PLUS TWO PHYSICS MADE SIMPLE

(HSE, VHSE, CBSE)

An Easy Book For A^+
Based On NCERT Syllabus

HIGHLIGHTS

- **Important points given**
- **Multitude of short questions with answers**
- **Analysis Questions with Answers**
- **Problems with solutions**
- **Selected multiple choice questions with keys**
- **7 Solved Question Papers & 1 Sample Question Paper**

Prof. C K Xavier M.Sc., M.Phil.,B.Ed &
Associate Professor
Head of the Department of Physics
St. Thomas' College, Thrissur

Prof. P M Joy M.Sc.,M.Ed , M.Phil
Associate Professor
Department of Physics
St. Thomas' College, Thrissur
(Member, UG Board of Studies
University of Calicut)

ROSARY PUBLISHERS (P) LTD
Vimala Buildings, Rice Bazaar East
Thrissur – 680 001
Ph: 8893092004, 8281789009

PLUS TWO PHYSICS MADE SIMPLE

(HSE, VHSE, CBSE)

XAVIER &	JOY
Chiramal (H)	**Pellissery (H)**
Peacock Nagar	**Paradise Avenue**
Pipe Line Road	**Palakkal, Palissery P O**
Thrissur East-680 005	**Thrissur 680 027**
(Ph. Mob. 9847928841	(Ph. Mob. 9446143106
Res. 0487 2338841)	Res. 0487 2348866)
xavierchiramal@gmail.com	pmjoy10@yahoo.com

Type setting by : ***Lissy Sebastian Chettupuzha***

Cover : Ebenezer

Printed at : EBENEZER PRINTPACK (p) LTD

Published by : **Rosary Publishers**
Vimala Building
Rice Bazar East
Thrissur – 680 001

For copies : Ph: 8893092004, 8281789009

Price : **Rs. 125**

PREFACE

We are introducing with pleasure "**PLUS TWO PHYSICS MADE SIMPLE"** for the benefit of the students of 'Plus Two Physics' who are eager to study and practice more and more applied and analysis questions suited to the present grading system.

We decided to publish this volume giving due regard to the demand of the students and the teachers, to collect various analysis questions and grading model questions with their answers as given in our text book **"PLUS TWO PHYSICS". Answers are given for questions from Edumate, Source book of teachers and for selected questions from NCERT text book. Seven solved previous HSE question papers and a sample question paper are given at the end of the book.**

We have given a lot of short questions with answers, worked out problems and objectives questions with keys in this volume, which are most important in the present grading system as well as in the entrance examinations. We have taken much pain but with pleasure to select the problems and objective questions often asked in various examinations. They will enlighten the students in their scientific thoughts and will develop their analytical skill and will make them confident to face the public examination and other various entrance examinations. We hope that this book would be really helpful to the students to score A+ grade in the public examinations and a higher score in the entrance examinations.

We take this opportunity to thank the teachers and students who welcomed and accepted our books **'Plus One Physics and Plus Two Physics** and for their valuable suggestions for the improvement of the book. We are thankful to Ebenezer (P) Ltd and Rosary publishers Thrissur for printing and publishing this book in time.

Suggestions for the improvement of this book will be gratefully accepted.

Xavier & Joy

CONTENTS

9

RAY OPTICS AND OPTICAL INSTRUMENTS

- Reflection of Light by Spherical Mirrors
- Refraction
- Total Internal Reflection
- Refraction at Spherical Surfaces and by Lenses
- Refraction through a Prism
- Dispersion by a Prism
- Some Natural Phenomena due to Sunlight
- Optical Instruments

POINTS TO REMEMBER

VELOCITY OF LIGHT

The velocity of light in free space or vacuum is 3×10^8 m/sec. This is the maximum possible velocity in nature. In any material medium of refractive index n, the velocity of light is $\frac{c}{n}$. Since n > 1, *the speed of light in a medium is < c.*

- **Ray Optics or Geometrical Optics:**

Geometrical or ray optics is the study of the properties of light and optical instruments. The image produced by the light is constructed by geometrical methods.

- **Rectilinear Propagation:**

Light is assumed to travel along straight line. This is the rectilinear propagation of light.

- **Beam of Light:**

A collection of rays of light is called a beam of light. It can be convergent, divergent or parallel.

IMAGE

1) Real Image:

If the light rays after reflection or refraction converge to a point, a real image is formed. Real image can be obtained on a screen.

2) Virtual Image:

If the rays after reflection or refraction appear to diverge from a point, a virtual image is formed at that point. *We can't obtain this on a screen.* But we can see the virtual image.

LAWS OF REFLECTION

1. The incident ray, the reflected ray and the normal at the point of incidence lie in the same plane.

2. The angle of incidence (i) is equal to the angle of reflection (r). i.e., **i = r**.

[Note: When the medium changes, frequency of light remains the same while velocity and wavelength change]

SPHERICAL MIRRORS

Spherical mirror is a reflecting surface which is part of a spherical body. If the inner surface of a spherical mirror reflects light, it is called a concave mirror. If the outer surface of a spherical mirror reflects light, it is called convex mirror.

- **Centre of Curvature (C):**

Centre of curvature of a spherical mirror is the centre of the sphere of which the mirror is a part.

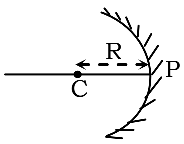
- **Radius of Curvature (R):**

Radius of curvature of a spherical mirror is the radius of the sphere of which the mirror is a part.

- **Pole (P):**

Pole (P) of a spherical mirror is the geometrical centre of spherical mirror.

- **Principal Axis:**



Principal axis is a straight line passing through the pole (P) and the centre of curvature (C) of the mirror.

- **Principal Focus (F):**

A narrow beam of light parallel and close to the principal axis after reflection converges to a point on the principal axis in the case of a concave mirror and appears to diverge from a point on the principal axis in the case of a convex mirror. This point is called principal focus (F) of the spherical mirror.

- **Focal Length (f):**

Focal Length (f) is the distance between pole and the principal focus.

- **Relation between f and R**

R = 2f i.e., *the radius of curvature is twice the focal length.*

THE NEW CARTESIAN SIGN CONVENTION

1. All distances are measured from the pole of the mirror.

2. The distances measured in the direction of incident light are taken positive. (Normally the incident ray is assumed to travel from left to right.)

3. The distances measured opposite to the direction incident light are taken negative.

4. The heights measured upward from the principal axis are taken positive and heights measured downward are taken negative.

IMAGE CONSTRUCTION

Any two light rays starting from a point on the object are reflected by the mirror and then meet at a point to form an image.

1. The ray coming from the object and parallel to the principal axis, after reflection passes through the principal focus of the mirror in the case of a concave mirror (and appears to diverge from the focus in the case of a convex mirror).

2. The ray coming from the object and passing along the principal axis retraces its path after reflection at the pole.

3. The ray coming from the object and directed towards the principal focus goes parallel to the principal axis after reflection.

4. The ray falling at the pole reflects with an angle of reflection equal to angle of incidence.

LAW OF DISTANCES

If **u** is the distance of the object from the mirror and **v** that of the image from the mirror then,

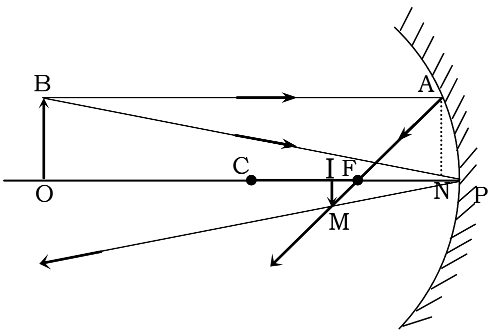
1. Equation for a concave mirror $\frac{1}{u}+\frac{1}{v}=\frac{1}{f}$

2. Equation for a Convex mirror

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

MAGNIFICATION

1) Linear Magnification:



Linear magnification is the ratio of linear size of the image (h_i) to the linear size of the object (h_o). i.e., Magnification

$$m=\frac{\text{linear size of image}}{\text{linear size of object}}=\frac{IM}{OB}=\frac{h_i}{h_0}$$

$m=\frac{IM}{OB}=\frac{v}{u}$, where u is the distance of the object and v the distance of the image from the mirror.

Applying new Cartesian convention, $m=-\frac{v}{u}$. *This is true for all types of images formed by convex or concave mirror.*

2) Areal Magnification:

Areal magnification is the ratio of area of the image to the area of the object. If h_0 and b_0 are the height and breadth of the object and h_i and b_i the height and breadth of the image then

areal magnification $=\frac{\text{Area of image}}{\text{Area of object}}$

$$=\frac{h_i \times b_i}{h_o \times b_o}=m\times m=m^2=\frac{v^2}{u^2}$$

a) Magnification in terms of v and f:

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

b) Magnification in terms of u and f:

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

- **Conjugate Foci:**

For a concave mirror the position of the object and the image are interchangeable. *These positions on the principal axis are called conjugate foci or conjugate points.*

- **Spherical Aberration:**

For a spherical mirror, only the rays parallel and close to the principal axis (*paraxial rays*) pass through the principal focus for a concave mirror. But the rays away from the axis (*marginal rays*) converge to a point nearer to the mirror than the principal focus. Hence the image formed will be blurred (not clear).This defect is known as spherical aberration. It can be minimized by using diagrams to cut either marginal rays or paraxial rays. *Using parabolic mirror spherical aberration can be eliminated.*

IMPORTANT POINTS FOR SOLVING PROBLEMS

1. *The relation* $\frac{1}{u}+\frac{1}{v}=\frac{1}{f}$ *is valid in all cases.*

2. *Magnification* $m=\frac{-v}{u}$ *and thus m is negative for real image and positive for virtual image.*

3. *Give appropriate signs for u, v, f and m except for the particular quantity to be determined*

REFRACTION OF LIGHT

The bending of light at the surface of separation of two media is called refraction.

- **Laws of Refraction:**

1. The incident ray, refracted ray and the normal at the point of incidence on the interface all lie in the same plane.

2. The ratio of sine of angle of incidence (i) to sine of angle of refraction (r) is a constant for a given pair of media and for a given colour of light. This is called *Snell's law.*

i.e., $\frac{\sin i}{\sin r}$ = a constant. The constant is called refractive index ($_1n_2$) of second medium with respect to the first. i.e., $\frac{n_2}{n_1} = {}_1n_2 = \frac{\sin i}{\sin r}$. Here n_1 and n_2 are the absolute refractive indices of medium 1 and medium 2 respectively.

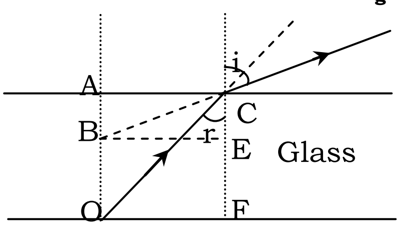
- **Absolute Refractive Index (n):**

The refractive index of the medium with respect to air or vacuum is called the absolute refractive index (n). The ratio of the velocity of light in vacuum **(c)** to the velocity of light in the medium **(v)** is called the absolute refractive index of the medium.

(i.e.) $\mathbf{n} = \frac{\mathbf{c}}{\mathbf{v}}$

- **Apparent Depth:**

$$\textbf{Apparent depth(d)} = \frac{\textbf{original depth(D)}}{\mathbf{n_g}}$$



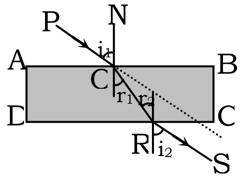
The image is apparently raised from O to B. Now *the elevation* = D – d, where d = apparent depth and D = Actual depth.

The elevation $= D - \frac{D}{n_g} = \mathbf{D}\left(\mathbf{1} - \frac{\mathbf{1}}{\mathbf{n_g}}\right)$

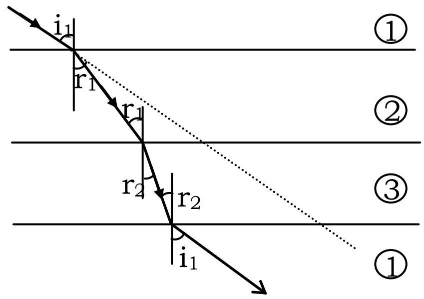
- **Refraction Through a Glass Slab:**

$r_1 = r_2$ hence $i_1 = i_2$

i.e. the incident angle and emerging angle are equal. Hence *the emerging ray is parallel to the incident ray.* But there is a lateral shift when light travels through a glass slab.



- **Refraction through Successive Media:**



Consider a light ray passing through different media (1), (2) and (3) and finally entering the medium (1) as shown in figure.

$$_1n_2 = \frac{\sin i_1}{\sin r_1}, \quad _2n_3 = \frac{\sin r_1}{\sin r_2}, \quad _3n_1 = \frac{\sin r_2}{\sin i_1}$$

$$_1n_2 \times {}_2n_3 \times {}_3n_1 = \frac{\sin i_1}{\sin r_1} \times \frac{\sin r_1}{\sin r_2} \times \frac{\sin r_2}{\sin i_1}$$

$$= \frac{\sin i_1}{\sin i_1} = 1 \quad \therefore \quad _1n_2 \times {}_2n_3 \times {}_3n_1 = 1 \quad \text{or}$$

$$_1n_2 \times {}_2n_3 = \frac{1}{_3n_1} = {}_1n_3 \qquad \text{i.e.,} \quad \mathbf{_2n_3} = \frac{\mathbf{_1n_3}}{\mathbf{_1n_2}}$$

If medium (1) is air then, $_1n_3 = n_3$ and $_1n_2 = n_2$ (the absolute refractive indices). In general $_an_b = \frac{n_b}{n_a}$.

Thus ***the refractive index of medium b with respect to a is the ratio of absolute refractive index of medium b to absolute refractive index of medium a.***

- **Critical Angle:**

At a particular angle of incidence called the critical angle(C), the refracted ray grazes the surface of separation of two media. *The angle of incidence in a denser medium for which angle of refraction in a rarer medium is 90° is called the critical angle of the medium.*

TOTAL INTERNAL REFLECTION

When the angle of incidence just increases from critical angle the ray of light reflects totally into the denser medium itself. *This phenomenon is called total internal reflection.*

At the critical angle of incidence (C) the refractive index of the medium,

$$\mathbf{n} = \frac{\mathbf{1}}{\mathbf{sinC}}$$

- **Two Conditions for Total Internal Reflection:**

1. Light must travel from denser to rarer medium.

2. The angle of incidence in the denser medium should be greater than the critical angle.

- **Advantages:**

1) During total internal reflection, light energy is not lost.

2) The direction of light can be bent using total internal reflection. This is utilized in

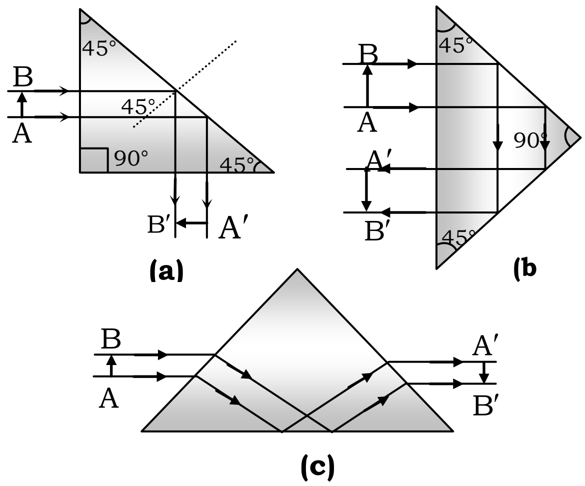
a) Endoscopy using optic fibre and

b) In optic fibre communication

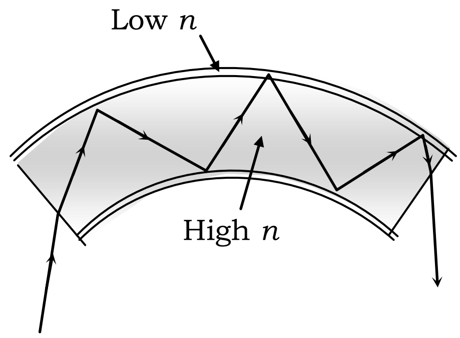
APPLICATION OF TOTAL INTERNAL REFLECTION

- **Total Reflecting Prisms:**

Total reflecting prism is an isosceles right angled glass prism whose critical angle is less than 45°. Total reflecting prisms are used to turn the light ray by 90° and 180° and also to invert the image.



