Ray optics

- Reflection by plane mirror
- Reflection by spherical mirror
- Refraction
- Total Internal Reflection
- Refraction by Spherical surface & lenses
- Dispersion
- Optical Instruments

2-3 Q|s

Reflection by plane mirror

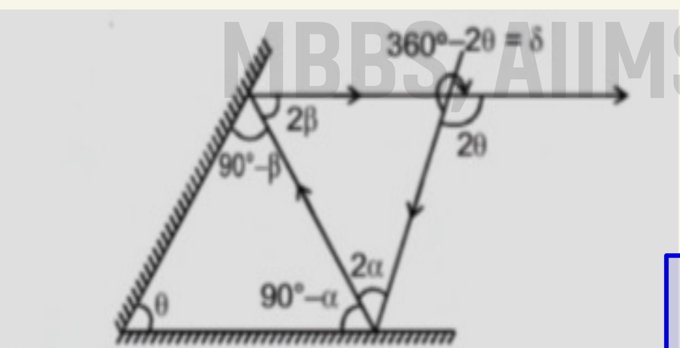
- For a plane mirror, image of virtual object is real and inverted.

- For a given incident ray, if plane mirror is rotated through an angle θ in plane of incidence, reflected ray turns through angle 2θ.

- No. of images formed by two inclined plane mirrors if object is placed between them facing each other at angle θ -

n =

- $\dfrac{360^\circ}{\theta^\circ} - 1$ if $\dfrac{360^\circ}{\theta^\circ}$ = even
- $\dfrac{360^\circ}{\theta^\circ} - 1$ if $\dfrac{360^\circ}{\theta^\circ}$ odd and object lies symmetrically
- $\dfrac{360^\circ}{\theta^\circ}$ if $\dfrac{360^\circ}{\theta^\circ}$ odd and object lies unsymmeterical



$$\theta + (90^\circ - \alpha) + (90^\circ - \beta) = 180$$

$$\alpha + \beta = \theta$$

$$2\alpha + 2\beta = 2\theta$$

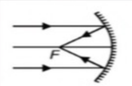
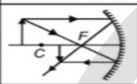
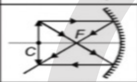
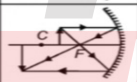
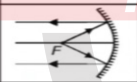
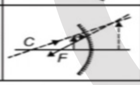
Deviation produced by 2 mirrors inclined at θ

$$\delta = 360^\circ - 2\theta$$

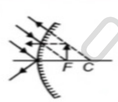
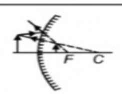
Reflection by Spherical Mirror

Location, size and nature of image formed by Spherical Mirrors

Concave Mirror

Position of object	Figure	Position of image	Nature of image
1. At infinity		At the principal focus or in the focal plane	Real, inverted, extremely diminished in size
2. Beyond the centre of curvature		Between the principal focus and centre of curvature	Real, inverted and diminished
3. At the centre of curvature		At the centre of curvature	Real, inverted and equal to object
4. Between focus and centre of curvature		Beyond centre of curvature	Real, inverted and bigger than object
5. At the principal focus		At infinity	Extremely magnified
6. Between the pole and principal focus		Behind the mirror	Virtual, erect and magnified

Convex Mirror

Position of object	Figure	Position of image	Nature of image
1. At infinity		Appears at the principal focus	Virtual, erect and extremely diminished
2. Between infinity and the pole		Appears between the prinicipal focus and the pole	Virtual, erect and diminished

$f = \frac{R}{2}$ (radius of curvature)

The Mirror Equation

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$$

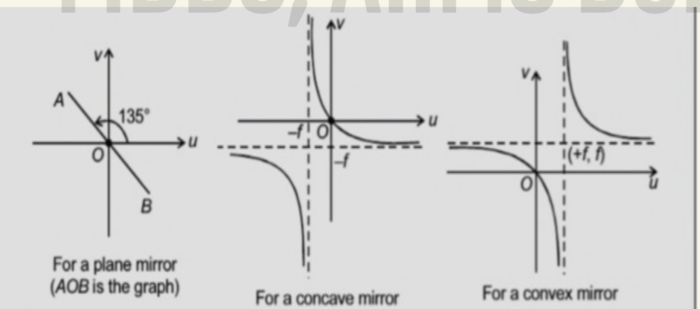
v : image distance
u : object distance
f : focal length
(Pole is taken as reference)

Lateral Magnification

$$m = \frac{h_{image}}{h_{object}} \quad (h: \text{Height})$$

$$m = \frac{-v}{u}$$

$$\boxed{m = \frac{f}{f-u} = \frac{f-v}{f}}$$



For a plane mirror (AOB is the graph)

For a concave mirror

For a convex mirror

Refraction

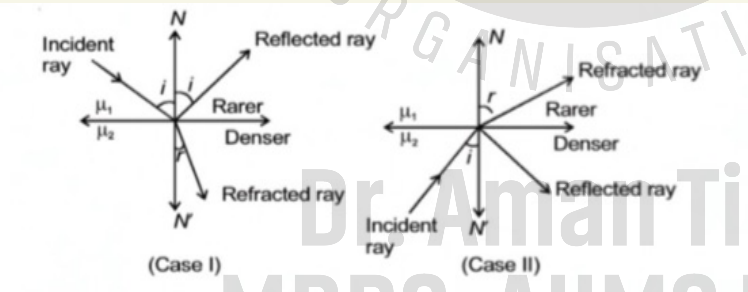
When a light ray travels from one transparent medium to other, it deviates from its original path. This phenomenon : Refraction

Snell's Law

$$\frac{\sin i}{\sin r} = {}^1\mu_2 = \text{constant}$$

i : incident angle
r : refracted angle

$$\mu = \frac{c}{v} = \frac{\text{velocity of light in vaccum}}{\text{velocity of light in medium}}$$

