Optics

Second year / First semester
Lecture 3

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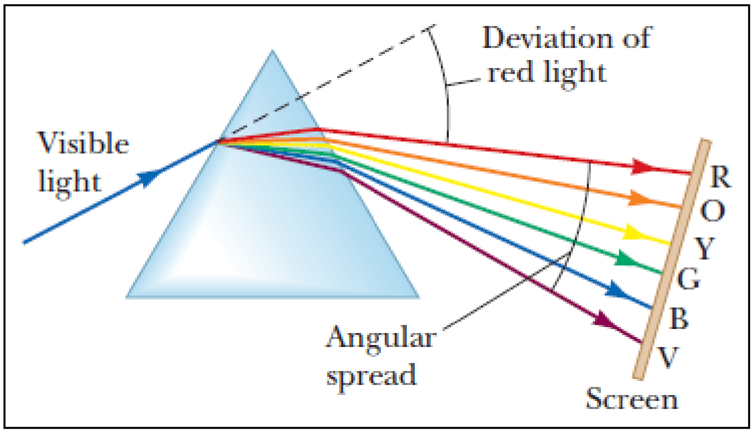
Refraction by prism

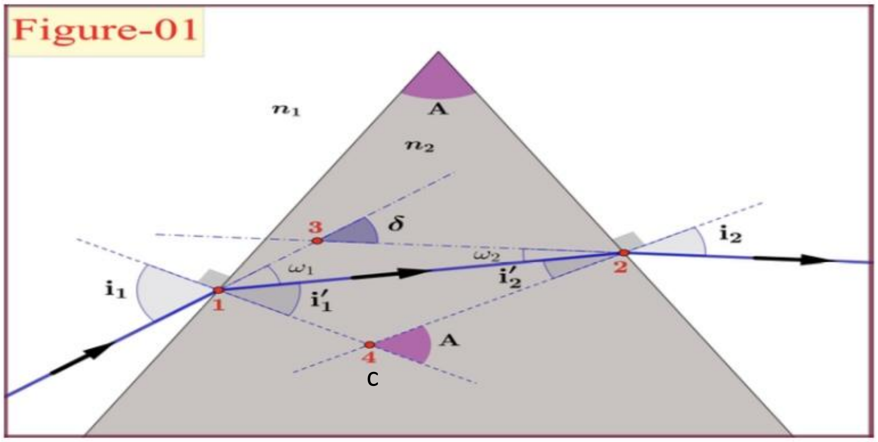


Prism

Is a transparent optical object with flat , polished surfaces that refract light . At least two of the flat surfaces must have an angle between them.

Bending of light:-

Light changes its speed when it moves from one medium to another . This speed change causes the light to be refracted and to enter the new medium at a different angle. The degree of bending of the light's path depends on the angle that the incident ray of the light makes with the surface , and on the ratio between the refractive index of the two media.



1

$\delta = \omega_1 + \omega_2$ ....(1)

$i_1 = \omega_1 + i_1'$ ....(2) , $i_2 = \omega_2 + i_2'$ ......(3)

From equations 2,3

$\omega_1 = i_1 - i_1'$......(4) , $\omega_2 = i_2 - i_2'$ ......(5)

1234 = 360°

A + C = 180°.......(6) مجموع زاويتين متقابلتين

Δ 124 **180° مجموع زواياه**

$i_1' + i_2' + C = 180°$

From equation (6) A + C = 180°

∴ $A = i_1' + i_2'$ ......(7)

We substitute equations (4) and (5) in equation (1)

$\delta = (i_1 - i_1') + (i_2 - i_2')$

$\delta = i_1 - i_1' + i_2 - i_2'$

$\delta = (i_1 + i_2) - (i_1' + i_2')$

From equation (7) $A = i_1' + i_2'$

$\delta = (i_1 + i_2) - A$……(8)

$i_1 = i_2 , \omega_1 = \omega_2 , i_1' = i_2' , \delta = \delta_{min}$

$\therefore \delta_{min} = 2i_1 - A$

$2i_1 = \delta_{min} + A$

$i_1 = \frac{\delta_{min} + A}{2}$ …….(9)

$\because i_1' = i_2'$

$\therefore A = 2i_1'$

$i_1' = \frac{A}{2}$ ……(10)