- **Optical Fibre:**

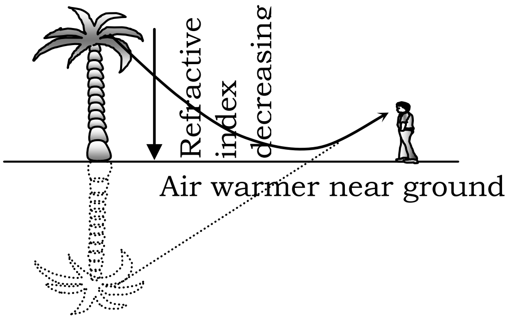


Optical cable consists of a number of glass or quartz fibres. Each fibre consists of a core and a cladding. The refractive index of the core is higher than that of the cladding. Light entering into the core satisfies the two conditions for total internal reflection. Hence it undergoes repeated total internal reflections along the fibre and finally comes out with negligible energy loss.

- **Mirage:**

Mirage is an optical illusion usually observed in hot deserts and hot tarred roads. Reflected image of distant objects can be seen from the ground giving a false impression of the presence of water nearby.

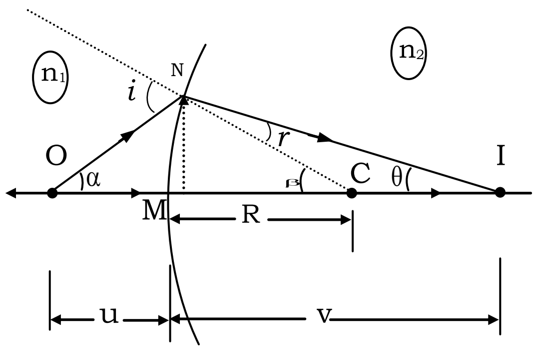
The air close to hot ground is less dense (rarer) as compared with the top layers. Thus density and refractive index gradually decreases as the light goes down.



When the light from a tall object passes through the medium downwards continuous refraction will take place.

The condition for total internal reflection will be satisfied from a layer close to the hot ground. The light now undergoes total internal reflection producing a reflected image of distant object.

- **Refraction at a Spherical Surface (Convex):**



$$\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$$

. When the object is in the denser medium and the ray refracted into a rarer medium, n_1 and n_2 are just interchanged in the above equation.

LENSES

A lens is a transparent medium bounded by two spherical surfaces.

- **Principal Axis:**

There are two centres of curvature for a lens. Principal axis of a lens is the line joining the centres of curvature of the two spherical surfaces of the lens.

a) Convex Lens:

A narrow parallel beam of light parallel and close to principal axis after refraction at a convex lens *actually converges to a fixed point on the principal axis*. This fixed point is called principal focus of a convex lens.

b) Concave Lens:

A narrow parallel beam of light parallel and close to principal axis after refraction at a concave lens *appears to come from a fixed point* on the principal axis. This fixed point is called principal focus of a concave lens.

Note: There are two principal foci each on either side of the lens.

- **Optic Centre (P):**

When a ray of light is incident on one side of a lens in such a way that the emerging ray is parallel to the incident ray, the path of the ray within the lens will cut the principal axis at a point. This fixed point is called optic centre of the lens.

- **Focal Length (f)**

Focal length (f) is the distance between the principal focus and the optic centre.

REFRACTION THROUGH A LENS: - LENS MAKER'S FORMULA

$$\mathbf{\frac{1}{f}=\left(\frac{n_2}{n_1}-1\right)\left[\frac{1}{R_1}-\frac{1}{R_2}\right]}$$

If the lens is kept in air then n_1=1 and n_2 = n, where n_2 is the absolute refractive index of the lens,

then $\mathbf{\frac{1}{f}=(n-1)\left[\frac{1}{R_1}-\frac{1}{R_2}\right]}$.

This formula is called lens makers formula. This is true for all types of lenses.

- **Law of Distances:**

$\mathbf{\frac{1}{v}-\frac{1}{u}=\frac{1}{f}}$ **or** $\mathbf{f=\frac{uv}{u-v}}$. *This is called the law of distances for any lens.*

IMAGE CONSTRUCTION

For constructing the image formed by a lens two light rays coming from the same point of the object are considered.

1. A ray traveling parallel to the principal axis after refraction passes through the principal focus on the other side in the case of a convex lens or appears to diverge from the first principal focus on the same side in the case of a concave lens.

2. A ray passing through the optic centre of the lens emerges without any deviation after refraction.

- **Magnification:**

Magnification is defined as the ratio of linear size of the image (h_i) to the linear size of the object (h_0).

i.e $m=\frac{\text{linear size of image}}{\text{linear size of object}}=\frac{h_i}{h_0}=\frac{v}{u}$,

where v = the distance of the image from the lens and u = the distance of the object from the lens.

For erect (or virtual) image formed by a convex or concave lens m is positive. For inverted (or real) image m is negative.

POWER OF A LENS (P)

Power of a lens (P) *is the reciprocal of the focal length expressed in meter.*

i.e. Power, $P=\frac{1}{f}$.

The unit of power is **dioptre** (**D**).

- **Dioptre:**

One dioptre is the power of a lens of focal length 1m. Power P is positive for a converging and it is negative for a diverging lens.

- **Combination of Thin Lenses (in contact):**

Consider two lenses A and B of focal lengths f_1 and f_2 kept in contact. Then, the effective focal length f is given by

$$\mathbf{\frac{1}{f}=\frac{1}{f_1}+\frac{1}{f_2}}.$$

If there are several thin-lenses of focal lengths f_1, f_2, f_3, etc. in contact then, the effective focal length f is given by

$$\frac{1}{f}=\frac{1}{f_1}+\frac{1}{f_2}+\frac{1}{f_3}\ \text{etc.}$$

If P_1, P_2 and P_3 etc. are the powers of lenses, then effective power, P is given by,

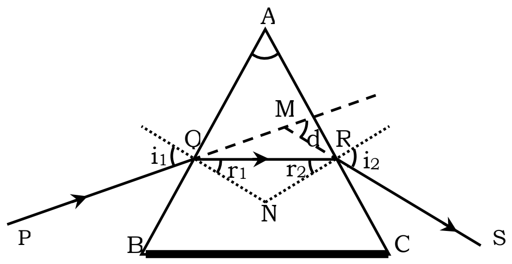
$$P = P_1+P_2+P_3+\ldots$$

If m_1, m_2 and m_3 etc. are the magnification produced by the lenses, then the resultant magnification, m is given by

$$\mathbf{m = m_1 \times m_2 \times m_3} \ldots\ldots$$

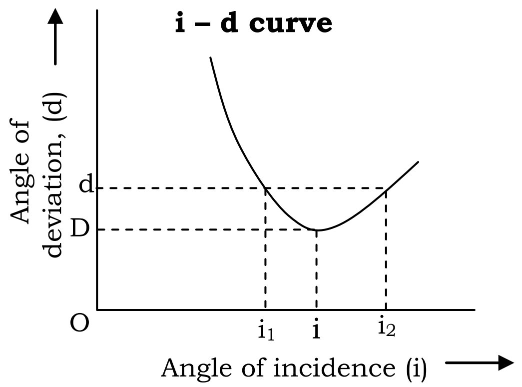
REFRACTION THROUGH A PRISM

The course of ray through a glass prism is as shown in the fig.



Angle of prism, $\mathbf{A = r_1 + r_2}$,

The deviation produced by the prism, $\mathbf{d = i_1 + i_2 - A}$, where $\mathbf{i_1}$ is the angle of incidence and $\mathbf{i_2}$, the angle of emergence.



$\mathbf{r} = \dfrac{\mathbf{A}}{\mathbf{2}}$, $\mathbf{i} = \dfrac{\mathbf{A+D}}{\mathbf{2}}$. The refractive index,

$$n = \frac{\sin i}{\sin r} = \frac{\sin\frac{A+D}{2}}{\sin\frac{A}{2}}$$

- **The i-d Curve:**

A graph drawn with angle of incidence i along X-axis and deviation d along Y-axis is known as the i-d curve. For a given value of deviation d, there are two possible angles of incidence i_1 and i_2.

- **Angle of Minimum Deviation D:**

As the angle of incidence increases, the angle of deviation decreases, it reaches a minimum value and then increases. *The smallest value of deviation is called the angle of minimum deviation D.*

- **At the Minimum Deviation Position:**

At the minimum deviation position,

$\mathbf{i_1 = i_2 = i}$, $\mathbf{r_1 = r_2 = r}$ and $\mathbf{d = D}$

Now, *the ray passes through the prism horizontal to the base.*

- **Dispersion of Light due to a Prism:**

When a beam of white light passes through a prism, it splits into constituent colours. This phenomenon is called dispersion.

SPECTRUM OF LIGHT

The angle of refraction is maximum for violet and minimum for red. Hence violet is deviated the most and red is deviated the least. The sequences of different colours obtained on the screen are called the spectrum of light.

- **Angular Dispersion:**

The angular dispersion between two colours is the difference between their deviations. *If d_v and d_R are the deviations for the violet and the red respectively, then angular dispersion is equal to d_v-d_R.*

DEVIATION PRODUCED BY A SMALL ANGLED PRISM: D = A (N–1)

- **Dispersive Power (ω):**

The dispersive power (ω) of the material of the prism for any two colours is defined as the ratio of the angular dispersion of the colours to their mean deviation.

Dispersive power, $\boldsymbol{\omega} = \dfrac{\mathbf{d_V - d_R}}{\mathbf{d}}$

Here $d = \dfrac{d_V + d_R}{2}$ is the mean deviation.

- **Dispersive Power of a Small Angled Prism:**

Dispersive power of a small angled prism, $\boldsymbol{\omega} = \dfrac{(\mathbf{n_v - n_R})}{\mathbf{n - 1}}$

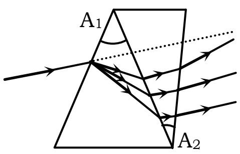
Here $n = \dfrac{n_v + n_R}{2}$, is the mean refractive index of violet and red.

COMBINATION OF PRISMS

Two prisms of suitable materials and suitable angles can be combined to produce either dispersion without deviation for the mean ray or deviation without dispersion for the mean ray.

a) Dispersion without deviation:

In this case deviation produced by first prism will be equal and opposite to the deviation produced by the second prism. $\dfrac{\mathbf{A_1}}{\mathbf{A_2}} = -\left(\dfrac{\mathbf{n_2 - 1}}{\mathbf{n_1 - 1}}\right)$ The condition for the combination to have dispersion without deviation



b) Deviation without dispersion (Achromatic combination):

In this case, the dispersion produced by first prism will be equal and opposite to the dispersion produced by the second prism. This combination is also called an achromat. The condition for achromatic combination $\dfrac{A_1}{A_2} = -\left(\dfrac{n_{2V} - n_{2R}}{n_{1V} - n_{1R}}\right)$

- **Some Natural Phenomena Due To Sunlight:**

Some of the natural phenomena due to sunlight are red hue at sunrise and sunset, the blue of the sky, white clouds, the rainbow, and brilliant colours of some pearls and shells etc.

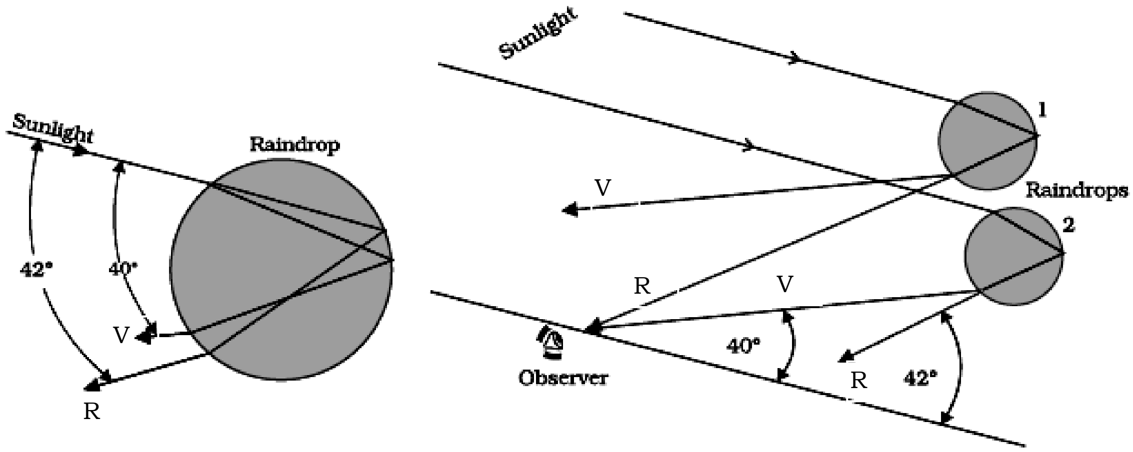
- **The Rain bow:**

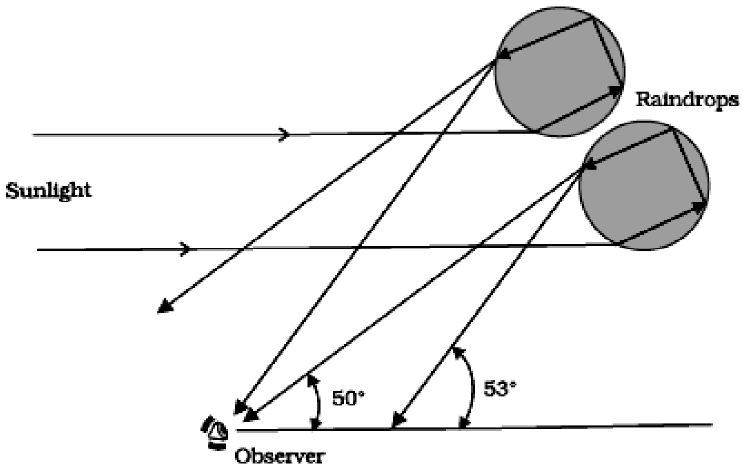
Rainbow is a phenomenon due to combined effect of dispersion, refraction and reflection of sunlight by water droplets of rain. The rainbows are observed during rainy days near the eastern horizon if the sun is in western sky. The rainbow appears near western horizon if the sun is the eastern sky. Various colours appear in the primary rainbow with ***red colour on the top and violet on the bottom.*** fig. (a and b) Sometimes a fainter second rainbow called secondary rainbow appears over the primary rainbow.

For the secondary rainbow violet colour is on the top and the red is at the bottom. fig. (c)

The formation of rainbow is as follows. The sunlight is first refracted as it enters into rain drop. The colours are separated, violet bending the most and red the least. The refracted colours are totally reflected from the inner surface of the drop if the angle of incidence is greater than the critical angle (48^0 for water). These rays are further refracted and come out of the drop.

The violet light emerges at an angle of 40^0 ***and red light at an angle of*** 42^0 ***with the initial direction of the sunlight. Thus red appears at the top and violet at the bottom of the rainbow.*** ***Fig.*** (a & b)





A secondary rainbow is formed when the light undergoes two total internal reflections inside the rain drop (fig c). The violet light emerges at an angle of 53^0 ***and red at an angle of*** 50^0 ***with the initial direction of the sunlight. Hence the violet colour comes at the top and red colour at the bottom of the secondary rainbow.***

SCATTERING OF LIGHT

• Rayleigh Scattering:

Light is scattered by dust particles or molecules of the atmosphere. *According to Rayleigh, the intensity of scattered light is inversely proportional to the fourth power of wavelength of the incident light.*

i.e, $I \propto \frac{1}{\lambda^4}$

- **Coherent Scattering:**

Rayleigh scattering is a coherent scattering as the wavelength is unchanged on scattering.

- **Blue Colour of Sky:**

The sunlight is scattered by large number of molecules present in the earth's atmosphere. $I \propto \frac{1}{\lambda^4}$ i.e. The light of shorter wavelength (blue) is scattered much more than the light of longer wavelength. Thus blue colour is dominated in the light scattered from the sky. Hence the sky appears blue.