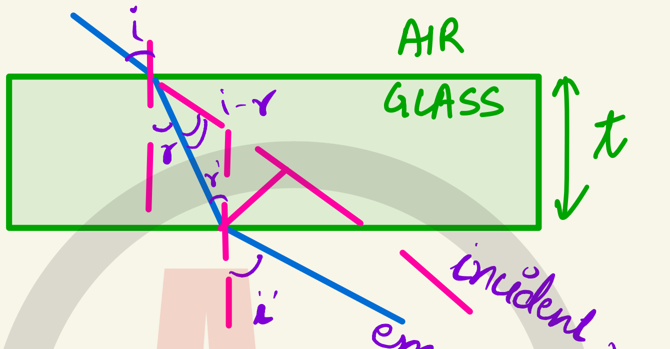


Denser μ > Rarer μ

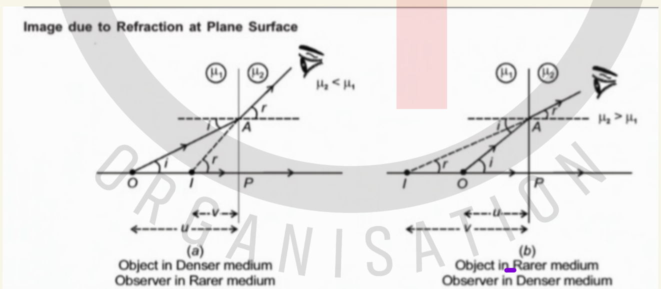
- maximum μ value for Diamond
- Optical path = μx
- Cauchy's formula = $\mu = A + \frac{B}{\lambda^2} + \frac{C}{\lambda^4}$.

λ increases ; μ decreases

Refraction through glass slab



$$\boxed{\text{lateral shift} = \frac{t\,\sin(i-r)}{\cos r}}$$

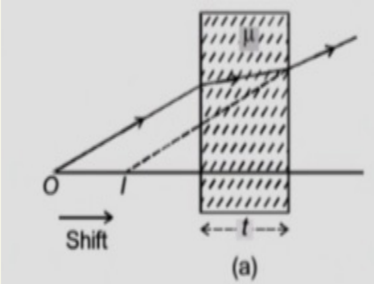


$$\frac{\mu_2}{\mu_1} = \frac{\text{Apparant distance (image distance)}}{\text{Real distance of object}}$$

- If beaker is filled with immiscible liquids of refractive indices $\mu_1, \mu_2, \mu_3 ..$ having respective thickness t_1, t_2, t_3

$$\text{Apparent depth} = \frac{t_1}{\mu_1} + \frac{t_2}{\mu_2} + \frac{t_3}{\mu_3} ..$$

$$\boxed{\text{Apparent shifting} = t_1\left(1-\frac{1}{\mu_1}\right) + t_2\left(1-\frac{1}{\mu_2}\right) + t_3\left(1-\frac{1}{\mu_3}\right) + ..}$$



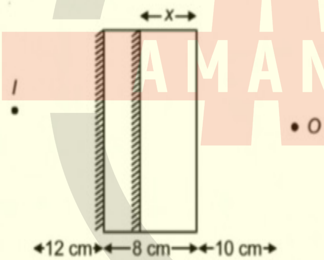
(a)

$\boxed{\text{Shift } OI = t\left(1-\frac{1}{\mu}\right)}$

Question Practice

: *One face of a rectangular glass plate of 8 cm thickness is silvered. An object held 10 cm in front of the unsilvered face forms an image 12 cm behind the silvered face. What is the refractive index of the glass?*

Apparent position of the silvered face is shifted towards the object by $(8 - x)$ cm.

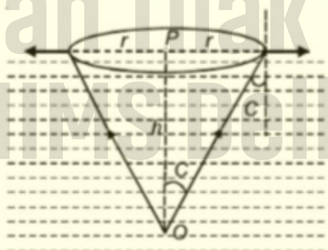


Hence $10 + x = 12 + (8 - x)$. [$\because$ object distance = image distance]

or, $x = 5$ cm.

Hence $\mu = \dfrac{\text{Real thickness}}{\text{Apparent thickness}} = \dfrac{8\text{ cm}}{5\text{ cm}} = 1.6$

: *A disc is placed on the surface of pond which has refractive index $\frac{5}{3}$. A source of light is placed 4 m below the surface of liquid. Calculate the minimum area of the disc so that light does not come out of the liquid.*



$\sin C = \dfrac{1}{\mu}$

or, $\dfrac{r}{\sqrt{r^2+h^2}} = \dfrac{1}{\mu}$

or, $\mu = \dfrac{\sqrt{r^2+h^2}}{r}$

or, $\mu^2 = \dfrac{r^2+h^2}{r^2} = 1+\dfrac{h^2}{r^2}$

or, $\dfrac{h^2}{r^2} = \mu^2 - 1$

or, $r = \dfrac{h}{\sqrt{\mu^2-1}} = \dfrac{4}{\sqrt{\frac{25}{9}-1}} = \dfrac{4}{\frac{4}{3}} = 3$ m

$\therefore$ Required area of the disc $= \pi r^2 = 3.14 \times 9\text{ m}^2 = 28.28\text{ m}^2$

Total Internal Reflection

Critical Angle

Angle of incidence corresponding to which angle of refraction becomes 90°.

$$\sin C = \frac{1}{\mu}$$

T.I.R. is phenomenon which occurs when the light in denser medium strikes the interface seperating denser and rarer mediums - at an angle of incidence greater than critical angle total light is reflected without any deviation through prism.