From Snell's law

$n_1 \sin i_1 = n_2 \sin i_1'$

$\sin i_1 = \frac{n_2}{n_1} \sin i_1'$ ……(11) , $n_1 = 1$

We substitute equations (9) and (10) in equation (11)

$$\sin\left(\frac{\delta_{min} + A}{2}\right) = n_2 \sin\frac{A}{2}$$

THE REFRACTIVE INDEX OF THE PRISM IS CALUCALTED BY

$$n_2 = \frac{\sin\left(\frac{\delta_{min} + A}{2}\right)}{\sin\frac{A}{2}}$$

$$\sin\left(\frac{\delta_{min} + A}{2}\right) = \frac{\delta_{min} + A}{2} \quad , \quad \sin\frac{A}{2} = \frac{A}{2}$$

$$n_2 = \frac{\frac{\delta_{min} + A}{2}}{\frac{A}{2}} \rightarrow n_2 = \frac{\delta_{min} + A}{2}\frac{2}{A} = \frac{\delta_{min}}{A} + \frac{A}{A} = \frac{\delta_{min}}{A} + 1$$

$$n_2 = \frac{\delta_{min}}{A} + 1$$

$\therefore \delta_{min} = A(n_2 - 1)$ **(Minimum deviation angle)**

- A ray passing through a prism is deflected twice: once entering, and again when exiting. The sum of these two deflections is called the deviation angle.

The deviation angle in a prism depends upon:

1. **Refractive index of the prism**
2. **Angle of the prism**
3. **Angle of incidence**

Dispersion

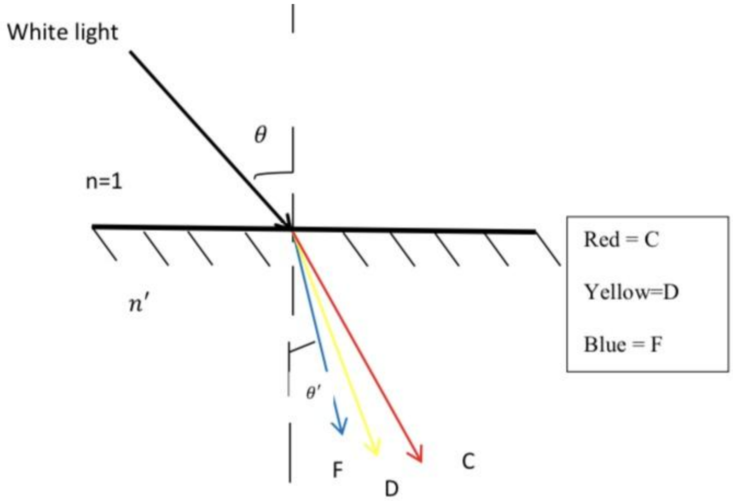
In optics, dispersion is the phenomenon in which depends on The speed of light is related to its frequency, which varies depending on the medium through which it travels.

The most familiar example of dispersion is probably a rainbow, in which dispersion causes the spatial separation of a white light into components of different wavelengths (different colors).

- refractive index n decreases with increasing wavelength λ. In this case, the medium is said to have normal dispersion. Whereas, if the index increases with increasing wavelength the medium has anomalous dispersion.
- In optics, one important and familiar consequence of dispersion is the change in the angle of refraction of different colors of light.

Color Dispersion

It is well known to those who have studied elementary physics that refraction causes a separation of white light into its component colors. Thus, as is shown in Fig, the incident ray of white light gives rise to refracted rays of different colors (really a continuous spectrum) each which has a different value of . The value of n' must therefore vary with color.