- **Reddish Colour During Sunrise or Sunset:**

During sunrise or sunset, the light from the sun has to travel longer distance through earth's atmosphere. Most of the blue colour and shorter wavelengths are removed by scattering. Red colour is scattered less and hence it reaches our eye. Hence the setting sun or rising sun appears red.

OPTICAL INSTRUMENTS

1) Simple Microscope:

A simple microscope is a converging lens of short focal length. The lens is held near the object such that the object is within the focal length of the lens. Eye is kept close to the lens. A virtual magnified erect image is formed on the same side as that of the object.

- **Magnifying Power (Angular Magnification) (m):**

Magnifying power is defined as the ratio of the angle subtended by the image at the eye to the angle subtended by the object seen directly when both are at the least distance of distinct vision.

i.e. $$m = \frac{(IM/D)}{(OB/D)} = \frac{IM}{OB}.$$

$$\therefore \quad \mathbf{m} = \mathbf{1} + \frac{\mathbf{D}}{\mathbf{f}}.$$

2) Compound Microscope:

For a compound microscope, two convex lenses are used. One lens is of short focal length, known as the objective. The other lens is of long focal length, known as the eyepiece. These lenses are mounted at the ends of two co-axial tubes.

- **Magnification(m):**

The magnification produced by the objective,

$\mathbf{m_0} = \frac{\mathbf{v_0}}{\mathbf{u_0}}$, where v_0 is the distance of image and u_0 the distance of the object from the objective. Magnification produced by the eyepiece, when the image is at the least distance of distinct vision is given by

$\mathbf{m_e} = \mathbf{1} + \frac{\mathbf{D}}{\mathbf{f_e}}$, where f_e is the focal length of the eyepiece.

The magnification produced by the microscope is the product of the magnification produced by the eyepiece and that produced by the objective.

$$\mathbf{m} = \mathbf{m_0} \times \mathbf{m_e} = \frac{\mathbf{v_0}}{\mathbf{u_0}}\left(\mathbf{1} + \frac{\mathbf{D}}{\mathbf{f_e}}\right)$$

If L is the distance between the objective and the eyepiece, then $\mathbf{m} = \frac{\mathbf{L}}{\mathbf{f_0}}\left(\frac{\mathbf{D}}{\mathbf{f_e}}\right)$, where f_0 is the focal length of the objective.

3) a) Astronomical Telescope (Refracting type):

For an astronomical telescope, two convex lenses are used, one lens is of short focal length called *eyepiece* and other lens is of long focal length called the objective. These lenses are mounted at the ends of the co-axial tubes.

The final image can be formed at the least distance of distinct vision or at infinity. *When the final image is formed at infinity, the telescope is said to be in normal adjustment. Now the total distance between the lenses will be* f_o+f_e.

- **Magnification:**

Magnification of a telescope is defined as the ratio of the angle subtended by the final image (β) at the eye to the angle subtended by the object (α).

Magnification, $\mathbf{m} = \frac{\beta}{\alpha} = \frac{f_0}{f_e}$

(in the normal position)

Or $\mathbf{m} = \frac{f_0}{f_e}\left(1 + \frac{f_e}{D}\right)$

(when the final image is formed at the least distance of distinct vision, D)

b) Astronomical Telescope (Reflecting Type):

In the reflecting telescope, the objective will be a parabolic concave mirror of large aperture. The image will be formed at the focal plane of this mirror. Using a convex mirror the light is focused on the eye piece through a hole on it.

RESOLVING POWER OF AN OPTICAL INSTRUMENT

The resolving power of an optical instrument is the ability to resolve two points which are close to each other.

- **Resolving Power of Microscope:**

The resolving power of the microscope is defined as the reciprocal of the minimum distance between two point objects which can just be seen through the microscope separately.

$$\text{Resolving power} = \frac{1}{d} = \frac{2n\sin\theta}{\lambda}$$

Resolving power can be increased by increasing n and θ and decreasing λ

- **Resolving Power of Telescope:**

The resolving power of a telescope is defined as the reciprocal of the smallest angular separation between two distant objects whose images are seen separated in the telescope. If dθ is the smallest angular separation, then

the resolving power $= \frac{1}{d\theta} = \frac{a}{1.22\lambda}$, where λ is the wavelength of the light used and 'a' is the aperture of the objective.

SPECTROMETER

The spectrometer is an instrument to analyse the spectrum of a composite light. It is used to measure the wavelength of the spectral lines and also the refractive index of the material of prism.

1. Collimator:

The function of a collimator is to collimate (make parallel) the light from the source.

2. Telescope:

The telescope is usually set to receive the parallel rays coming from collimator. The telescope along with the circular scale can be rotated about a vertical axis.

3. Prism Table:

Prism table is a circular disc provided with leveling screws. It is attached with a **vernier table** with two verniers V_1 and V_2 arranged diametrically opposite on the circular scale.

SHORT QUESTIONS WITH ANSWERS

SQ1) *On which factors does the speed of light in vacuum depend?*
Ans: *Speed of light in vacuum is a universal constant.*
SQ2) *What is the speed of light in still water if n is the refractive index of water?*
Ans: *The speed of light in water is* $\frac{c}{n}$.
SQ3) *What was the failure of corpuscular theory in the prediction of velocity of light?*
Ans: *Corpuscular theory predicted greater velocity of light in denser medium. This was disproved by Foucault's experiment.*
SQ4) *How does a blue coloured object appear in sodium lamp light?*
Ans: *It will look black. Because a blue object absorbs all colours except blue.*
SQ5) *According to new Cartesian sign convention give the nature of u, v, f and R for a) concave mirror, b) convex mirror.*
Ans: *a) For concave mirror: i) for real image u, v, f and R all negative. ii) for virtual image v positive and u, f and R all negative.*
b) for convex mirror: ***only virtual image****: u negative and v, f and R all positive.*
(Note: For virtual image ***(concave mirror)*** *v +ve, all others –ve.*
For virtual image ***(convex mirror)*** *u –ve all others +ve)*
SQ6) *Explain why a ground glass does not produce a clear image*
Ans: *The reflected light will be diffused because of the irregularities on the surface of ground glass. Hence the image will not be clear.*
SQ7) *Can we see or photo graph a virtual image? Explain how.*
Ans: *We can see and photograph a virtual image. This is done by focusing the virtual image by the eye lens or camera lens.*
SQ8) *What will be the focal length of a plane mirror?*
Ans: *The radius of curvature of a plane mirror is infinity. Therefore focal length also will be infinity.*
SQ9) *Can a convex mirror form a real image Why?*
Ans: *Convex mirror cannot form a real image. It always forms a virtual image. A convex mirror always diverges the incident beam. That is it appears to diverge from a point behind the mirror. Hence the image is always virtual.*
SQ10) *Show that for a plane mirror image is as far behind as the object is from the mirror.*
Ans: $\frac{1}{f}=\frac{1}{u}+\frac{1}{v}$. *By sign convention u is -ve and v is +ve.* $\therefore \frac{1}{f}=\frac{1}{-u}+\frac{1}{v}$

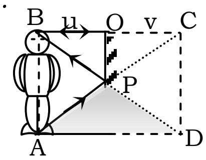
$$\because f=\infty,\ \frac{1}{f}=0\ \ \therefore 0=\frac{1}{-u}+\frac{1}{v}$$

$$i.e.,\ \frac{1}{u}=\frac{1}{v}\quad or\quad u=v.$$

That is the distance of the object is equal to distance of the image from the plane mirror.
SQ11) *Explain why parabolic mirrors are used in search lights?*
Ans: *If the source of light is kept at the principle focus of the parabolic mirrors the reflected light will go long distances parallel to the principal axis. Thus spherical aberration is eliminated in a parabolic mirror.*
SQ12) *Can you focus a converging beam using a plane mirror?*
Ans: *Yes. A converging beam can be focused using a plane mirror.*
SQ13) *What is the type of mirror used to see the rear side of a motor cycle? Explain.*
Ans: *A convex mirror is used. The image formed by convex mirror will be erect, virtual and diminished. Hence the motor cyclist gets a wider field of view of the back side.*
SQ14) *Show that to see the image of a body of height h, the height of the mirror should be h/2*
Ans: *u = v, BO = OC.*
ΔABC and Δ POC are similar.

$$\therefore \frac{OC}{OP}=\frac{BC}{AB}.$$

$$\therefore\ OP=\frac{OC}{BC}\times AB=\frac{1}{2}AB$$



SQ15) *If a and b are the distances of object and the real image away from the focus of a concave mirror of focal length f, get Newton's formula or show that* $f=\sqrt{ab}$.

Ans: *u = – (f+a), v = – (f+b) and f= –f.*

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

$$\frac{1}{-(f+a)}+\frac{1}{-(f+b)}=\frac{1}{-f},$$

$$\frac{-f-b-f-a}{f^2+fb+fa+ab}=\frac{1}{-f}$$

$$-2f^2-fb-fa=-f^2-fb-fa-ab$$

i.e, $f^2 = ab$ *or* $f=\sqrt{ab}$

SQ16) *When a parallel beam is incident on a plane mirror what is the angle of deviation*

Ans: *Angle of deviation = 180-2i, where i is the angle of incidence.*

SQ17) *Does a man appear shorter or taller for a fish under water? Explain*

Ans: *The man looks taller for the fish under water. This is because the light entering water deviates towards the normal on refraction.*

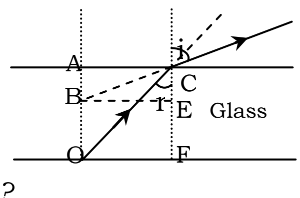
SQ18) *Is the apparent depth of a tank with water greater than the original depth? Explain.*

Ans: *The apparent depth is less than the original depth. This is because the light coming from bottom surface of the water tank deviates away from the normal on refraction.*

SQ19) *Sun is visible for a few seconds before sunrise and after sunset. Explain*

Ans: *Light coming from the sun under horizon is refracted as shown. The final image is seen above the horizon. Thus we can see sun even after sunset and before sunrise.*

SQ20) *In the given diagram (fig.) showing apparent depth, glass is replaced by water and the air is replaced by glass medium. Then what change is produced in the apparent depth?*



Ans: *The apparent depth will increase as the light from the rarer medium (water) entering the denser medium (glass) is deviated towards the normal drawn at the surface of separation. The increase in depth is given by,* $D({}_g n_w - 1)$

SQ21) *What is the cause of refraction?*

Ans: *The velocities of light are different for different media. This causes refraction.*

SQ22) *What is the principle behind the glittering of diamonds?*

Ans: *The refractive index of diamond is very high of about 2.42. Hence the critical angle is about 24°. In a properly cut diamond the light entering into it will undergo total internal reflections several times and emerge through certain sides producing a glittering effect.*

SQ23) *If* ${}_i n_j$ *represents the refractive index of medium j with respect to medium i then, what will be the product of the refractive indices* ${}_2n_1 \times {}_3n_2 \times {}_4n_3$*?*

Ans: *The product =* $(n_1/ n_2) \times (n_2/ n_3) \times (n_3/ n_4) = (n_1/ n_4) = {}_4n_1$ *i.e. refractive index of medium 1 w.r.t medium 4*

SQ24) *If the absolute refractive index of glass is 3/2 and that of water is 4/3, then explain how to find the critical angle at the interface of the two media.*

Ans: *Refractive index of glass w.r.t water* $({}_w n_g) = (3/2) / (4/3) = 9/8$.

At the critical angle, $\sin C = 1/{}_w n_g = 8/9$.

$\therefore$ *critical angle* $C = \sin^{-1}(8/9)$

SQ25) *Why does mirage disappear as we approach the object?*

Ans: *If the object is nearby the rays from the object come downwards at a smaller angle of incidence and hence may not attain the critical angle even from the lowest layer. Hence total internal reflection will not take place. So the image disappears.*

SQ26) *What are the advantages of optical fibre communication?*

Ans: *The advantages of optical fibre communication are (1) Minimum energy loss (2) high bandwidth and (3) no electromagnetic interference.*

SQ27) *Explain why an air bubbles in a jar of water shines brightly.*

Ans: *Light entering water in the jar gets totally reflected from the bubble. Hence the bubble appears bright.*

SQ28)a) *Explain why a lens has foci on either side while a spherical mirror has only one focus.*

Ans: *For a lens light can be incident from both sides. Correspondingly there are two foci. But for a spherical mirror light can be incident only from one side of the mirror. Hence it has only one focus.*

SQ28) b) *There is a dot at the centre of a spherical glass. If it is viewed from a medium of water surrounding the glass, where will be the image of the dot formed?*

Ans: *As the dot is at the centre of the curvature light passes straight at the interface. Hence the image formed will be virtual and it is at the centre itself.*

SQ29) *What happens to the focal length for a concave mirror and a convex lens kept under water?*

Ans: *A concave mirror forms an image due to reflection hence medium change dos not alter its focal length. But the convex lens forms an image due to the refraction. Its focal length depends on the refractive index of the medium. The focal length of the convex lens is given by,* $\frac{1}{f}=\left(\frac{n_2}{n_1}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$. *Focal length of convex lens will increase since the refractive index of glass with respect to water is less than the refractive index of glass with respect to air.*

SQ30) *The power of sun glasses is zero though they have curved surfaces. Explain.*

Ans: *Both the surfaces of the sun glass have the same radii. i.e.,* $R_1 = R_2 = R$;

$\therefore\ P = \frac{1}{f} = (n-1)\left(\frac{1}{R}-\frac{1}{R}\right) = 0$. *So the sun glass is neither converging nor diverging.*

SQ31) *A convex lens of refractive index* n_2 *is immersed in a medium of refractive index* n_1. *Is the lens convergent or divergent if i)* $n_2 > n_1$ *ii)* $n_2 < n_1$ *and iii)* $n_2 = n_1$?

Ans:. $\frac{1}{f}=\left(\frac{n_2}{n_1}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$. *If* $n_2 > n_1$, *f is +ve, the lens is convergent (convex) lens. If* $n_2 < n_1$, *f is -ve, the lens is divergent (concave) lens. When* $n_2 = n_1$, $1/f = 0$ *or* $f = \infty$. *The lens will behave as a plane glass plate.*

SQ32) *Can you (1) get the virtual image on a screen (2) photograph a virtual image and (3) see a virtual image? Explain.*

Ans: *(1) No, Virtual image is a divergent light. Hence cannot focus on a screen.*
(2) Yes. We can photograph a virtual image
(3) Yes. We can see a virtual image. During photographing or seeing the divergent beam is further focused by the camera lens or the eye lens.

SQ33) *Find the magnification produced by a combination of a convex lens with magnification 2 and a concave lens with magnification* $\frac{1}{3}$. *Is the combination diverging?*

Ans: *Resultant magnification,* $m = m_1 \times m_2$.
i.e., $m = 2 \times \frac{1}{3} = \mathbf{\frac{2}{3}}$. *It is diverging.*

SQ34) *A convex lens of focal length* f_1 *and concave lens of focal length* f_2 *were combined. Give the condition for the combination to be* ***(i)*** *converging* ***(ii)*** *diverging and* ***(iii)*** *plane glasses.*

Ans: *Focal length of the combination is*

$\frac{1}{F}=\frac{1}{f_1}+\frac{1}{f_2}$ $\quad\therefore\ F=\frac{f_1 f_2}{f_1+f_2}$.

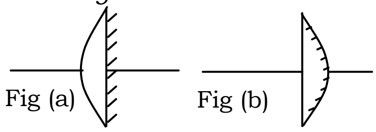
But f_2 *is –ve.* $\quad\therefore\ F=\frac{f_1 f_2}{f_2-f_1}$.