Applications of T.I.R (NCERT) ☆

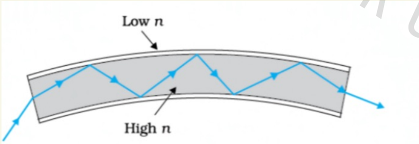
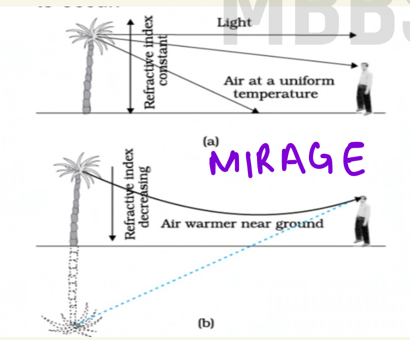


Figure 9.16 *Light undergoes successive total internal reflections as it moves through* an optical fibre.



MIRAGE

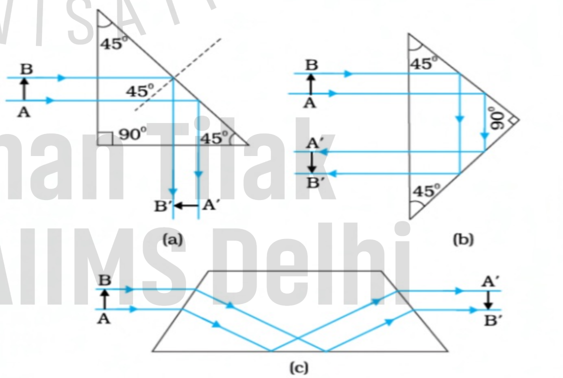
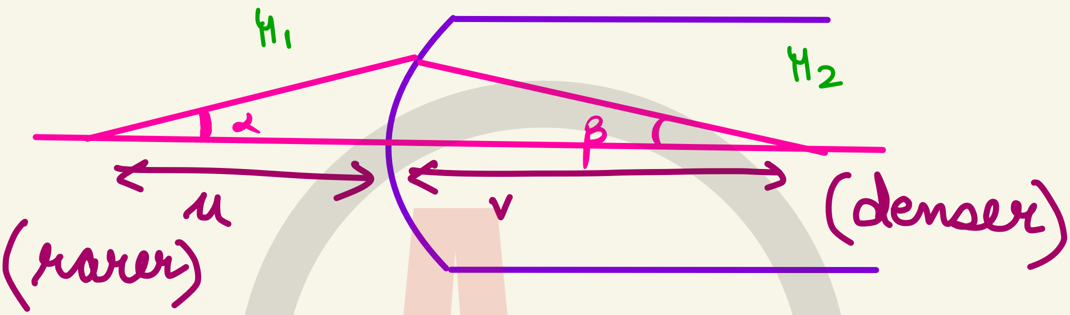


Figure 9.15 *Prisms designed to bend rays by 90° and 180° or to invert image without changing its size make use of total internal reflection.*

Refraction by Spherical Surface



$$\boxed{\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}}$$

There is a small air bubble inside a glass sphere ($\mu = 1.5$) of radius 10 cm. The bubble is 4 cm below the surface and is viewed normally from outside. Find the approx. apparent depth of the bubble.

The observer will see the image formed due to refraction at the spherical surface when light from the bubble goes from glass to air.

Here $u = -4$ cm, $R = -10$ cm, $\mu_1 = 1.5$, $\mu_2 = 1$

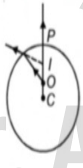
$\therefore$ From formula, $\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$, we get

$$\frac{1}{v} - \frac{1.5}{-4\text{cm}} = \frac{1-1.5}{-10\text{cm}}$$

or $\frac{1}{v} = \frac{0.5}{10\text{cm}} - \frac{1.5}{4\text{cm}}$

or $v = -3$ cm

$\therefore$ The bubble will appear 3 cm below the surface.



: *A concave mirror of radius 40 cm lies on a horizontal table and water is filled in it up to a height of 5 cm. A small dust particle floats on water surface vertically above the point of contact of the mirror with the table. Locate the image of the dust as seen from a point directly above it.*

O is the real position of the dust particle. O_1 is the image of O due to reflection at concave mirror. O_2 is the image of O_1

due to refraction at water-air interface.

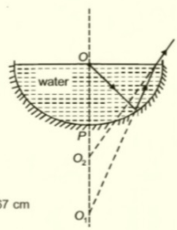
For reflection at concave mirror, $u = -PO = -5$ cm,

$R = -40$ cm

$\therefore$ From $\frac{1}{v} + \frac{1}{u} = \frac{2}{R}$, we get

$$\frac{1}{v} = \frac{-2}{40} - \frac{1}{-5} = \frac{6}{40} \text{ cm}$$

or $v = \frac{40}{6}$ cm = 6.67 cm



O_1 will act as an object for refraction at water-air interface.

