normal at the point of incidence on the surface of separation of the two media, all lie in one plane.



ii. For the same pair of media and for the same colour of light, the ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant. This is known as **Snell's law**. $\mu = \frac{\sin i}{\sin r}$.

If the first medium is vacuum, then it is called absolute refractive index.

3. When a ray is incident normally i = 0, r = 0 and hence there is no deviation.

4. When a ray of light travels from a rarer medium into a denser medium, its velocity decreases, wavelength decreases and its frequency remains unaltered.

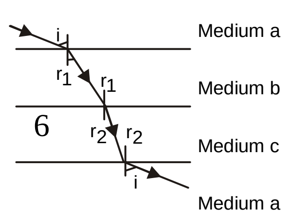
5. Refractive index is dependent on the colour of light. It is minimum for red and maximum for violet.

6. Refractive index "❍" varies with wave length ● as ❍ = $A + \frac{B}{\lambda^2}$. This relation is known as Cauchy's relation.

7. **Principle of reversibility of light**: If the path of a light ray, after going through a number of reflections and refractions is reversed, it always retraces its path in the opposite direction.

8. As the temperature of a medium increases, its refractive index decreases.

$${}_a\mu_b = \frac{\mu_b}{\mu_a} = \frac{1}{{}_b\mu_a}$$



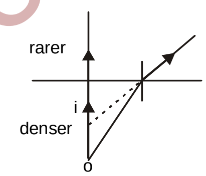
$_a\mu_b \cdot {_b\mu_c} \cdot {_c\mu_a} = 1$

9. When a ray is passing from one medium (μ_1) into another medium (μ_2), then $\mu_1 \sin i = \mu_2 \sin r$.

10. $\mu = \frac{V_o}{V}$ Where V_o = velocity of light in vacuum and V = velocity of light in the medium.

$_1\mu_2 = \frac{V_1}{V_2}$ Where V_1 = velocity of light in medium 1 & V_2 =velocity of light in medium 2.

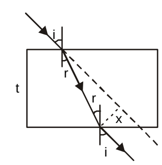
11. When light is traveling from rarer medium to denser medium it bends towards normal. When light is traveling from denser medium to rarer medium it bends away from normal.



12. When an object placed in a denser medium is seen through a rarer medium, it appears to be closer. Eg. a coin placed inside water. When an object in a rarer medium is seen from a denser medium, it appears to be shifted to a point farther away from the eye of the observer.

$\mu = \frac{\text{Real depth}}{\text{Apparent depth}}$

13. The apparent shift produced by a denser medium of thickness (t) is $t(1-\frac{1}{\mu})$.



The apparent shift due to multiple layers= $t_1(1-\frac{1}{\mu_1})+t_2(1-\frac{1}{\mu_2})+\ldots\ldots$

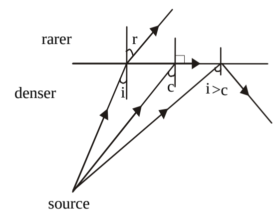
14. When a ray travels through a glass slab, it suffers displacement or lateral shift but is not deviated. Lateral shift (x) is given by $x = \frac{t \sin(i-r)}{\cos r}$.

15. When a light ray travels from a denser medium into a rarer medium, the angle of incidence for which the angle of refraction becomes 90° is known as **critical angle** (C) of the denser medium with respect to the rarer medium.

16. The critical angle for water (μ = 4/3) is $48°35^{I}$ and for glass (μ = 3/2) it is $41°49^{I}$.

17. The critical angle is proportional to the wavelength of the spectral line. It is maximum for red and minimum for violet. The critical angle is proportional to temperature.

18. The critical angle (C) depends on the two media. If the angle of incidence is greater than the critical angle, instead of refraction, reflection occurs. This is known as **total internal reflection**.



$${}_a\mu_b = \frac{1}{\sin C_b};\ \sin C_b = \frac{1}{{}_a\mu_b} = {}_b\mu_a$$

19. Mirages and looming are due to total internal reflection.

20. Diamond has maximum refractive index and hence the least critical angle. Hence a well cut diamond shines brilliantly due to total internal reflection.

21. A small air bubble in water shines due to total internal reflection.

22. A bob coated with lamp black, placed under water appears silvery white due to total internal reflection.

23. The conditions for total internal reflection are (i) light must travel from a denser medium to a rarer medium and (ii) the angle of incidence must be greater than the critical angle.

24. **Uses of total internal reflection:**

i) It confines the light only to the denser medium and avoids refraction,

ii) It permits lossless propagation known as non radioactive propagation i.e., there is no energy loss during transmission;

iii) The phenomenon finds wide application in optical communication.

25. For a fish or diver under water, the outside world appears to be within a cone of vertex angle 2C (= 98°).

26. If h is the depth of the fish from the surface of water of refractive index μ, the radius of the circle R on the surface of water through which it can see the outside world is

$$R = h\tan C \text{ or } R = \frac{h}{\sqrt{\mu^2 - 1}}.$$