(i) *The combination will be converging when F is +ve i.e. when* $f_2 > f_1$ *i.e., when focal length of concave lens is greater than that of the convex lens.*

(ii) *The combination will be diverging when F is –ve i.e. when* $f_2 < f_1$ *i.e., when focal length of concave lens is less than that of the convex lens.*

(iii) *The combination will be neither converging nor diverging when F is infinity i.e. when* $f_2 = f_1$ *i.e., when focal length of concave lens is equal to that of the convex lens.*

SQ35) *Figure shows a Plano-convex lens, with its plane surface silvered in fig (a) and the concave surface silvered in fig (b). Calculate the focal length in each case.*



Ans: i) *When the plane surface is silvered,*

The effective focal length F, is given by, $\frac{1}{F} = \frac{1}{f}+\frac{1}{f}+\frac{1}{f_m}$ *...(1) where f is the focal length of the convex surface.*

A light ray, entering the lens undergoes refraction twice (so $\frac{1}{f}+\frac{1}{f}$ *is taken) before coming out of the lens after reflection from the plane surface. The focal length of the plane mirror,* $f_m = \infty$

Substituting $f_m = \infty$ *in (1) we get,*
$\frac{1}{F}=\frac{2}{f}$; $\therefore F=\frac{f}{2}$

By the lens makers formula we have,
$\frac{1}{f}=(n-1)\left(\frac{1}{R}-\frac{1}{\infty}\right)=\frac{n-1}{R}$. $\therefore F=\frac{f}{2}=\frac{R}{2(n-1)}$

ii) *When the curved surface is silvered.*
$\frac{1}{F}=\frac{2}{f}+\frac{1}{f_m}$. *In this case,* $f_m=\frac{R}{2}$; $\frac{1}{f}=\frac{n-1}{R}$.

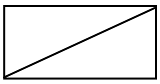
$\frac{1}{F}=\frac{2(n-1)}{R}+\frac{2}{R}=\frac{2n}{R}$, *or* $F=\frac{R}{2n}$.

SQ36) *Can dispersion be produced by reflection?*

Ans: *No. Dispersion is produced only by refraction. This is because the angle of refraction is different for different colours.*

SQ37) *Explain why a rectangular glass slab does not produce dispersion*

Ans: *The dispersion produced by the first diagonal half of the glass slab is cancelled by the other half.*



SQ38) *Can you make an achromatic combination using a convex lens and concave lens of same material? Why?*

Ans: *No. For the same material* $\omega_1 = \omega_2 = \omega$.
$\therefore$ *Condition for achromatism becomes*
$\frac{\omega}{f_1}+\frac{\omega}{f_2}=0$ *or* $\frac{1}{f_1}+\frac{1}{f_2}=0$. *i.e. the combination becomes of infinite focal length. i.e., combination is neither converging nor diverging.*

SQ39) *Can you make an achromatic combination using two prisms of same material?*

Ans: *No. Condition for achromatism* $(n_{1V}-n_{1R})A_1=-(n_{2V}-n_{2R})A_2$.

For the same material $(n_{1V}-n_{1R})=(n_{2V}-n_{2R})$

$\therefore$ *We get,* $A_1=-A_2$. *i.e., the combination acts as a rectangular slab.*

SQ40) *Explain why some clouds appear white*

Ans: *Clouds contain water droplets. As they are quite large, Rayleigh scattering is not obeyed. They scatter all colours equally. Hence clouds appear white.*

SQ41) a) *Explain why the danger signals are red even though yellow light is most sensitive to the eye*

Ans: *According to Rayleigh, intensity of scattered light is inversely proportional to the fourth power of wavelength. So scattering of red is less than yellow. Red light can pass long distances without much loss of intensity. Hence red is preferred in danger signals.*

SQ41) b) *Explain why red appears at the top of primary rainbow while violet appears at the top of secondary rainbow*

Ans: *Refer page 9 - 9 & 9 - 10*

SQ42) a) *Explain why rainbow has the shape of a bow or an arc*

Ans: *The locus of water droplets sending total internally reflected rays to the observer's eyes will be in the form of part of a circle or an arc. Hence it appears as bow.*

SQ42) b) *Explain why the rainbow appears only for a few minutes and then vanishes completely*

Ans: *As the position of the sun changes the direction of total internally reflected rays also changes. Hence we can see the rainbow only for a few minutes.*

SQ43) a) *If a glass prism is surrounded by water what happens to the deviation produced?*

Ans: *Refractive index of glass with respect to air,* ${}_an_g=\frac{\sin(A+D)/2}{\sin A/2}$. *i.e, n depends on D.*

${}_wn_g < {}_an_g$ $\therefore$ *D also decreases. i.e., deviation produced by the prism decreases.*

SQ43) b) *A ray of light incident at* 90^0 *on one side of a prism (A=*60^0*) emerges through the other side gracing the surface. What is the refractive index of the material?*

Ans: *In this condition the refracted ray passes through the prism parallel to the base.*

$\therefore$ *Angle of refraction will be* 30^0.

$\therefore$ *refractive index,* $n=\frac{\sin 90}{\sin 30}=\frac{1}{1/2}=2$.

SQ44) *What are the drawbacks of simple microscope?*

Ans: *The magnifying power of a simple microscope cannot be increased beyond a certain limit as focal length cannot be decreased very much.*

SQ45) *Magnifying power of a simple microscope is m=D/f. Making the focal length of a convex lens smaller and smaller can we achieve greater magnifying power?*

Ans: *As f decreases the effect of spherical and chromatic aberrations becomes greater. Hence it is difficult to reduce the focal length beyond certain limit.*

SQ46) *In which colour of the light the object should be viewed by a microscope for better magnifying power?*

Ans: *Magnifying power, $m = 1 + \frac{25}{f}$. Focal length for violet is minimum. Hence for better magnifying power the object should be viewed in violet light.*

SQ47) *Can you convert a microscope into a telescope by interchanging its objective and eye-piece?*

Ans: *No. For a telescope f_o should very large. This cannot be achieved by interchanging the objective and the eye piece of a microscope.*

SQ48) *What are the advantages and disadvantages of using large aperture for the objective of a telescope?*

Ans: *Advantage: The large aperture is necessary to get sufficient intensity for the image. Disadvantage: When large aperture is made, spherical aberration will be large.*

SQ49) *Binoculars are telescopes. But the length is short. Explain.*

Ans: *In a binocular the light is twice bent using total reflecting prisms. Hence its effective length of binocular is thrice its length*

SQ50) *The objective of a telescope A has a diameter 3 times that of the objective of telescope B. Find the ratio of the light gathered by A to B?*

Ans: *Light incident is proportional to face area of the lens. For lens A diameter is 3 times the diameter of B. Hence area is 9 times the area of B. Hence the ratio of the light gathered by A to the light gathered by B is 9:1.*

SQ51) *What is the difference of a terrestrial telescope from an astronomical telescope regarding the image concerned?*

Ans: *The image in a terrestrial telescope will be erect while the image in the astronomical telescope will be inverted*

SQ52) *Explain how the astronomical telescope is converted to a terrestrial telescope?*

Ans: *The final image of the astronomical telescope is made erect by using erecting lens*

MODEL QUESTIONS WITH ANSWERS

1. When a light ray travels from medium I in to medium II it bends at the surface of separation of the two media. n_1 is refractive index of medium I and n_2 the refractive index of medium II .

a) What is this phenomenon called?

b) If the angle of incidence is greater than the angle of refraction, which is true

(i) $n_1 > n_2$ (ii) $n_1 < n_2$ (iii) $n_1 = n_2$

c) Give Snell's law hence defines refractive index.

Ans. a) This phenomenon is called refraction.

b) ii) $n_1 < n_2$

c) The ratio of sine of angle of incidence (i) to the sine of angle of refraction (r) is a constant, for a given pair of media and for a given colour of light.

i.e., $\frac{\sin i}{\sin r}$ ***= a constant. The constant is called refractive index ($_1n_2$) of second medium with respect to the first.***

i.e., $\frac{n_2}{n_1} = {}_1n_2 = \frac{\sin i}{\sin r}$

2. a) Draw a diagram showing the incidence ray refracted ray, angle of incidence and angle of refraction when a light ray enters from a denser medium into a rarer medium.

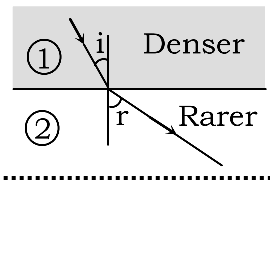
b) How does the angle of refraction vary with angle of incidence?

c) State whether true or false. Correct the statements if false.

(i) Incident ray, the normal at the point of incidence and the refracted ray will not lie in the same plane

(ii) If $n_2 < n_1$, then $i > r$, where i is angle of incidence in the first medium

Ans. a)



b) The angle of refraction (r) increases with the increase of angle of incidence (i) such that $\frac{\sin i}{\sin r}$ is equal to a constant.

c) (i) False. Incident ray, the normal at the point of incidence and the refracted ray will lie in the same plane

(ii) False. If $n_2 < n_1$, then i <r, where i is angle of incidence in the first medium

3 a) Express the refractive index of a medium as a ratio of the velocities of light in vacuum (C) and in medium (v) respectively

b) What is absolute refractive index?

c) What is refractive index of free space or vacuum?

d) If absolute refractive index of glass is n_g and absolute refractive index of water is n_w, what is refractive index of glass with respect of water?

Ans: a) Refractive index of a medium. $\frac{c}{v}$

b) The refractive index of the medium with respect to air or vacuum is the absolute refractive index (n).

c) The refractive index of free space or vacuum will be equal to one.

d) The refractive index of glass with respect of water is equal to $\frac{n_g}{n_w}$

4. a) What is total internal reflection?

b) What are the necessary conditions for total internal reflection?

c) Explain mirage on the basis of total internal reflection

Ans a) When a light ray enters from a denser to a rarer medium and when the angle of incidence is greater than a particular angle called the critical angle the light is not refracted, but reflected totally into the medium itself. This is called total internal reflection.

b) The necessary conditions for total internal reflection are (i) Light must travel from denser to rarer medium and (ii) The angle of incidence in the denser medium should be greater than the critical angle

c) Refer Page 9-5

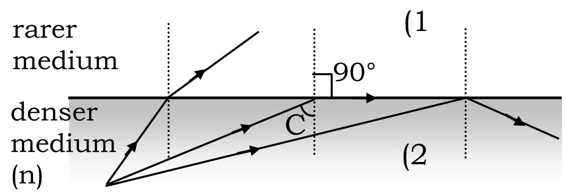
5. a) Give a diagram showing total internal reflection

b) What is critical angle?

c) What happens to the ray of light when incident at critical angle?

d) Obtain a relationship between refractive index and critical angle

Ans. a)



b) The angle of incidence in a denser medium for which angle of refraction in a rarer medium is 90° is called the critical angle of the medium.

c) At the critical angle of incidence the ray grazes the surface of separation of the two media.

d)Refractive index

$$n = \frac{\sin i}{\sin r} = \frac{\sin 90}{\sin C} = \frac{1}{\sin C} \quad \text{i.e. } \mathbf{n} = \frac{\mathbf{1}}{\mathbf{\sin C}}$$

6. a) Which principle is used in optical fibers?

b) What are the uses of optic fibers?

c) What is the use of total internal reflection in binoculars?

d) What is the principle behind the glittering of diamonds?

Ans a) The principle used in optic fibers is the total internal reflection.

b) Optical fibres are used i) in telecommunications (ii) in endoscope .....

c) Two total reflecting prisms are used in binoculars, so that the rays of light are bent twice at 180°. This helps to reduce the size of the binocular.

d) The diamonds are cut properly so that the light entering the diamond undergoes multiple total internal reflections and comes out through certain sides producing the glittering effect.

7. A coin is placed at the bottom of a water tank. The height of water from the bottom is '***h***' and the refractive index of water is n_g.

a) Is the apparent depth ***d*** less than or greater than ***h*** when viewed from above?

b) Can you derive an expression for the refractive index of water using apparent depth ***d*** and actual depth ***h***?

c) Does the apparent depth increase or decrease when viewed at an angle?

d) State true or false. Correct if it is false.

When the angle of view is increased, at a particular angle the coin disappears from the view.

Ans a) Apparent depth d is less than h.

b) Refractive index

$$n_w = \frac{\text{original depth}}{\text{apparent depth}} = \frac{h}{d}$$ ***(Refer text)***

c) The apparent depth decreases when viewed at an angle

d) True

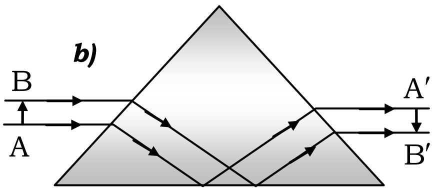
8. a) What are total reflecting prisms?

b) Draw the figures showing the rays of light passing through the prism when i) image is inverted without bending the beams ii) rays are bent by 180° iii) rays are bent by 90°

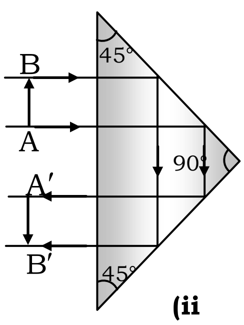
c) What is the main advantage for the total reflecting prisms over plane mirrors?

Ans a) Total reflecting prisms are isosceles right angled glass prisms whose critical angle is less than 45°.

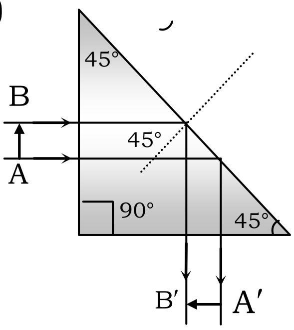
b)



(i)



(ii



(iii)

c) The intensity of light reflected from mirrors will be reduced due to th absorption of the mirrors. But in total reflecting prisms the reflected images will be brighter as the light is totally reflected.

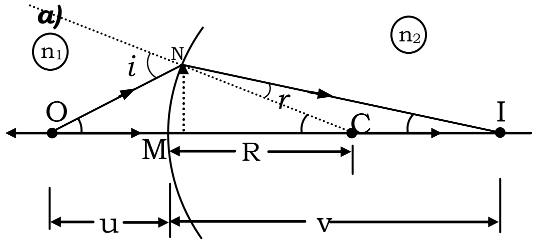
9. Consider a curved surface separating two media of refractive indices n_1 and n_2 respectively. Light is incident in the first medium (n_1) and refra cted in the second medium (n_2). The surface separating the media is convex for the incident ray.

a) Draw the course of rays when $n_2 > n_1$

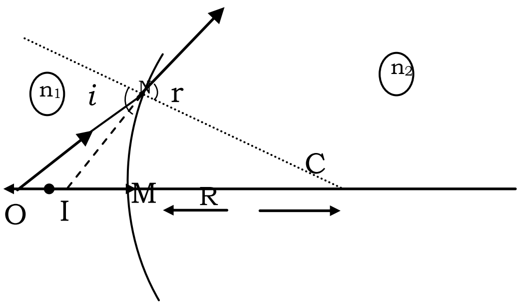
b) Draw the course of rays when $n_2 < n_1$.

Ans:

a)



b)



10. Consider the above case for the ray incident at a concave surface separating two media of refractive indices of n_1 and n_2.respectively

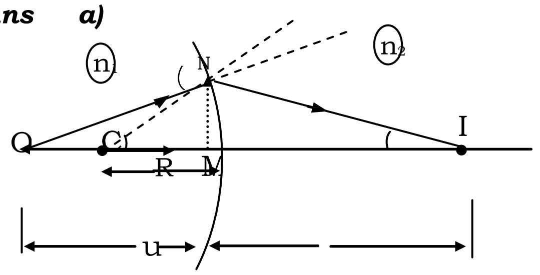
a) Draw the course of rays when n_1 is greater than n_2.

b) Draw the course of rays when n_2 is greater than n_1.

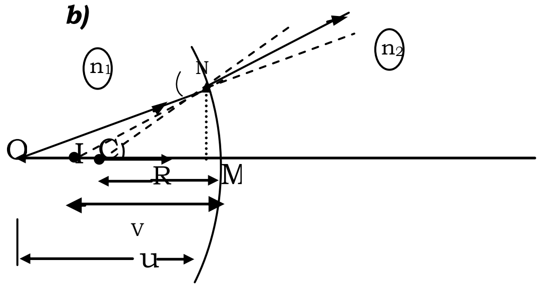
c) State true or false. Correct if it is false.