Hence OO_1 = real depth of the object = 5 cm + 6.67 cm = 11.67 cm

OO_2 = the apparent depth of O_1

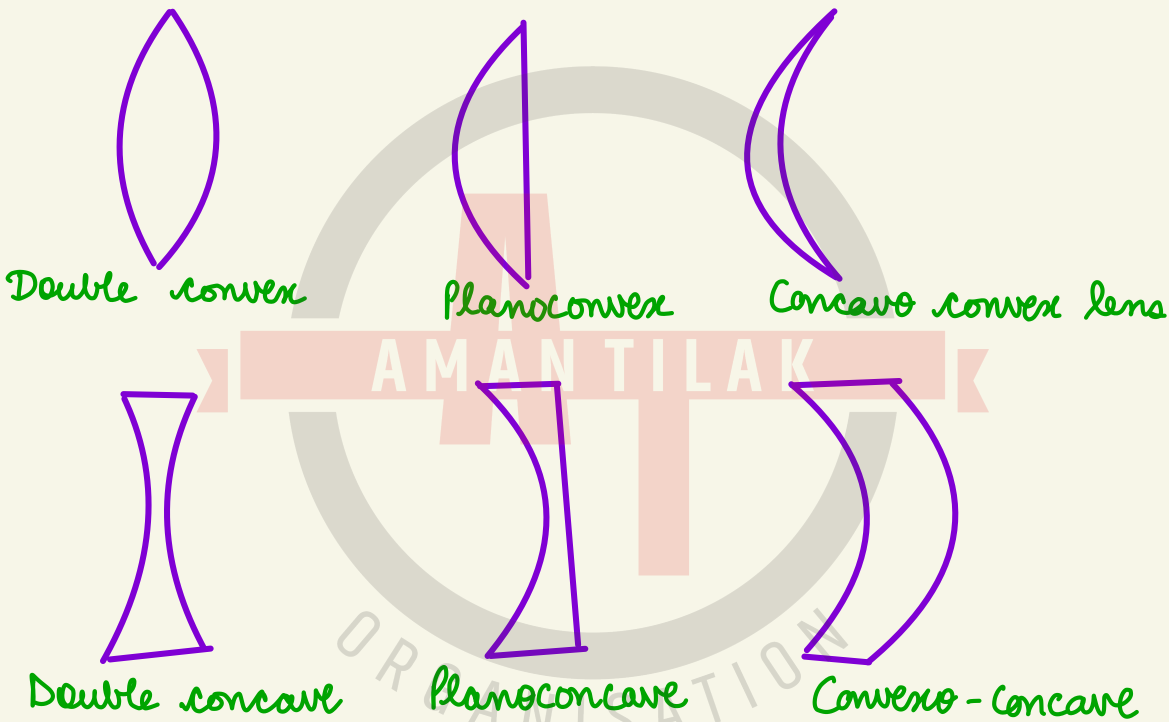
$\therefore$ From $\mu = \frac{\text{real depth}}{\text{apparent depth}}$

apparent depth $= \frac{\text{real depth}}{\mu} = \frac{11.67\text{ cm}}{1.33} = 8.75$ cm

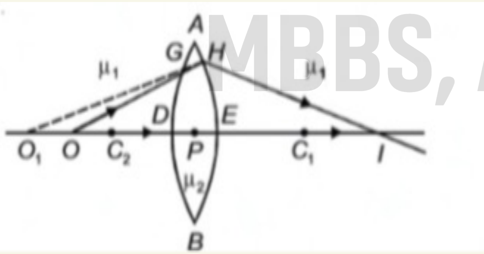
Hence, the dust will be seen at a depth of 8.75 cm below the water surface.

Question Practice

Refraction by Lenses



Lens Makers Formula



$$\boxed{\frac{1}{f} = \left(\frac{\mu_2}{\mu_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)}$$

$\therefore$ f depends on medium in which lens is placed.

- If lens is placed in medium of refractive index μ_m and refractive index of lens μ_g –

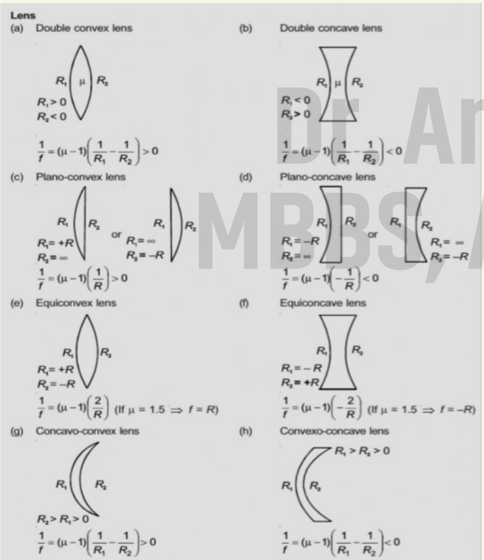
$\mu_m < \mu_g$	Nature of lens does not change but focal length increases
$\mu_m > \mu_g$	Sign of f changes ∴ Nature of lens changes.
$\mu_m = \mu_g$	Lens invisible and behaves as plane glass slab.

- Newton's formula :

If x_1 = distance of object from 1st focus
x_2 = distance of image from 2nd focus

$$x_1 x_2 = f^2$$

IMPORTANT APPLICATIONS



Lens

(a) Double convex lens

$R_1 > 0$, $R_2 < 0$

$$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) > 0$$

(b) Double concave lens

$R_1 < 0$, $R_2 > 0$

$$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) < 0$$

(c) Plano-convex lens

$R_1 = +R$, $R_2 = \infty$ or $R_1 = \infty$, $R_2 = -R$

$$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R}\right) > 0$$

(d) Plano-concave lens

$R_1 = -R$, $R_2 = \infty$ or $R_1 = \infty$, $R_2 = -R$

$$\frac{1}{f} = (\mu - 1)\left(-\frac{1}{R}\right) < 0$$

(e) Equiconvex lens

$R_1 = +R$, $R_2 = -R$

$$\frac{1}{f} = (\mu - 1)\left(\frac{2}{R}\right) \text{ (If } \mu = 1.5 \Rightarrow f = R)$$

(f) Equiconcave lens

$R_1 = -R$, $R_2 = +R$

$$\frac{1}{f} = (\mu - 1)\left(-\frac{2}{R}\right) \text{ (If } \mu = 1.5 \Rightarrow f = -R)$$

(g) Concavo-convex lens

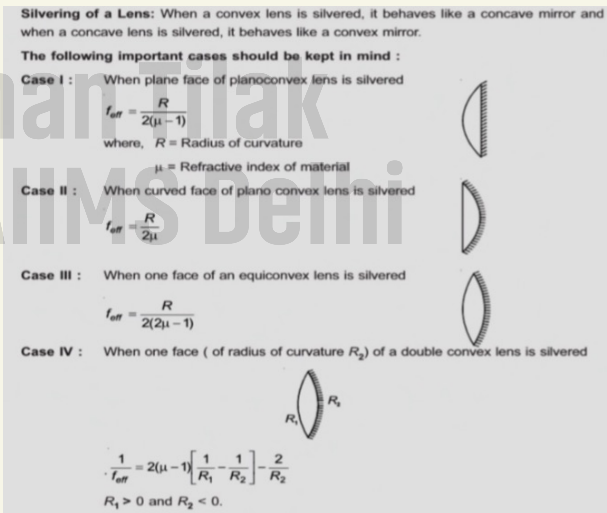
$R_2 > R_1 > 0$

$$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) > 0$$

(h) Convexo-concave lens

$R_1 > R_2 > 0$

$$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) < 0$$



Silvering of a Lens: When a convex lens is silvered, it behaves like a concave mirror and when a concave lens is silvered, it behaves like a convex mirror.