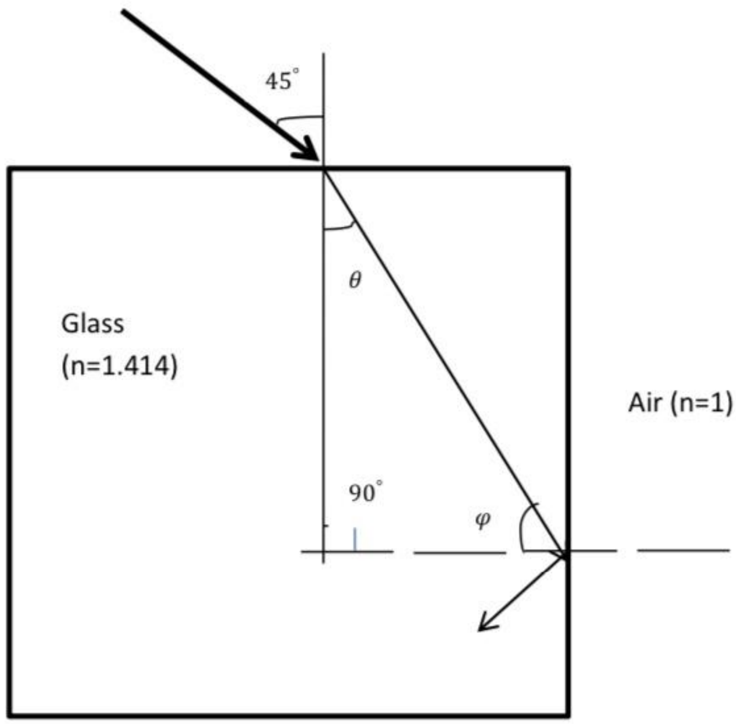
Laws Lecture 3

1- $\delta_{min} = A(n_2 - 1)$

2- $n_2 = \frac{\sin\left(\frac{\delta_{min} + A}{2}\right)}{\sin\frac{A}{2}}$

δ_{min} : زاوية الانحراف الصغرى للموشور
A : زاوية رأس الموشور
n_2 : معامل انكسار الموشور

Example1: ray of light is incident at an angle 45° of on the top surface of cubic glass (n=1.414) that surrounded by air on all sides as shown in figure ,Does a light is refracted or no from the lateral right side of cubic.



sol

Critical angle (glass-air)

$n_1 = 1.414$, $n_2 = 1$

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

$$\theta_c = sin^{-1}\left(\frac{1}{1.414}\right)$$

$$\theta_c = sin^{-1}(0.707)$$

$$\theta_c = 45°$$

Using snell's on the top of cubic

$n_1 = 1$, $n_2 = 1.414$

n_1 sin45° = n_2 sinθ

1 sin45° = 1.414 sinθ

Sinθ = $\frac{1}{1.414}$ sin45° = 0.5

$\theta = sin^{-1}(0.5)$= 30°

φ = 90° - 30° = 60°

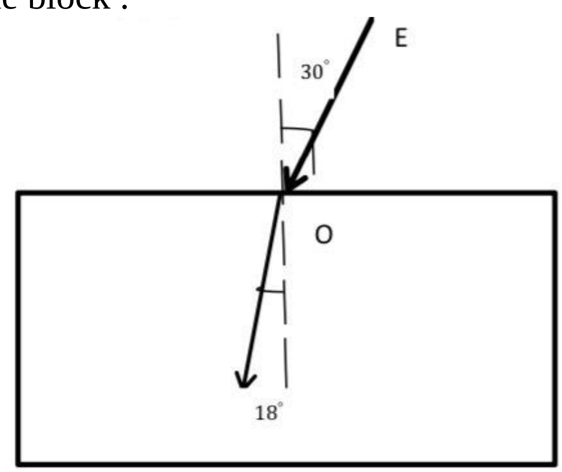
$\varphi > \theta_c$ total internal occur inside the cubic

Example2: A prism glass has apex angle of 25°,and the minimum deviation angle is measured to be 15.8° what is refractive index of a prism.

sol

$$\boldsymbol{n_2}= \frac{\sin\left(\frac{\delta_{min}+A}{2}\right)}{\sin\frac{A}{2}} = \frac{\sin\left(\frac{15.8+25}{2}\right)}{\sin\frac{25}{2}} = \mathbf{1.61}$$

Example3: A ray of light traveling in the direction EO in air enters a rectangular block at an angle of incidence 30° , and angle of refraction is 18° Find the critical angle for the block .



sol

the refractive index of block

n_1 sin 30° = n_2 sin 18°

$n_2 = \frac{\sin 30°}{\sin 18°} = 1.62$

To find the critical angle for the block

$\theta_1 = \theta_c \rightarrow \theta_2 = 90°$, $n_2 = 1$, $n_1 = 1.62$

$1.62 \sin \theta_c = 1 \sin 90°$

$\sin \theta_c = \frac{1}{1.62}$

$\theta_c = sin^{-1} \frac{1}{1.62} = 38.1°$