The ray deviates at the curved surface separating the two media of the same refractive indices.

Ans a)



b)



c) False. There is no deviation for the ray incident at curved surface separating two media of same refractive indices.

11. Consider the new Cartesian sign convention. State whether the following is negative or positive.

a) Focal length of convex lens.
b) Focal length of concave lens.
c) Radius of curvature of convex lens.
d) Radius of curvature of concave lens.

Ans a) Focal length of convex lens is positive.

b) Focal length of concave lens is negative.

c) Radii of curvatures of convex lens are R_1 positive (for the left surfaces) and R_2 negative (for the right surfaces)

d) Radii of curvatures of concave lens are R_1 negative and R_2 positive.

12. a) Can you apply the Snell's law for refraction at spherical surface?

b) Derive the relation $\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$.

Ans a) Yes. We can apply the Snell's law for a refraction at a spherical surface.

b) Refer text .

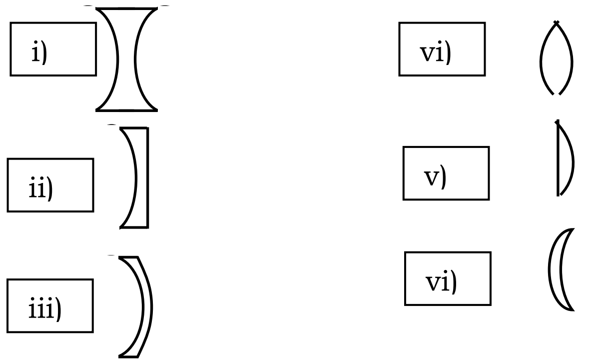
13. a) What is meant by a lens?

b) Which are the different types of lenses?

Ans a) A lens is a transparent medium bounded by two spherical surfaces.

b) The different types of lens are (i) Biconvex lens or convex lens (ii) Plano convex lens (iii) Concavo convex lens (iv) Biconcave lens or concave lens (v) Plano concave lens and Convexo concave lens

14. Give the names of the different lenses shown in the pictures.



Ans: i) Biconcave lens ii) Plano concave lens iii) Convexo concave lens iv) Biconvex lens v) Plano convex lens vi) Concavo convex lens.

15. a) What is meant by optic centre?

b) Explain the terms principal foci, principal axis and focal length.

c) A lens has two foci while a mirror has only one. Explain.

Ans a) If a ray of light is incident on one side of lens in such a way that the emergent ray is parallel to the incident ray, the path of the ray within the lens will cut the principal axis at a point. This fixed point is called the optic centre of the lens.

b) For principal foci Refer page 9-2. Principal axis of a lens is the line joining the centres of curvature of the two spherical surfaces of the lens. Focal length is the distance between the principal focus and the optic centre.

c) For a lens, light can be refracted from both sides. Hence a lens has two foci. But for a mirror light can be incident from one side only. Hence it has only one focus.

16. a) What are the conditions of formation of image by a thin lens?

b) Draw the diagram showing the production of virtual image by a convex lens.

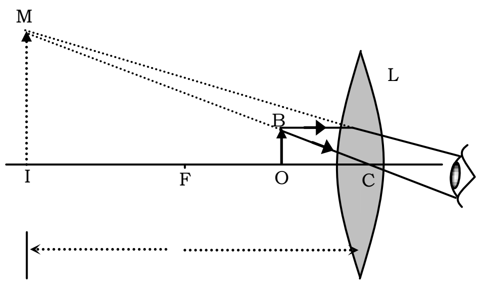
c) Can a concave lens form a real image? Why?

d) State whether true or false. Correct if false.

i) A lens whether concave or convex can produce a magnified or diminished image depending upon the position of the object from the lens.

ii) A lens whether concave or convex can always produce an inverted or erect image depending upon the position of the object from the lens.

Ans a) For Image construction Refer Text 9-7



b)

c) No. Light passing through the concave lens will be diverged after refraction

d) (i) False. A convex lens can produce a magnified or diminished image depending upon the position of the object from the lens. But a concave lens always forms a diminished image.

(ii) False. A convex lens can produce inverted or erect image depending upon the position of the object from the lens. But a concave lens can always form an erect image.

17. a) What happens when a ray of light parallel and close to the principal axis is incident on a convex lens?

b) What is the deviation when the light passes through the optic centre of a lens?

c) Derive the equation giving the law of distances for a convex lens.

Ans a) A ray of light parallel and close to the principal axis when incident on a convex lens will be focused at a point on the principal axis after refraction.

b) There is no deviation when light passes through the optic centre of a lens.

c) Refer Text.

18. By considering refraction at the two spherical surfaces of a lens we can obtain the lens marker's formula.

a) What is the equation for refraction at a spherical surface of radius of curvature R_1?

b) Give the refraction formula at the second surface of radius of curvature R_2?

c) Arrive at the lens marker's formula.

Ans a) $$\frac{n_2}{v'} - \frac{n_1}{u} = \frac{n_2 - n_1}{R_1}$$

b) $$\frac{n_1}{v} - \frac{n_2}{v'} = \frac{n_1 - n_2}{R_2}$$

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

Refer Text for the derivation.

19. a) Why is the lens maker's formula so called?

b) If the first medium is air and the second medium (lens) is glass, get a relation connecting the focal length and the radii of curvatures of the lens.

c) Get the expression for focal length if two radii of curvatures are the same magnitude.

d) State true or false. Correct if it is false.

A convex lens of refractive index n_1 kept in a medium of refractive index n_2 can act as a concave lens when n_1 is greater than n_2.

Ans a) The lens makers use this formula to design the lens.

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

c) $$\frac{1}{f} = (n-1)\left[\frac{2}{R}\right]$$

d) False. A convex lens of refractive index n_1 kept in a medium of refractive index n_2 can act as a concave lens when n_2 is greater than n_1.

20. a) Assuming the lens maker's formula for a doubly convex lens obtain the equation for a plano convex lens.

b) Show that a plano-convex lens has double the focal length of a doubly convex lens of the same radius of curvature.

c) Show that when the radius of curvature of the plano-convex lens is doubled, the focal length is also doubled

Ans ***a) Take*** $R_1 = R$ and $R_2 = \infty$

$$\therefore \quad \frac{1}{f} = (n-1)\left[\frac{1}{R} - \frac{1}{\infty}\right] \quad or \quad \frac{1}{f} = (n-1)\left[\frac{1}{R}\right]$$

b) For double convex lens we have $\frac{1}{f} = (n-1)\left[\frac{2}{R}\right]$ ***................(1)***

For a plano convex lens we have $\frac{1}{f'} = (n-1)\left[\frac{1}{R}\right]$***...... ...(2)***

c) $\frac{1}{f''} = (n-1)\left[\frac{1}{2R}\right]$ ***......(3)***

$$\frac{(3)}{(2)} = \frac{f''}{f'} = \frac{1/R}{1/2R} = 2, \quad f'' = 2f'$$

21. Consider convex lens of focal length f and refractive index 1.5.

a) What is the radius of curvature of the lens?

b) What is the focal length when it is kept in a medium of water of refractive index $\frac{4}{3}$?

c) Consider an air space in water identical to that of a convex lens. How does the air space behave?

d) What will be the focal length of the air space in the water medium?

Ans ***a)*** $\frac{1}{f} = (n-1)\left[\frac{2}{R}\right] \quad \therefore$ ***R = 2 (n-1)***

f = 2 (1.5-1) f = f

i.e. Radius of curvature of lens is its focal length.

b) $$\frac{1}{f'} = \left(\frac{n_2}{n_1} - 1\right)\left[\frac{2}{R}\right] = \left(\frac{1.5}{4/3} - 1\right)\left[\frac{2}{R}\right]$$

$$\therefore f' = 4R = 4f$$

i.e. focal length becomes four times.

c) The space behaves as a concave lens.

d) $$\frac{1}{f'} = \left(\frac{n_2}{n_1} - 1\right)\left[\frac{2}{R}\right] = \left(-\frac{1}{4}\right)\left[\frac{2}{R}\right] = -\frac{1}{2R}$$

$$\therefore f' = -2R = 2f$$

i.e. focal length is doubled. The negative sign shows that the air space behaves as a concave lens.

22. Two thin lenses of focal length f_1 and f_2 are combined.

a) What is the expression for effective focal length?

b) If f_1 is convex and f_2 concave, what is the expression for effective focal length?

c) What is the condition for the combination to be a diverging lens?

d) What is the condition for the combination to be neither diverging nor converging?

Ans ***a) The effective focal lens is given by*** $\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} \therefore f = \frac{f_1 f_2}{f_1 + f_2}$

b) For concave lens f_2 is negative therefore $f = \frac{f_1(-f_2)}{f_1 + (-f_2)} \therefore f = \frac{f_1 f_2}{f_2 - f_1}$

c) The combination is diverging when f is negative i.e. when f_1 is greater than f_2

d) When f_1 =f_2 combination is neither converging nor diverging.

23. a) What is the power of a lens of focal length f?

b) What is the unit of power? Define it.

c) State whether true or false. Correct if it is false.

A large power convex lens will have large focal length.

d) A convex lens and a concave lens of same focal length are combined together.

(i) What is effective focal length (ii) What is the effective power?

Ans ***a) The power of a lens of focal length f is equal to the reciprocal of focal length expressed in meters.***

b) The unit of power is dioptre (D). One dioptre is power of lens of focal lens 1 m.

c) False. A large power convex lens will have small focal length.

d) (i) The effective focal length is infinity (ii) The effective power is zero.

24. a) Can we have negative and positive powers for the lenses?

b) What type of lens is recommended for a short-sighted person?

c) What type of lens is recommended for a long-sighted person?

Ans a) Yes. We can have negative and positive powers for the lenses.

b) A concave lens is recommended for short sighted person.

c) A convex lens is recommended for long sighted person

25. a) Give Rayleigh's scattering law.

b) Which colour has maximum wave length? Which is scattered the maximum

c) Why does sky appear blue?

d) Sky appears red during sunset and sunrise. Why?

Ans a) According to Rayleigh, the intensity of scattered light is inversely proportional to the fourth power of wavelength of the incident light.

b) Red colour has maximum wave length. Violet is scattered the maximum.

c) Refer page 9-11.

d) Refer page 9-11.

26. Deep sea appears bluish. Why?

Ans The blue colour is scattered the most. Hence deep sea appears bluish.

27. Consider a convex lens of focal length f.

a) If the object is placed at the focus, where will be image formed?

b) What is angular magnification?

c) What is linear magnification?

Ans a) The image is formed at infinity.

b) Angular magnification or magnifying power is defined as the ratio of the angle subtended by the image at the eye to the angle subtended by the object seen directly when both are at the least distance of distinct vision.

c) Linear magnification $m = \frac{v}{u}$

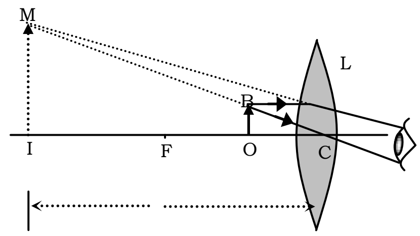
28. a) Can a convex lens act as a simple microscope?

b) What is the nature of the image and draw the image formation.

c) Can a concave lens act as a simple microscope? Why?

Ans: a) Yes.

b)



c) No. A concave lens always forms a diminished image.

29. a) How can we increase the order of magnification?

b) What is the effective magnification if two lenses of magnification m_1 and m_2 are combined?

c) What is the effective magnification if two lenses of same focal length one concave and the other convex are combined?

Ans: a) Magnifying power $\mathbf{m} = \mathbf{1} + \frac{\mathbf{D}}{\mathbf{f}}$.

Hence magnification will be larger if focal length is smaller.

b) The effective magnification of two lenses equal to $m_1 x m_2$

c) The effective magnification will be equal to one.

30. a) What is the magnification for a convex lens when the objective is placed at its focus ?

b) If the object is placed on the focus of the concave lens, where will be the image formed?

c) What is the nature of image in this case?

Ans: a) Magnification $\mathbf{m} = \frac{\mathbf{D}}{\mathbf{f}}$

b) The image will be formed between principal focus and the lens but nearer to the lens.

c) The image is virtual erect and diminished.

31. a) What is the least distance of distinct vision? Explain.

b) If f is the focal length of a convex lens and D the least distance of distinct vision then derive expression for magnification.

c) What is the advantage of viewing image at infinity than at the least distance of distinct vision?

Ans a) For clear vision the image should be formed at the least distance of distinct vision (about 25cm)

b) Refer text)

c) We can view the image without strain if it formed at infinity.

32. In a microscope minimum two lenses are used. One is called objective and the other is called the eyepiece.

a) Which lens has larger focal length?

b) What is the magnification produced by the objective.

c) What is the magnification produced by the eye piece?

d) If the final image is formed at the near point of eye, what will be magnification produced by the microscope?

Ans: a) Eyepiece has larger focal length in a microscope.

b) The magnification produced by the objective, $m_0 = \frac{v_0}{u_0}$***, where*** v_0 ***is the distance of image and*** u_0 ***the distance of the object from the objective.***

c) Magnification produced by the eyepiece, when the image is at the least distance of distinct vision is given by $m_e = 1 + \frac{D}{f_e}$ ***, where*** f_e ***is the focal length of the eyepiece.***

d) The magnification produced by the microscope is the product of the magnification produced by the eyepiece and that produced by the objective.

$$m = m_0 \times m_e = \frac{v_0}{u_0}\left(1 + \frac{D}{f_e}\right)$$

33. A telescope also uses minimum two lenses. One is called objective and the other called the eyepiece.

a) Which lens has larger focal length?

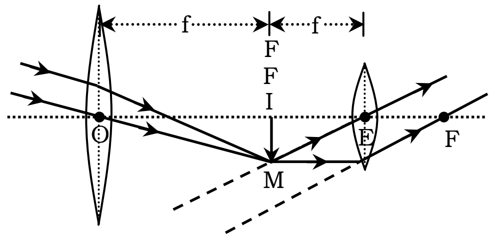
b) If f_1 is the focal length of the objective and f_2 the focal length of the eyepiece, what is the maximum length of the telescope?

c) Draw the course of ray in a refracting telescope?

Ans: a) The objective has larger focal length in a telescope.

b) Maximum length of telescope equal to (f_1+f_2)

d)



34. a) What is the normal position for a telescope?

b) What is the magnification in this case, if f_e and f_o are the focal length of the eyepiece and the objective respectively?

c) If the final image is formed at the least distance of distinct vision D, get the expression for magnification.

Ans: a) When the final image is formed in infinity, the telescope is said to be in normal position (normal adjustment)

b) Magnification $m = \frac{f_0}{f_e}$

c) Magnification $m = \frac{f_0}{f_e}\left(1 + \frac{f_e}{D}\right)$

35. a) What is the angular magnification of a telescope?

b) What are the limitations of refracting telescope?

Ans: a) Angular magnification of a telescope is defined as the ratio of the angle subtended by the final image (β) at the eye to the angle subtended by the object (α).

Magnification, $m = \frac{\beta}{\alpha} = \frac{f_0}{f_e}$

(in the normal position)

b) There are chromatic and spherical aberrations. Fainter objects or very distant galaxies can not be viewed clearly.

36. a) What is the reflecting telescope?

b) What type of mirrors are used in the reflecting telescope?

c) Draw the picture of the reflecting telescope.

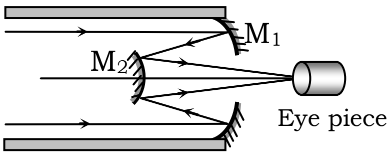
d) Where are the largest reflecting and refracting telescopes located?

e) What are the advantages of reflecting telescope over refracting telescope?

Ans: a) In a reflecting telescope the objective will be a parabolic concave mirror of large aperture.

b) Parabolic mirrors are used in reflecting telescope.

c)



d) The largest reflecting telescope, 'Subaru' is in Japan. The largest refracting telescope 'Yerkes' is in America at Williams Bay.

e) The main advantages are

(i) The fainter objects or very distant galaxies can be viewed because of the large aperture of the concave mirror.