The following important cases should be kept in mind :

Case I : When plane face of planoconvex lens is silvered

$$f_{eff} = \frac{R}{2(\mu - 1)}$$

where, R = Radius of curvature
μ = Refractive index of material

Case II : When curved face of plano convex lens is silvered

$$f_{eff} = \frac{R}{2\mu}$$

Case III : When one face of an equiconvex lens is silvered

$$f_{eff} = \frac{R}{2(2\mu - 1)}$$

Case IV : When one face (of radius of curvature R_2) of a double convex lens is silvered

$$\frac{1}{f_{eff}} = 2(\mu - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right] - \frac{2}{R_2}$$

$R_1 > 0$ and $R_2 < 0$.

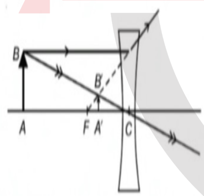
- **Lens formula** - $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

- **Magnification** $m = \frac{f}{f+u} = \frac{f-v}{f}$

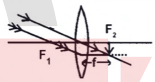
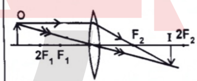
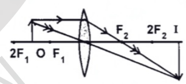
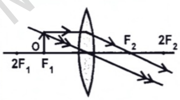
Image formation

Images Formed by a Concave Lens

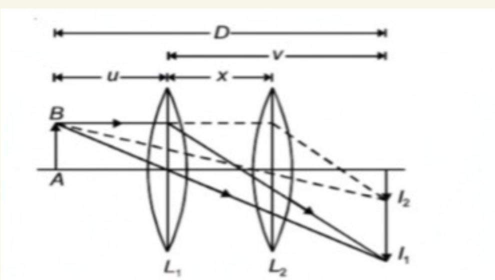
The image A′B′ of the object AB formed by concave lens is **virtual**, **erect** and **diminished**. It is formed on the same side as that of the object.



Position size and nature of the images formed by a Convex lens :

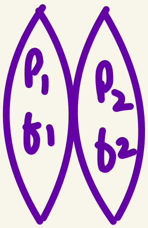
Position of Object	Position of image	Ray – Diagram	Nature (size)
At infinity	At focus		Real, inverted ,[Highly Diminished] (m << – 1)
Between ∞ and 2F	Between F & 2F		Real, inverted, [Diminished (m < –1)]
At 2F	At 2F		Real, inverted, [Equal (m = –1)]
Between 2F and F	Between 2F & ∞		Real, inverted, [Enlarged (m > –1)]
At F	At ∞		Real, inverted, [Highly Enlarged (m >> – 1)]
Between F and P	Between ∞ & O on same side		Virtual, erect [Enlarged (m > +1)]

Displacement Method



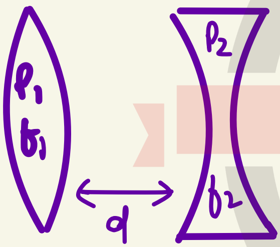
$$\boxed{f = \frac{D^2 - x^2}{4D}}$$

Power of lens



$P = P_1 + P_2$ (with sign)

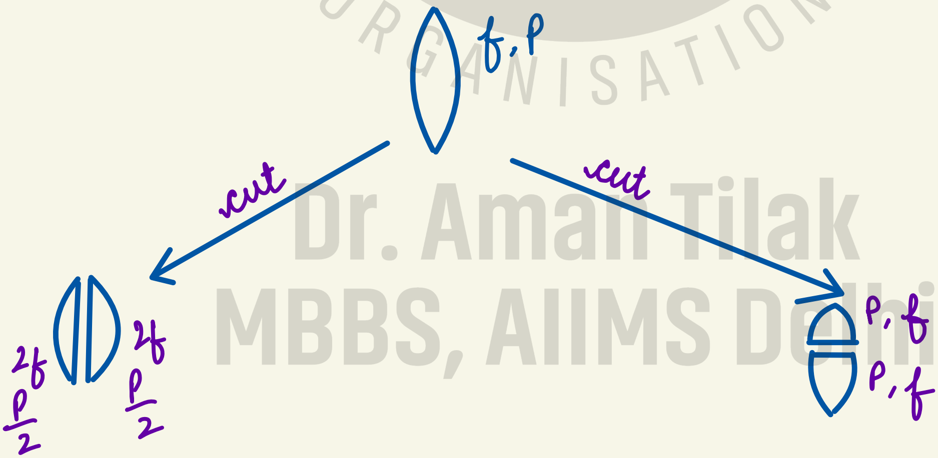
$$\boxed{\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}}$$



$P = P_1 + P_2 - dP_1P_2$

$$\boxed{\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}}$$

Cutting of lens

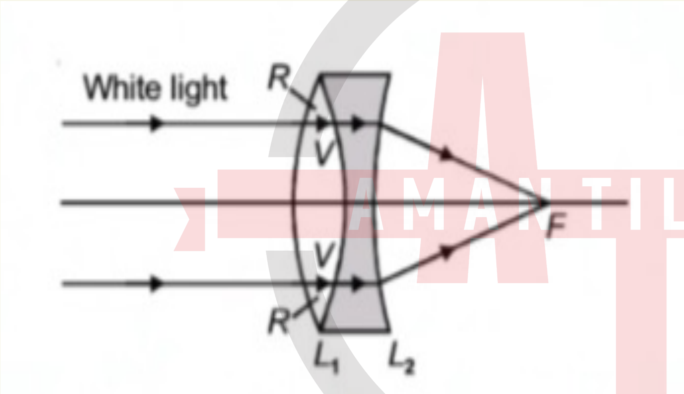


No. of focal lengths = No. of different media (n)
= No. of images

Achromatism

Property of combination of lens free from chromatic abberration

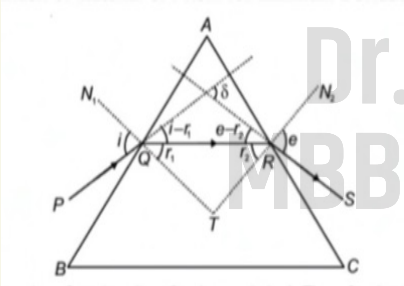
→ Inability of lens to focus all component colours of white light at single point



In such arrangement -

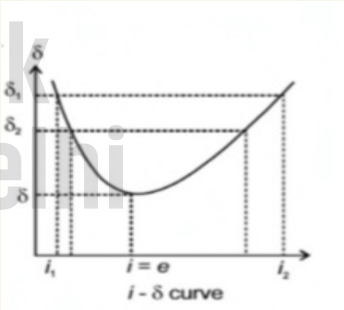
$$\boxed{\frac{\omega_1}{\omega_2} = \frac{-f_1}{f_2}}$$

Refraction through PRISM



$$i + e = A + \delta$$
$$r_1 + r_2 = A$$

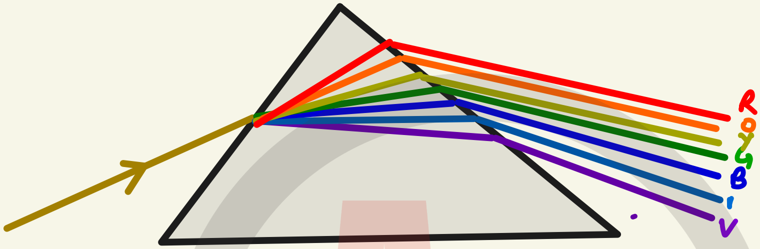
$$\mu = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$



For small Angled Prism

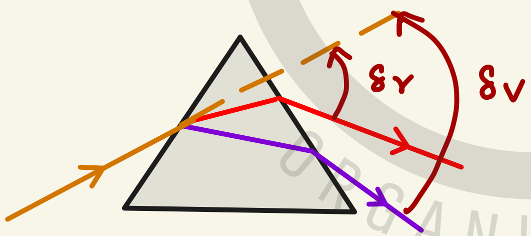
$\boxed{\delta = (\mu - 1)A}$ $(A < 10^\circ)$

Dispersion



Seperation of white light into constituent colours is called dispersion.

Angular Dispersion : Difference between angles of devation of 2 colours



$$\theta = \delta_V - \delta_R$$

$$= A(\mu_V - 1) - A(\mu_R - 1)$$

$$\boxed{\theta = A(\mu_V - \mu_R)}$$

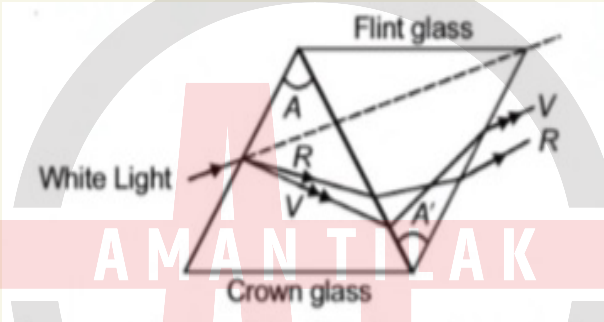
Dispersive Power : Ratio of angular dispersion between two extreme colours to their mean deviation.

$$\boxed{\omega = \frac{\delta_V - \delta_R}{\frac{\delta_V + \delta_R}{2}} = \frac{\delta_V - \delta_R}{\delta_Y}}$$

δ_Y : yellow light

$$\boxed{\omega = \frac{\mu_V - \mu_R}{\mu - 1}}$$

Two cases :-



Dispersion without Deviation

$\delta + \delta' = 0$ (No Deviation)

$$\frac{A'}{A} = \frac{\mu - 1}{\mu' - 1}$$

$\therefore \theta = (\mu - 1)A(\omega - \omega')$

Net Dispersion

Deviation without dispersion

$\theta + \theta' = 0$ (No Dispersion)

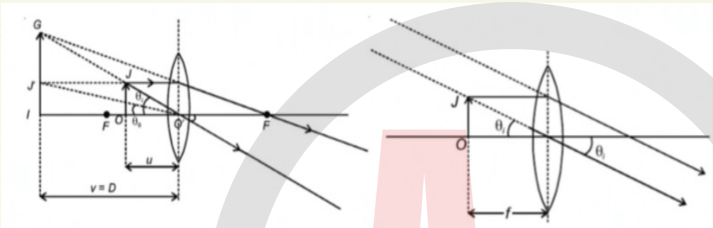
$$\frac{A'}{A} = \frac{\mu_v - \mu_r}{\mu_v' - \mu_r'}$$

$\delta + \delta' = (\mu - 1)A\left(1 - \frac{\omega}{\omega'}\right)$

Net Deviation

Optical Instuments

Simple Microscope



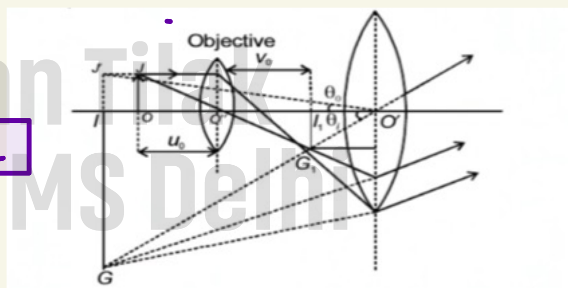
- when image formed at near point $v = D = 25cm$

$$\boxed{m = 1 + \frac{D}{f}}$$

- when image is at far point $v = \infty$

$$\boxed{m = \frac{D}{f}}$$

Compound Microscope



- when image formed at near point $v = D$

$$m = \frac{v_o}{u_o}\left(1 + \frac{D}{f_o}\right) \qquad \boxed{L = v_o + u_e}$$