(ii) No chromatic and spherical aberration

(iii) The weight of the concave mirror is less than that of a lens. Hence the mechanical structure to support the telescope is not difficult to make.

37. When white light pass through a prism, the different colours are separated.

a) What is this phenomenon called?

b) Explain why the different colours are separated?

c) Which colour is deviated the most?

d) Which colour is deviated the least?

Ans: a) This phenomenon is called dispersion.

b) The different colours are separated as the refractive indices are different for different colours.

c) Violet colour is deviated the most.

d) Red colour is deviated the least.

38. a) What is a spectrum?

b) How can you produce a spectrum?

c) What are the necessary conditions to obtain a pure spectrum through a prism?

Ans: a) A spectrum is a view of different distinct colours.

b) When a beam of composite colours is passed through a prism the different colours are separated. In this way a spectrum can be produced.

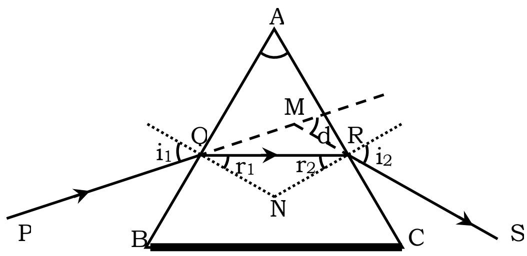
c) The incident rays should be parallel. The prism should be in the minimum deviation position.

39. Consider an equilateral prism of refractive index 1.5.

a) Draw a figure showing a course of ray when it is incident at the first face and refracted through the second face, mentioning angle of incidence, angle of emergence, angle of refraction and angle of deviation.

b) Explain why the third face of the prism is ground. What is this face called?

c) Can you get the spectrum through the second reflecting face when light is incident normally at the first reflecting face? Why?



Ans:

a)

b) This is to avoid the light entering through the third face. The ground face is called the base.

c) No. Because the light will be totally reflected at the second face

40. a) What is a spectrometer?

b) What are the essential parts of a spectrometer?

c) What are the adjustments of collimator and telescope?

d) State whether true or false. Correct if it is false.

The slit is arranged to be at the focus of the collimating lens.

Ans: a) The spectrometer is an instrument to analyse the spectrum of a composite light and it is used to find the

wave length of spectral lines and refractive indices of materials of prisms.

b) The main parts of spectrometer are (i) collimator (ii) telescope (iii) prism table.

c) Refer text.

d) True

41. Using a spectrometer angles of deviation for different angles of incidence are measured and a graph is plotted using monochromatic light.

a) What is monochromatic light?

b) Can you get a spectrum using monochromatic light?

c) What is the graph called?

d) Using the graph show that there are two angles of incidence possible for a given deviation.

Ans: a) A monochromatic light is a light of single wave length

b) No. Monochromic light is not a composite light.

c) The graph is called is i-d curve.

d) Refer text.

42. a) In the above case, what is the minimum point of the graph called?

b) If A is the angle of equilateral prism, D the minimum deviation, get an expression for the refractive index for the material of the prism.

c) Is the refractive index the same when we do the experiment with a monochromatic light of different wavelength? Why?

Ans: a) The minimum deviation point.

b) Refer page 9-8.

c) No. Refractive index depends upon the wave length of the light used

43. Let i_1 be the angle of incidence and i_2 be the angle of emergence for an equilateral prism. The angle of deviation is represented by ***d*** and refractive index is n.

a) If i_2 is the angle of incidence what is the angle of emergence?

b) What is the deviation when the angle of incidence is i_2?

c) If $i_2 = 0°$, what is the angle of incidence? $\boldsymbol{i_1}$

Ans: a) The angle of emergence will be $\boldsymbol{i_1}$

b) The deviation is unchanged. It is the same as d.

c) When $\boldsymbol{i_2 = 0}$, $\boldsymbol{r_2 = 0}$. ***Now*** $\boldsymbol{r_1 = 60°}$

and $\dfrac{\sin i_1}{\sin r_1} = n$

$\therefore \quad \sin i_1 = n \times \sin 60 = \dfrac{n\sqrt{3}}{2}$

or $\quad i_1 = \sin^{-1}(\dfrac{\sqrt{3}}{2} n)$

MULTIPLE CHOICE QUESTIONS

1) Interference of two light waves is constructive if

a) the two waves are in same phase

b) the two waves are in opposite phase

c) the two waves differ in phase by $\dfrac{\pi}{2}$

d) the two waves differ in phase by 3π

2) Polarization of light is a convincing evidence of its

a) Longitudinal nature

b) transverse nature

c) dual nature

d) quantum nature

3) The diameter of the aperture of a camera lens is doubled; the exposure time should be

a) $\dfrac{1}{4}$ of the initial value

b) twice the initial value

c) $\dfrac{1}{2}$ of the initial value

d) four times the initial value

4) The galaxies are moving away from us as indicated by

a) red shift

b) blue shift

c) no shift in spectral line

d) intense light

5) Path difference between waves in constructive interference is (n is an integer)

a) $n\lambda$ b) $\dfrac{\lambda}{2}$ c) $\dfrac{3\lambda}{2}$ d) $\dfrac{\lambda}{4}$

6) Which of the following waves cannot be polarized?

a) x-rays b) radio waves

c) sound waves d) ultraviolet rays

7) The refractive index of diamond is 2.42, critical angle for diamond-air refraction is

a) 44.77° b) 24.41° c) 38.3° d) 41.14

8) For studying the motion of stars, scientists use
a) Seebeck effect b) Photoelectric effect
c) Doppler effect d) Faraday effect

9) When a ray of light enters a glass slab from air
a) its wavelength decreases
b) its wavelength increases
c) its frequency increases
d) neither wavelength nor frequency changes

10) The refractive index of glass is 1.5. The velocity of light in glass is
a) 3×10^8 ms^{-1} b) 4.5×10^8 ms^{-1}
c) 2×10^8 ms^{-1} d) 1.5×10^8 ms^{-1}

11) The refractive index of diamond is 2. The velocity of light in diamond in ms^{-1} is approximately
a) 6×10^8 b) 3×10^8
c) 2×10^8 d) 1.5×10^8

12) Interference is possible with two sources which emit radiations
a) of same frequency
b) of nearly same frequency
c) of same frequency and have a definite phase relationship
d) of different wavelengths

13) A convex lens of focal length 40 cm is in contact with a concave lens of focal length 25 cm. The power of the combination is
a) + 6.5 D b) - 6.5 D
c) + 0.065 D d) – 1.5 D

14) The necessity to retain the wave theory of light is to explain
a) diffraction b) photoelectric effect
c) Compton effect
d) black body radiation

15) To get parallel beam of light without any spreading, the source of light must be at the
a) centre of curvature of a concave mirror
b) focus of a concave mirror
c) centre of curvature of a convex mirror
d) focus of a parabolic mirror

16) The velocity of light through a medium is 2.14×10^8 ms^{-1}. Its refractive index is
a) 1.2 b) 1.4 c) 1.5 d) 1.65

17) Whichof the following does not support the wave nature of light
a) Interference b) Diffraction
c) Polarization d) Photoelectric effect

18) An object kept 10 cm, from a concave mirror of focal length 15 cm. The magnification is
a) 4.5 b) 3 c) 2.5 d) 1.5

19) A colorless liquid is poured into a beaker and a glass rod is put in it. It immediately seems to disappear if the
a) glass and liquid have same density
b) glass and liquid have same colour
c) glass reflects the light transmitted by the liquid
d) glass and liquid have same refractive index

20) Cloud appears white because
a) light reflected by large dust and water droplets give white colour sense
b) of total internal reflection of light by water droplets
c) of scattering of all colours by water droplets
d) interference effect of light

21) The colour of thin films is due to which phenomenon of light
a) interference b) diffraction
c) reflection d) refraction

22) When light travels from a glass slab to air, which is true?
a) velocity remains the same
b) wavelength unchanged
c) amplitude remains the same
d) frequency remains the same

23) Two thin convex lenses of focal length 10 cm and 15 cm are combined together so that the combination will have a focal length
a) 25 cm b) 6 cm
c) 12.5 cm d) 15 cm

24) The fringe width due to interference of light can be increased by
a) increasing the distance between the source and screen
b) decreasing the distance between the sources
c) decreasing the wavelength of the source
d) both a and b

25) The image formed by a plane mirror is
a) real and same size as the object
b) virtual and same size as the object
c) real and magnified
d) virtual and diminished

26) The refractive index of a prism depends on
a) the angle of the prism

b) the deviation produced by the prism
c) the intensity of light
d) the wavelength of light

27) The colour of the sky is due to which phenomena of light
a) scattering
b) refraction
c) interference
d) reflection of light

28) The colour of light which travels with maximum speed in glass is
a) blue b) green
c) violet d) red

29) Monochromatic light is refracted from air into glass of refractive index n. The ratio of wavelength of the incident and refracted wave is
a) 1:n b) n:1 c) 1:1 d) n^2 :1

30) Which will not reduce spherical aberration of a concave mirror?
a) Increasing aperture of mirror
b) Cutting a portion of incident light
c) Covering the peripheral portion of the mirror by a black paper
d) Covering the central portion of the mirror by a black paper

31) For a converging lens as a magnifying glass the object is
a) at the principal focus
b) at nearer to the lens as possible
c) at a distance equal to 2f
d) at infinity

32) The focal length of a convex lens is minimum for
a) red b) violet c) blue d) green

33) When a telescope is in normal adjustment, the distance of the objective from eyepiece is found to be 100 cm. If the magnifying power of the telescope at normal adjustment is 24, the focal length of the lenses are
a) 96 cm, 4 cm b) 90 cm, 10 cm
c) 80 cm, 20 cm d) 50 cm, 50 cm

34) A lens of power +2 dioptre is placed in contact with a lens of power -1 dioptre. The combination will behave like a
a) convergent lens of f = 50 cm
b) divergent lens of f = 100 cm
c) convergent lens of f = 100 cm
d) convergent lens of f = 200 cm

35) The radius of curvature of a concave mirror, forming a real image, magnified twice, when an object is placed 12 cm away from its pole is
a) 8 cm b) 16 cm c) 48 cm d) 24 cm

36) In Young's double-slit experiment, if one of the slits is closed
a) the fringes become closer
b) one half of the fringe system disappears
c) the intensity of the fringe system decreases
d) the screen will have uniform illumination without fringes

37) As light travels from a denser to rarer medium, which is constant?
a) frequency b) amplitude
c) wavelength d) none

38) In Young's double slit experiment, the band width is
a) directly proportional to the wavelength
b) proportional to square of wavelength
c) inversely proportional to the wavelength
d) inversely proportional to the distance

39) A cut diamond sparkles because of the
a) hardness
b) high refractive index
c) emission of light by the diamond
d) absorption of light by the diamond

40) The critical angle of glass is 42°. The velocity of light in glass is
a) 3×10^8 ms^{-1} b) 2×10^8 ms^{-1}
c) 1.5×10^8 ms^{-1} d) 2.5×10^8 ms^{-1}

41) A biconvex lens of focal length 20 cm is cut into two plane convex lenses. The focal length of each part is equal to
a) 10 cm b) 20 cm c) 30 cm d) 40 cm

42) The resolving power of a telescope depends upon
a) the focal length of the eye lens
b) the focal length of the objective
c) the focal length of the telescope
d) the diameter of the objective lens

43) Two coherent monochromatic light beams of intensities I and 4I are superposed. The maximum and minimum intensities are
a) 5I and I b) 9I and I
c) 5I and 3I d) 9I and 3I

44) Total internal reflection occurs when light travels from
a) air to water b) air into glass

c) water into glass d) glass into water

45) The magnifying power of a telescope can be increased by using

a) objective of large focal length
b) objective of small focal length
c) eye lens of large focal length
d) All the above

46) A convex lens of focal length of 50 cm is in contact with a concave lens of focal length 25 cm. The power of the combination is

a) +1 dioptres b) -1 dioptres
c) +2 dioptres d) -2 dioptres

47) In Young's experiment, the ratio of maximum and minimum intensities in the fringe system is 9:1. The ratio of amplitudes of sources is

a) 9:1 b) 3:1
c) 2:1 d) 1:1

48) The magnifying power of an astronomical telescope increases by

a) increasing f_o and f_e
b) decreasing f_o and f_e
c) increasing f_o and decreasing f_e
d) decreasing f_o and increasing f_e

49) In Young's double slit experiment, if the slit width is increased three times the fringe width becomes

a) 1/3times b) 3 times
c) 3/6 times d) 6 times

50) The refractive index of the material of a prism is maximum for

a) red b) green
c) blue d) yellow

51) The distance between source and screen is doubled. Intensity is

a) four times the original value
b) two times the original value
c) half the original value
d) one quarter of the original value

52) When light travels from an optically rarer medium to an optically denser medium, the velocity decreases because of change in

a) wavelength b) frequency
c) amplitude d) phase

Key To Multiple Choice Questions

1.a	2.b	3.a	4.a	5.a	6.c
7.b	8.c	9.a	10.c	11.d	12.c
13.d	14.a	15.d	16.b	17.d	18.b
19.d	20.c	21.a	22.d	23.b	24.d
25.b	26.d	27.a	28.d	29.b	30.a
31.b	32.b	33.a	34.c	35.b	36.d
37.a	38.a	39.b	40.b	41.d	42.d
43.b	44.d	45.a	46.d	47.c	48.c
49.a	50.c	51.d	52.a		

PROBLEMS WITH SOLUTIONS

Problem 1: A light ray of wavelength 600nm gets reflected on the surface of water. Calculate the speed, wavelength and the frequency of reflected light if refractive index of water is 4/3.

Ans: Since there is no change in medium (air) the speed of light ray remains the same. Wavelength, λ also remains unchanged.

Frequency, ν of reflected light

$$= \frac{c}{\lambda} = \frac{3\times10^{8}}{600\times10^{-9}} = \mathbf{5\times 10^{14}\ Hz}$$

Problem 2: The radius of a curvature of a concave mirror is 30cm.Find its focal length.

Ans: We have R = 2f or $f = \frac{R}{2}$

Here R = –30cm (for concave mirror) $f = \frac{R}{2} = \frac{-30}{2}$ = **–0.15 m**

Problem 3: If the height of the object and that of the real image formed by a concave mirror are 2 cm and 6 cm respectively, find the magnification produced.

Ans: For a concave mirror real image is inverted, so height of image, h_i =–6cm

Height of object, h_0 = 2cm

∴ Magnification $= \frac{h_i}{h_0} = \frac{-6}{2} = \mathbf{-3}$

Problem 4: Thrice magnified image of an object is formed on a screen 12cm away from the object. Calculate the focal length of the mirror.

Ans: Magnification, $m = -\left(\frac{v}{u}\right)$,

For real image, m = – 3

$\therefore\ -3 = -\frac{v}{u}$ or $v = +3u$ ....(1)

But $v = u - 12$ (given),
Substituting in eq.(1), we get

$\therefore\ 3u = u - 12$ or $u = \frac{-12}{2} = -6cm$

But from eq.(1), $v = 3 \times (-6) = -18cm$

Focal length, $f = \frac{uv}{u+v} = \frac{-6 \times (-18)}{-6-18}$

$= -$ **4.5 cm** (concave mirror)

<u>Problem 5</u>: An object is placed at a distance 6cm from a concave mirror of focal length 12cm. Find the position, nature and magnification of the image.

Ans: For a concave mirror, $f = -12cm$, $u = -6cm$, $v = ?$

By the mirror equation,

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v} \quad \text{or} \quad \frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{u-f}{uf}$$

$$\therefore v = \frac{uf}{u-f} = \frac{-6 \times (-12)}{-6-(-12)} = \frac{72}{6} = \mathbf{12cm}$$

i.e., the image formed is virtual and at a distance 12cm behind the mirror.

$$\text{Magnification, } m = -\left(\frac{v}{u}\right) = -\left(\frac{+12}{-6}\right) = \mathbf{2}$$

<u>Problem 6</u>: An object is placed at a distance of 20cm in front of a convex mirror of radius of curvature 30cm. Find the position of the image and magnification.