If $u_o = f_o$; $v_o \sim L$

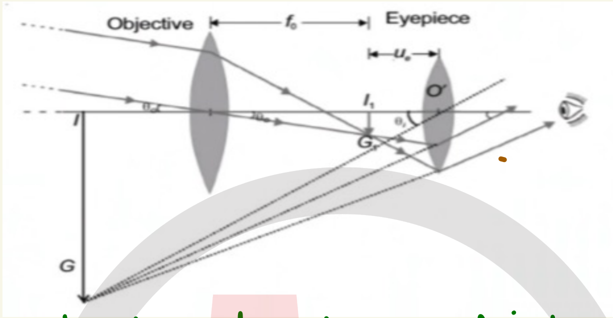
$$\boxed{m = -\frac{L}{f_o}\left(1 + \frac{D}{f_o}\right)}$$

- when image formed at $v = \infty$ $\quad m = \frac{v_o}{u_o}\frac{D}{f_e}$

If $u_o = f_o$; $v_o \sim L$

$$\boxed{m = -\frac{L}{f_o}\left(\frac{D}{f_e}\right)}$$

Telescope



- If image is formed at near point $v = D$

$$m = -\frac{f_o}{f_e}\left(1 + \frac{f_e}{D}\right)$$

Length of telescope $= L = f_o + u_e$

$$\boxed{L = f_o + \frac{Df_e}{D + f_e}}$$

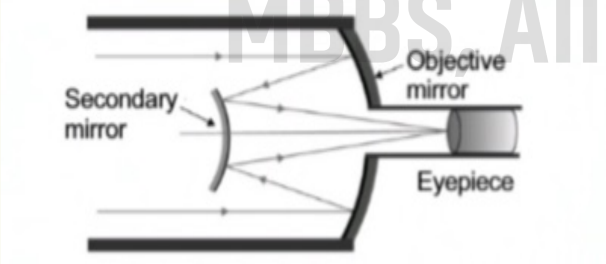
- If image is formed at $v = \infty$

$$m = -\frac{f_o}{f_e}$$ (only possible when $u_e = f_e$)

Length of telescope $\boxed{L = f_o + f_e}$

Cassegrain (Reflecting Telescope)

- $M = -\frac{f_o}{f_e}$



Advantages :-

- No chromatic aberration in mirrors
- Parabolic surface chosen, no spherical Aberration

PREVIOUS YEARS IMPT.

A double convex lens has focal length 25 cm. The radius of curvature of one of the surfaces is double of the other. Find the radii if the refractive index of the material of the lens is 1.5 [NEET-2019 (Odisha)]

- A. 50 cm, 100 cm
- B. 100 cm, 50 cm
- C. 25 cm, 50 cm
- D. 18.75 cm, 37.5 cm

ANSWER AND EXPLANATION

$$\frac{1}{f} = (\mu - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

$$\frac{1}{25} = (1.5 - 1)\left[\frac{1}{2R} - \frac{1}{-R}\right]$$

$$\frac{2}{25} = \frac{3}{2R}$$

$$R = \frac{75}{4} = 18.75 \text{ cm}$$

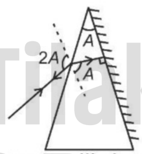
For 2^{nd} surface $= 2R$

$= 37.5$ cm

The angle of a prism is A. One of its refracting surface is silvered. Light rays falling at an angle of incidence 2A on the first surface returns back through the same path after suffering reflection at the silvered surface. The refractive index μ, of the prism is: [AIPMT-2014]

- A. $2 \sin A$
- B. $2 \cos A$
- C. $\frac{1}{2} \cos A$
- D. $\tan A$

ANSWER AND EXPLANATION



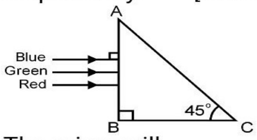
By Snell's law at point of incidence

$\sin 2A = \mu \sin A$

$2 \sin A \cos A = \mu \sin A$

$\therefore \quad \mu = 2 \cos A$

A beam of light consisting of red, green and blue colours is incident on a right angled prism. The refractive index of the material of the prism for the above red, green and blue wavelengths are 1.39, 1.44 and 1.47, respectively. [Re-AIPMT-2015]



The prism will

A. Separate the red colour part from the green and blue colours

B. Separate the blue colour part from the red and green colours

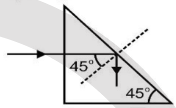
C. Separate all the three colours from one another

ANSWER AND EXPLANATION

For total internal reflection $45^o > C$

$\sin 45^o > \sin C$

$\frac{1}{\sqrt{2}} > \frac{1}{\mu}$



$\therefore$ $\mu > \sqrt{2}$

i.e. $\mu > 1.414$

$\therefore$ Green & blue will suffer total internal reflection as a result of red colour will separate from other two colours.