Ans: For a convex mirror, $R = +30cm$,

$\therefore f = \frac{R}{2} = \frac{+30}{2} = +15cm$, $u = -20cm$, $v = ?$

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v} \quad \text{or} \quad \frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{u-f}{uf}$$

$$\therefore v = \frac{uf}{u-f} = \frac{-20 \times 15}{-20-15} = \frac{-300}{-35} = \mathbf{8.57\ cm}$$

$\therefore$ The image is formed at a distance 8.57 cm behind the mirror.

$$\text{Magnification, } m = -\frac{v}{u} = -\left(\frac{+8.57}{-20}\right) = \mathbf{0.429}$$

<u>Problem 7</u>: An object is kept in front of a concave mirror of focal length 30cm. The image formed is twice the size of the object. Find the possible distances of the object from the mirror.

Ans: $f = -30cm$, $m = -2$ for real image and $m = +2$, for virtual image

We have $m = \frac{f}{f-u}$

i) for virtual image, $+2 = \frac{-30}{-30-u}$,

$u = -$ **15 cm**

ii) for real image, $-2 = \frac{-30}{-30-u}$,

$u = -$ **45 cm**

$\therefore$ The possible object distances are 15cm and 45cm in front of it.

<u>Problem 8</u>: The focal length of a concave mirror is 10cm.At what distance must an object be placed so that a real image of magnification 2 is obtained.

Ans: Magnification, $m = \frac{-v}{u}$, but $m = -2$.

$\therefore\ v = +2u$, $f = -10cm$

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v} \quad \text{i.e.,} \quad \frac{1}{-10} = \frac{1}{u} + \frac{1}{2u}$$

$\therefore\ \frac{-1}{10} = \frac{2+1}{+2u}$ $\quad 2u = -30$, $u = -15$ cm

$\therefore$ Object distance, $u =$ **–15cm**

<u>Problem 9</u>: What kind of spherical mirror must be used and what must be its radius of curvature in order to give an erect image $\frac{1}{5}$ as large as an object placed 15cm in front of

Ans: Here $u = -15cm$, magnification,

$$m = \frac{1}{5}, \quad m = \frac{f}{f-u} \quad \text{i.e.,} \quad \frac{1}{5} = \frac{f}{f-(-15)}$$

$5f = f + 15$ or $4f = 15$, $f = \frac{15}{4} =$ **3.75cm**

Since f is positive, the mirror is convex and $R = 2f = 2 \times 3.75 =$ **7.5 cm**

<u>Problem 10</u>: A square wire of size 3cm is placed 25cm away from a concave mirror of focal length 10cm. What is the area enclosed by the image of the wire? The centre of the wire is on the axis of the mirror with two sides normal to the axis.

Ans: Given that $u = -25cm$, $f = -10cm$, side of the square =3cm

Area of the object $= 3 \times 3 = 9cm^2$

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v} \quad \text{or} \quad \frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{u-f}{uf}$$

$$v = \frac{uf}{u-f} = \frac{-25\times(-10)}{-25-(-10)}$$

$= \frac{-250}{15} = \frac{-50}{3} = -16.67$ cm

Areal magnification = $\frac{\text{area of the image}}{\text{area of the object}}$

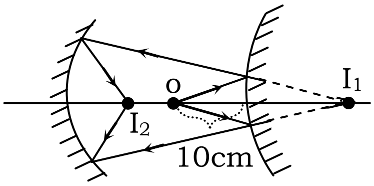
$= \frac{v^2}{u^2}$ $\therefore$ Area of the image

$= \frac{v^2}{u^2}\times\text{area of the object} = \frac{(-16.67)^2}{(-25)^2}\times 9$

= **4cm²**

Problem 11: In an arrangement, the focal lengths of concave and convex mirror are 15cm and 30cm respectively. The mirrors are facing each other and are 50cm apart. An object is placed in between them. Calculate the positions of image formed by the reflection initially at the convex mirror and finally at the concave mirror if the object is at a distance 10cm from the convex mirror.

Ans: For convex mirror forming the first image I_1,



u = –10cm,

f = +30 cm

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

or $\frac{1}{v}=\frac{1}{f}-\frac{1}{u}=\frac{u-f}{uf}=\frac{-10-30}{-10\times30}$

$v = \frac{-300}{-40} =$ **7.5 cm** (behind the convex mirror)

The image formed by the convex mirror acts as the object for the concave mirror. Object distance for the concave mirror = + (7.5 + 50) or

u = +57.5cm and f = 15cm

The position of second image(v) is given by

$\frac{1}{f}=\frac{1}{u}+\frac{1}{v}$, $\frac{1}{v}=\frac{u-f}{uf}=\frac{57.5-15}{57.5\times15}$

$v = \frac{57.5\times15}{57.5-15}=\frac{862.5}{42.5}$ = **20.29 cm**

(from concave mirror)

Problem 12: A ray of light is incident at an angle 30^0 on the surface of water. Find the angle of refraction, if the refractive index of water is 4/3.

Ans: $n = \frac{\sin i}{\sin r}$,

$\text{Sin } r = \frac{\sin i}{n} = \frac{\sin 30}{\left(\frac{4}{3}\right)} = \frac{1}{2}\times\frac{3}{4}=\frac{3}{8}$

$\therefore\ r = \sin^{-1}\left(\frac{3}{8}\right) =$ **$22^0 1'$**

Problem 13: Green light of mercury has λ = 5.5 × 10^{-7}m. What is its frequency? If refractive index of glass is 1.5, what is the wavelength in glass? (c = 3×10^8m/s)

Ans: Frequency, ν is given by

$\nu = \frac{c}{\lambda} = \frac{3\times10^8}{5.5\times10^{-7}}$ = **5.45 ×10^{14} Hz**

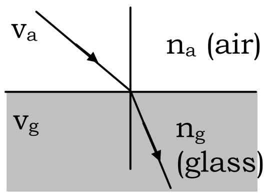
If the c′ is the velocity of light in glass, then refractive index, n of glass is given by

$n = \frac{c}{c'}$ or $c' = \frac{c}{n} = \frac{3\times10^8}{1.5} = 2\times10^8$ m/s

Wavelength of light in glass

$\lambda = \frac{c'}{\nu} = \frac{2\times10^8}{5.45\times10^{14}}$ = **366.9 × 10^{-9} m**

Problem 14: A light ray of wavelength 500nm gets refracted through a glass slab. Calculate the speed, frequency and wavelength of refracted light (n_g =1.5)



Ans: i) We have for refraction for air and glass media,

$\frac{v_a}{v_g}=\frac{n_g}{n_a}$, where n_a and v_a are the refractive index and the velocity of light ray in air and n_g and v_g are refractive index and velocity of light ray in glass.

Velocity in glass = $v_g = \frac{v_a n_a}{n_g}$

$= \frac{3\times10^8\times1}{1.5}$ = **2×10^8 m/s**

ii) During refraction, frequency remains unchanged.

$\therefore \quad \nu$ = frequency $= \dfrac{c}{\lambda} = \dfrac{3\times10^{8}}{500\times10^{-9}}$

$= 6\times 10^{14}$ Hz

Frequency of refracted ray = $\mathbf{6\times10^{14}}$ **Hz**

iii) We have, $v_g = \nu\lambda_g$ or wavelength in glass

$$\lambda_g = \frac{v_g}{\nu} = \frac{2\times10^{8}}{6\times10^{14}} = \mathbf{3.33\times10^{-7}\ m}$$

<u>Problem 15</u>: A black dot is marked on a white paper. A glass slab of n= 1.5 and the thickness 10cm is placed over the dot and the dot appears to be raised. Find the distance of raising the dot.

Ans: Elevation $= \text{Depth}\left(1-\dfrac{1}{n}\right)$

$= 10\left(1-\dfrac{1}{1.5}\right)$=10(1-0.6667) = **0.0333 m**

<u>Problem 16</u>: Calculate the critical angle of diamond in air if its refractive index is 2.42.

Ans: $n = \dfrac{1}{\sin C}$ or $\sin C = \dfrac{1}{n} = \dfrac{1}{2.42}$,

$$C = \sin^{-1}\left(\frac{1}{2.42}\right) = \mathbf{24^{0}24'}$$

Problem 17: The velocity of light in medium(1) is 2×10^{8} m/s and in medium(2) it is 2.5×10^{8} m/s. Find the critical angle at the interface of the two media.

Ans: As the velocity is minimum for the medium(1), its refractive index is greater.

$\therefore \quad {}_2n_1 = 2.5\times10^{8}/2\times10^{8} = 1.25.$

At the critical angle,

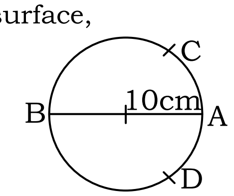
$\sin C = 1/{}_2n_1 = 1/1.25 = 0.8.$

$\therefore$ C = $\sin^{-1} 0.8$ = **53.13^{0}**

<u>Problem 18</u>: A dark spot at the centre of a glass sphere with refractive index 1.5, is viewed from one of the diametric end points. If the radius of the sphere is 10cm, find the position of the image.

Ans: For the refracting surface,

DAC $\dfrac{n_1}{v} - \dfrac{n_2}{u} = \dfrac{n_1 - n_2}{R}$



Here $n_1 = 1$, $n_2 = 1.5$,

u = –10cm, R = –10 cm

Then, $\dfrac{1}{v} - \dfrac{1.5}{-10} = \dfrac{1-1.5}{-10}$ or

$\dfrac{1}{v} = \dfrac{-0.5}{-10} - 0.15$ = 0.05 – 0.15 = – 0.1

$\therefore$ v = – **10cm** from A. It is a virtual image.

<u>Problem 19</u>: A beam of light converges to a point P. A lens is placed in the path of the convergent beam 12cm from P. At what point does the beam converge if the lens is (a) a convex lens of focal length 20cm (b) a concave lens of focal length 16cm

Ans: a) f = +20 cm (for convex lens)
u = +12 cm

By lens equation $\dfrac{1}{f} = \dfrac{1}{v} - \dfrac{1}{u}$ or

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

$$v = \frac{uf}{u+f} = \frac{12\times20}{12+20} = \frac{240}{32} = \mathbf{7.5\ cm}$$

$\therefore$ The point at which the beam of light converges is at a distance 7.5 cm from convex lens.

b) f = –16cm (for concave lens),
u = +12cm

$$v = \frac{uf}{u+f} = \frac{12\times(-16)}{12+(-16)} = \mathbf{48cm}$$

$\therefore$ The beam of light converges to a point 48cm from the concave lens.

<u>Problem 20</u>: A convex lens forms image on a screen, when placed at two different positions separated by 10cm. If the distance of the object from the screen is 100cm, find the focal length.

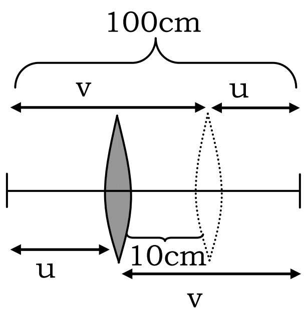
Ans: u + v = 100cm ...(1)

The two positions correspond to conjugate points. At these points u and v can be interchanged

$\therefore$ v – u = 10cm ...(2)

(1) + (2) gives

2v =110, v = 55cm



(1) – (2) gives 2u = 90, u = 45 cm

By sign convention,

u = –45cm, v = 55cm

$$\frac{1}{f}=\frac{1}{v}-\frac{1}{u}=\frac{1}{55}+\frac{1}{45}=\frac{45+55}{45\times55}$$

$\therefore$ f = $\frac{45\times55}{45+55}$ = **24.75 cm**

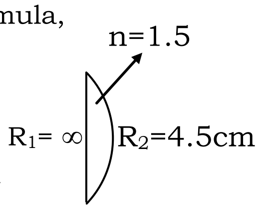
Alternative method:

D =100, d= 10; f = $\frac{D^2-d^2}{4D}$ = $\frac{10000-100}{4\times100}$ = $\frac{9900}{4\times100}$ = **24.75 cm**

Problem 21: A plano convex lens of refractive index 1.5 has radius of curvature of 4.5 cm. Calculate the focal length of the lens, the nature and position of image if the object distance is 10cm.

Ans: By lens maker's formula,

$$\frac{1}{f}=(n-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$



Here n =1.5, R_1 = ∞, R_2 = – 4.5cm, u = –10 cm

$$\frac{1}{f}=(1.5-1)\left(\frac{1}{\infty}-\frac{1}{-4.5}\right)$$

$$=0.5\left(0+\frac{1}{4.5}\right)=\frac{0.5}{4.5}=\frac{1}{9}.$$ $\therefore$ f = **9cm**

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

$\therefore v=\frac{uf}{u+f}=\frac{-10\times9}{-10+9}=\frac{-90}{-1}$ = **90cm**

$\therefore$ Image is real, formed on other side of object.

Problem 22: A convex lens forms a clear image on a screen, of an object placed 30cm from it. Its focal length is 10cm. A concave lens is placed midway between the convex lens and the screen. A clear image is obtained when the screen is moved 15cm away from the concave lens. Calculate the focal length of concave lens.

Ans: For the convex lens alone,

f = +10cm,
u = –30 cm

$$\frac{1}{v}-\frac{1}{u}=\frac{1}{f}.$$

$$\therefore \quad v=\frac{uf}{u+f}=\frac{(-30)\times10}{(-30)+10}$$

$=\frac{-300}{-20}=15$ cm (from the convex lens)

The image formed by the convex lens at a distance 15cm from it acts as the object for the concave lens.

For the concave lens,

$u=\frac{v}{2}=+\frac{15}{2}$ =+7.5 cm,

v = +7.5 + 15 = 22.5 cm

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

$$\therefore \quad f=\frac{uv}{u-v}=\frac{7.5\times22.5}{7.5-22.5}$$

$=\frac{168.75}{-15}=$ **–11.25cm**

$\therefore$ Focal length of concave lens = –11.25cm

Problem 23: A concave lens of focal length 20cm is placed at a distance of 35cm from an object. Find the position of the image and its magnification.

Ans: f =–20cm, u =–35 cm, v =?

$$\frac{1}{f}=\frac{1}{v}-\frac{1}{u} \quad \text{or}$$

$$\frac{1}{-20}=\frac{1}{v}-\frac{1}{-35} \quad \text{or} \quad \frac{1}{v}=-\frac{1}{20}+\frac{1}{-35}$$

$$\frac{1}{v}=\frac{-35-20}{20\times35}=\frac{-55}{20\times35}$$

Or v = $\frac{-20\times35}{55}$ = **–12.73 cm**

$\therefore$ The image is formed at a distance 12.73 cm to the left of concave lens.

Magnification, $m=\frac{v}{u}=\frac{-12.73}{-35}=$ **0.364**

Problem 24: A real image is to be produced with image size 2 times that of the object by using a convex lens of focal length 20cm.Find the object distance.

Ans: For real image, magnification, $m = \frac{v}{u} = -2$ then v = – 2u, f = + 20cm

By lens formula, $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$

$$\frac{1}{20} = \frac{1}{-2u} - \frac{1}{u} = \frac{-1-2}{2u} = \frac{-3}{2u} \quad \text{or}$$

$$2u = -60 \qquad u = \frac{-60}{2} = -\mathbf{30\,cm}$$

Problem 25: The radii of curvature of the two surfaces of a convex lens are 20cm and 25cm. Its focal length is 22cm. Find the power of the lens and refractive index of material of the lens.

Ans: Here R_1 = 20 cm and R_2 = – 25cm
Focal length f = +22cm = +0.22m.

Power of the lens, $P = \frac{1}{f} = \frac{1}{0.22} = \mathbf{4.5\ D}$

By Lens maker's formula,

$$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) = (n-1)\left(\frac{R_2 - R_1}{R_1 R_2}\right)$$

$$(n-1) = \frac{R_1 R_2}{f(R_2 - R_1)} \quad \text{or}$$

$$n = \frac{R_1 R_2}{f(R_2 - R_1)} + 1 = \frac{-20 \times 25}{-22(20+25)} + 1$$

$$= \frac{500}{22 \times 45} + 1 = \mathbf{1.5051}$$

Problem 26: A convex lens of power 0.04 dioptre produces a real image which is double the size of the object placed in front of it. Find the position of the object.