Two similar thin equi-convex lenses, of focal length f each, are kept coaxially in contact with each other such that the focal length of the combination is F_1. When the space between the two lenses is filled with glycerine (which has the same refractive index ($\mu = 1.5$) as that of glass) then the equivalent focal length is F_2. The ratio $F_1 : F_2$ will be :

[NEET-2019]

A. 2 : 1

B. 1 : 2

C. 2 : 3

D. 3 : 4

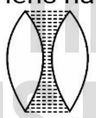
ANSWER AND EXPLANATION

When equiconvex lenses are placed in contact

$\frac{1}{F_1} = \frac{1}{f} + \frac{1}{f}$

$F_1 = \frac{f}{2}$

When space is filled with glycerine, it will act as concave lens having focal length "- f "



$\frac{1}{F_2} = \frac{1}{f} + \frac{1}{f} + \frac{1}{(-f)}$

$\frac{1}{F_2} = \frac{1}{f}$

$F_2 = f$

$\therefore \quad \frac{F_1}{F_2} = \frac{1}{2}$

An object is placed at a distance of 40 cm from a concave mirror of focal length 15 cm. If the object is displaced through a distance of 20 cm towards the mirror, the displacement of the image will be [NEET-2018]

(A) 30 cm away from the mirror

(B) 36 cm away from the mirror

(C) 36 cm towards the mirror

(D) 30 cm towards the mirror

ANSWER AND EXPLANATION

Explanation

For mirror $\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$

When $u = -40$ cm, $f = -15$ cm

$$\frac{1}{v_1}+\frac{1}{-40}=\frac{1}{-15}$$

$$\frac{1}{v_1}=\frac{1}{40}-\frac{1}{15}$$

$v_1 = -24$ cm

When object displaced 20 cm towards mirror

$u = -20$ cm, $f = -15$ cm

$$\therefore \quad \frac{1}{v_2}+\frac{1}{-20}=\frac{1}{-15}$$

$v_2 = -60$ cm

$\therefore$ Shift in position of image is

$= v_2 - v_1$

$= -36$ cm

i.e. 36 away from mirror

The refracting angle of a prism is A, and refractive index of the material of the prism is cot(A/2). The angle of minimum deviation is [AIPMT-2015]

(A) $180^o + 2A$

(B) $180^o - 3A$

(C) $180^o - 2A$

(D) $90^o - A$

ANSWER AND EXPLANATION

As $\mu = \dfrac{\sin\left[\dfrac{A+\delta_m}{2}\right]}{\sin\left[\dfrac{A}{2}\right]}$

$$\therefore \quad \cot\left(\frac{A}{2}\right)=\frac{\sin\left[\dfrac{A+\delta_{min}}{2}\right]}{\sin\left[\dfrac{A}{2}\right]}$$

$$\Rightarrow \quad \cos\left[\frac{A}{2}\right]=\sin\left[\frac{A+\delta_{min}}{2}\right]$$

$$\Rightarrow \quad \sin\left[\frac{180^\circ}{2}-\frac{A}{2}\right]=\sin\left[\frac{A}{2}+\frac{\delta_{min}}{2}\right]$$

$$\Rightarrow \quad \delta_{min} = 180^\circ - 2A$$

A beam of light from a source L is incident normally on a plane mirror fixed at a certain distance x from the source. The beam is reflected back as a spot on a scale placed just above the source L. When the mirror is rotated through a small angle θ, the spot of the light is found to move through a distance y on the scale. The angle θ is given by [NEET-2017]

A. $\frac{y}{2x}$

B. $\frac{y}{x}$

C. $\frac{x}{2y}$

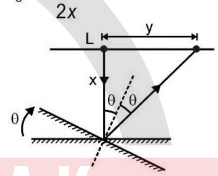
D. $\frac{x}{y}$

ANSWER AND EXPLANATION

When plane mirror turns through an angle θ about an axis in its plane, then spot of light will move y and subtends angle 2θ at point of incidence

$\therefore \quad 2\theta = \frac{y}{x}$

$\theta = \frac{y}{2x}$



Two identical glass (μ_g=3/2) equiconvex lenses of focal length f each are kept in contact. The space between the two lenses is filled with water (μ_w = 4/3). The focal length of the combination is [NEET-(Phase-2)-2016]

A. $\frac{f}{3}$

B. f

C. $\frac{4f}{3}$

D. $\frac{3f}{4}$

ANSWER AND EXPLANATION

For equiconvex

$f = \frac{R}{2(\mu-1)} = \frac{R}{2(1.5-1)}$

$f = R$

For concave lens made of water filled between equiconvex lens

$f' = \frac{-R}{2(\mu-1)} = \frac{-f}{2\left(\frac{4}{3}-1\right)}$

$f' = -\frac{3}{2}f$

For combination

$\frac{1}{f_{eq}} = \frac{1}{f} + \frac{1}{f} + \frac{1}{f'}$

$\frac{1}{f_{eq}} = \frac{2}{f} - \frac{2}{3f}$

$f_{eq} = \frac{3f}{4}$

A plano convex lens fits exactly into a plano concave lens. Their plane surfaces are parallel to each other. If lenses are made of different materials of refractive indices μ_1 and μ_2 and R is the radius of curvature of the curved surface of the lenses, then the focal length of the combination is [NEET-2013]

A $\frac{R}{2(\mu_1 - \mu_2)}$

B $\frac{R}{(\mu_1 - \mu_2)}$

C $\frac{2R}{(\mu_2 - \mu_1)}$

D $\frac{R}{2(\mu_1 + \mu_2)}$

ANSWER AND EXPLANATION

For plano convex $f = \frac{R}{\mu_1 - 1}$

For plano concave $f' = \frac{-R}{\mu_2 - 1}$

For combination $\frac{1}{f_{eq}} = \frac{1}{f} + \frac{1}{f'}$

$$\frac{1}{f_{eq}} = \frac{\mu_1 - 1}{R} - \frac{\mu_2 - 1}{R}$$

$$f_{eq} = \frac{R}{\mu_1 - \mu_2}$$

A person can see clearly objects only when they lie between 50 cm and 400 cm from his eyes. In order to increase the maximum distance of distinct vision to infinity, the type and power of the correcting lens, the person has to use, will be [NEET-(Phase-2)-2016]

A Convex, +2.25 diopter

B Concave, -0.25 diopter

C Concave, - 0.2 diopter

D Convex, +0.15 diopter

ANSWER AND EXPLANATION

Power of lens required to correct myopia is

$P = -\frac{1}{\text{far point distance}}$

$P = -\frac{1}{400\ (\text{cm})} = -\frac{1}{4(\text{m})}$

$P = -0.25$ diopter