Ans: Given P = 0.04D, m = –2, (for real image) i.e., $m = \frac{v}{u} = -2$ or v = – 2u

By lens formula, $P = \frac{1}{v} - \frac{1}{u}$,

$$0.04 = \frac{1}{-2u} - \frac{1}{u} = \frac{-3}{2u}$$

$$\therefore \quad u = \frac{-3}{2 \times 0.04} = -\mathbf{37.5m}$$

Problem 27: In a convex lens a real image of magnification 2 becomes a virtual image of magnification 4 when the object is shifted by 1m. Calculate the power of lens.

Ans: Magnification, $m = \frac{v}{u}$ (for a lens)

For the first case $m_1 = \frac{v}{u} = -2$ (for real image)

or $\quad v = -2u \qquad$ ...(1)

$\therefore$

$$\frac{1}{f} = \frac{1}{-2u} - \frac{1}{u} = \frac{-3}{2u} \qquad \text{...(2)}$$

For virtual image, $\frac{v'}{u'} = 4$,

$v' = 4u' = 4(u+1)$

For the second case, $u' = u+1$ (virtual image formed only when the object is shifted towards the lens).

$$m_2 = \frac{v'}{u+1} = 4 \quad \text{or} \quad v' = 4(u+1)$$

Now $\frac{1}{f} = \frac{1}{v'} - \frac{1}{u'}$

$$= \frac{1}{4(u+1)} - \frac{1}{u+1} = \frac{-3}{4(u+1)} \qquad \text{...(3)}$$

Comparing equations (2) and (3) we get,

$$\frac{-3}{2u} = \frac{-3}{4(u+1)} \quad \text{or} \quad 2u = 4u+4$$

$-2u = 4$ or $u = -2m$

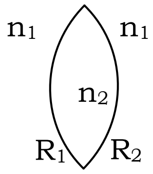
Substituting in equation (1),

$v = -2 \times (-2) = 4m$

Now, $P = \frac{1}{f} = \frac{1}{v} - \frac{1}{u} = \frac{1}{4} - \frac{1}{-2} = \mathbf{\frac{3}{4}}$ **D**

Problem 28: Calculate the power in air and in water of a convex lens of radii of curvature 50cm and 40cm. The refractive index of glass is 1.55 and that of water 1.33.

Ans:



Power, $P = \left(\frac{n_2}{n_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

Here n_2 = refractive index of material (glass) of convex lens =1.55

n_1= refractive index of medium in which lens is placed

R_1 = 50cm =0.5 m, R_2 = –40cm =–0.4 m

i) Power of the lens in air : n_1=1, for air

$$\therefore \quad P = \left(\frac{1.55}{1} - 1\right)\left(\frac{1}{0.5} - \frac{1}{-0.4}\right)$$

$$= 0.55 \times (2 + 2.5) = \mathbf{2.475\ D}$$

ii) Power of the lens in water : n_1=1.33, for water

$$\therefore \quad P = \left(\frac{1.55}{1.33} - 1\right)\left(\frac{1}{0.5} - \frac{1}{-0.4}\right)$$

=0.1654× 4.5 = **0.7443 D**

<u>Problem 29</u>: Find the power of the combination of a thin convex lens of focal length 10cm and concave lens of focal length 20cm.

Ans: f_1 = +0.10 m for convex lens,

f_2 = –0.20 m for concave lens

f = equivalent focal length

$$P = \frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{0.10} - \frac{1}{0.20} = \frac{0.2 - 0.1}{0.02} = \frac{0.1}{0.02} = \frac{10}{2} = 5$$

∴ Power, P = **5D**

<u>Problem 30</u>: Two lenses of powers – 1.5 and 2.5 dioptre are placed in contact. Find the focal length and the power of combination.

Ans: Power of combination,

$P = P_1 + P_2 = -1.5 + 2.5 =$ **+1D**

Effective focal length, $f = \frac{1}{P} = \frac{1}{+1}$ = **1m**

<u>Problem 31</u>: A long sighted person cannot see clearly objects within a distance of 80cm what should be the power of the lens to be used so that he can see clearly objects kept at a distance of 25cm.

Ans: Let f_1 be the focal length of the eye and v the distance of the eye from the retina.

Then $$\frac{1}{80} + \frac{1}{v} = \frac{1}{f_1} \quad \ldots (1)$$

If f_2 is the focal length of the lens used so that the person can see objects at a distance of 25cm. Then for the combination

$$\frac{1}{25} + \frac{1}{v} = \frac{1}{f_1} + \frac{1}{f_2} \quad \ldots (2)$$

(2) – (1) gives, $$\frac{1}{f_2} = \frac{1}{25} - \frac{1}{80} = \frac{11}{400}$$

$$\therefore \quad f_2 = \frac{400}{11}\text{cm} = \frac{4}{11}\text{m}$$

$$\therefore \text{ Power of the lens } = \frac{1}{f_2} = \frac{1}{\left(\frac{4}{11}\right)} = +\frac{\mathbf{11}}{\mathbf{4}}\ \mathbf{D}$$

<u>Problem 32</u>: The angle of minimum deviation for an equilateral glass prism is 48°30′. Find the refractive index of glass.

Ans: For an equilateral prism, A = 60°

The angle of minimum deviation, D = 48° 30′

Refractive index of glass,

$$n = \frac{\sin\left(\frac{A+D}{2}\right)}{\sin\frac{A}{2}} = \frac{\sin\left(\frac{60^\circ + 48^\circ 30'}{2}\right)}{\sin\left(\frac{60^\circ}{2}\right)}$$

=**1.623**

<u>Problem 33</u>: A ray of light is incident normally on one face of a prism of refractive index 1.5 and emerges from the other face just grazing the surface. Find the angle of the prism.

Ans: For normal incidence in the first face,

$i_1 = 0$ and $r_1 = 0$

Since the emergent ray grazes the second face, $i_2 = 90$ and r_2 =?

$$n = \frac{\sin i_2}{\sin r_2} \quad \text{or} \quad \sin r_2 = \frac{\sin 90}{1.5}$$

$$\therefore \quad r_2 = \sin^{-1}\left(\frac{1}{1.5}\right) = 41^\circ 48'$$

But $A = r_1 + r_2 = 0 + 41^\circ 48^1 =$ $\mathbf{41^0 48'}$

<u>Problem 34</u>: A ray of light incident on one face of a prism of refracting angle 60° just suffers total internal reflection at the other face. If the prism has a refractive index 1.524, at what angle the ray should incident on the first face?

Ans: For a prism, $r_1 + r_2 = A$

Here r_2 = critical angle(C) and A = 60°

$r_1 = A - r_2 = A - C \quad \ldots (1)$

$$n = \frac{1}{\sin C}, \quad 1.524 = \frac{1}{\sin C},$$

$$\therefore C = \sin^{-1}\left(\frac{1}{1.524}\right) = 41^\circ$$

Now Eq. (1) becomes $r_1 = 60^0 - 41^0 = 19^0$

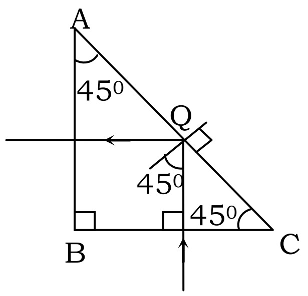
$$n = \frac{\sin i_1}{\sin r_1} \quad \text{or} \quad \sin i_1 = n \sin r_1$$

$= 1.524 \times \sin 19^o = 1.524 \times 0.3255,$

$i_1 = \sin^{-1}(0.4960) = \mathbf{29^0 46'}$

Problem 35: ABC is a right angled prism right angled at B. If A = 45° and a ray falls normal to BC then, calculate the angle of emergence into air. (n=1.55)

Ans: The light ray incident on BC travels without deviation and is incident on AC at an angle 45°.



The critical angle of glass is given by

$$\sin C = \frac{1}{n} = \frac{1}{1.55}$$

$$C = \sin^{-1}\left(\frac{1}{1.55}\right) = 40^o 10' \text{ nearly}$$

∴ The ray incident on AC will be totally internal reflected. The angle of reflection on AC = 45°. The ray will emerge into air normally to the face AB.

Problem 36: A ray of light is incident at an angle of 50° on one face of an equilateral glass prism of refractive index 1.5. Find the deviation produced by the prism

Ans: At the first face, $n = \frac{\sin i_1}{\sin r_1}$

Given that $i_1 = 50^o$ and n = 1.5

$$\sin r_1 = \frac{\sin 50}{1.5} = 0.5107$$

∴ $r_1 = \sin^{-1}(0.5107) = 30^o 43'$

But $r_1 + r_2 = A$

∴ $r_2 = A - r_1 = 60^o - 30^o 43' = 29^o 17'$

At the second face, $n = \frac{\sin i_2}{\sin r_2}$

$\sin i_2 = n \sin r_2 = 1.5 \sin 29^o 17' = 0.7337$

∴ $i_2 = \sin^{-1}(0.7337) = 47^o 12'$

∴ Angle of deviation,

$d = i_1 + i_2 - A = 50^o + 47^o 12' - 60^o = \mathbf{37^o 12^1}$

Problem 37: A certain prism is found to produce minimum deviation of 21° .It produces a deviation of 62° 40′ for two values of angle of incidence namely 40° 06′ and 82° 41′ respectively. Determine the angle of the prism and refractive index of the material of the prism.

Ans: Given D=21°, d=62°40′, i_1 = 40°06′ and i_2 =82°41′

We have deviation, $d = i_1 + i_2 - A$

∴ $A = i_1 + i_2 - d = 40^o 06' + 82o41' - 62^o 40'$

$= \mathbf{60^o 07'}$

$$\therefore \text{ Refractive index, } n = \frac{\sin\left(\frac{A+D}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

$$= \frac{\sin\frac{(60^o 07' + 21^o)}{2}}{\sin\left(\frac{60^o 07'}{2}\right)} = \mathbf{1.298}$$

Problem 38: A glass prism of refractive index 1.5 and angle 60° is placed in water (n_w = 1.33). Calculate the angle of minimum deviation produced when a parallel beam of light is incident on it.

Ans: In air $\frac{n_2}{n_1} = \frac{\sin\left(\frac{A+D}{2}\right)}{\sin\left(\frac{A}{2}\right)}$, where

n_2 = refractive index of the material of prism and n_1 that of air.

In water, n_2 = 1.5 and n_1 =1.33

$$\therefore \frac{n_2}{n_1} = \frac{1.5}{1.33} = \frac{\sin\left(\frac{60+D}{2}\right)}{\sin\left(\frac{60}{2}\right)} = \frac{\sin\left(\frac{60+D}{2}\right)}{\sin 30}$$

$$\sin\left(\frac{60+D}{2}\right) = \frac{1.5 \times 1}{2 \times 1.33} = 0.5639$$

∴ $60 + D = 2 \sin^{-1}(0.5639) = 68^0 39'$

or $D = 68^0 39' - 60 = \mathbf{8^0 39'}$

Problem 39: For a small angled prism the refractive index of the material of the prism is 1.5. A ray of light passes through it. Calculate the angle of deviation if the angle of the prism is 5⁰

Ans: Given n =1.5 and A=5^0

The angle of deviation, d = (n-1) A

$= (1.5 - 1)\, 5^0 = 0.5 \times 5 = \mathbf{2.5^0}$

Problem 40: Calculate the dispersive power of the prism if the refractive indices for red and violet are 1.646 and 1.666.

Ans: Given n_R = 1.646, n_V = 1.666,

$\therefore \quad n = \frac{n_R + n_V}{2} = \frac{1.646 + 1.666}{2}$ =1.656

Dispersive power,

$$\omega = \frac{n_V - n_R}{n - 1} = \frac{1.666 - 1.646}{1.656 - 1} = \frac{0.02}{0.656}$$

= **0.03049**

Problem 41: An achromatic combination of convex lens of crown glass and concave lens of flint glass has a power of +5 dioptre. Calculate the focal length of the two lenses if the dispersive power for crown glass and flint glass are 0.015 and 0.03 respectively.

Ans: Condition for achromatism is

$$\frac{\omega_1}{f_1} + \frac{\omega_2}{f_2} = 0 \qquad \text{or} \qquad \frac{\omega_2}{f_2} = -\frac{\omega_1}{f_1}$$

$$\frac{1}{f_2} = -\left(\frac{\omega_1}{\omega_2}\right) \times \frac{1}{f_1} = \frac{-0.015}{0.030} \times \frac{1}{f_1}$$

$$\therefore \quad \frac{1}{f_2} = -\frac{1}{2f_1} \qquad ....(1)$$

For the combination, $P = \frac{1}{f_1} + \frac{1}{f_2}$

i.e., $5 = \frac{1}{f_1} - \frac{1}{2f_1}$ (Using eq.(1))

i.e., $5 = \frac{1}{2f_1}$ or $\mathbf{f_1 = 0.1\ m}$ (convex lens)

From (1) $f_2 = -2f_1 = -2 \times 0.1 =$ **–0.2m** (concave lens)

Problem 42: A flint glass prism and a crown glass prism produce deviations in the ratio 5:6 and the angles are in the ratio 2:3. If the differences between refractive indices calculate find the refractive indices.

Ans: The deviation produced, d = (n-1)A

$$\therefore \frac{d_1}{d_2} = \left(\frac{n_1 - 1}{n_2 - 1}\right)\left(\frac{A_1}{A_2}\right) \quad \text{i.e.,} \quad \frac{5}{6} = \left(\frac{n_1 - 1}{n_2 - 1}\right)\left(\frac{2}{3}\right)$$

i.e., $15n_2 - 15 = 12n_1 - 12$

$5n_2 - 4n_1 = 1$ ....(1)

But $n_1 - n_2 = 0.12$ ....(2)

Solving Eq(1) and (2) we get

$\mathbf{n_1 = 1.6}$ **and** $\mathbf{n_2 = 1.48}$

Problem 43: A simple microscope of focal length 5cm forms the image of an object at the near point of eye. Find the magnification produced by the microscope.

Ans: f = 5cm and D =25cm ,

Magnification, $m = 1 + \frac{D}{f} = 1 + \frac{25}{5}$ = **6**

Problem 44: A compound microscope has an objective of focal length 2cm and an eye-piece of focal length 4cm. The length of the compound microscope tube is 40cm. Find the magnification produced if the image is formed at the least distance of distinct vision (25cm).

Ans: Here L = 40cm, D = 25cm, f_0 = 2cm and f_e = 4cm

Magnification, $m = \frac{L \times D}{f_o \times f_e} = \frac{40 \times 25}{2 \times 4}$ =**125**

Problem 45: A compound microscope has an objective of focal length 1 cm and an eye piece of focal length 5cm. If the length of the microscope is 20cm, find the object's distance from the objective so that the final image is formed at the least distance of distinct vision.

Ans: If the final image is formed at the least distance of distinct vision

v_e = 25cm, f_e = 5cm u_e = ?

We have $\frac{1}{v_e} - \frac{1}{u_e} = \frac{1}{f_e}$

or $\frac{1}{25} - \frac{1}{u_e} = \frac{1}{5}$

$$\frac{1}{u_e} = \frac{1}{25} - \frac{1}{5} = \frac{1-5}{25} = \frac{-4}{25}$$

$u_e = \frac{-25}{4} = -6.25$ cm from eye piece

Image distance of the objective = 20 – 6.25 = 13.75 (from objective)

For the image formation of objective v_0 = 13.75 cm, f_0 = 1cm, u_0 = ?

$$\frac{1}{v_0} - \frac{1}{u_0} = \frac{1}{f_0},$$

$$u_0 = \frac{v_0 f_0}{f_0 - v_0} = \frac{13.75 \times 1}{1 - 13.75} = \mathbf{-1.1cm}$$

∴ The object should be placed at 1.1cm from the objective.

Problem 46: The objective and eyepiece of a refracting telescope are separated by a distance 20cm. Its magnifying power in normal adjustment is 10. Find the focal length of eyepiece and objective.

Ans: Length of the telescope

$f_0 + f_e = 20$ ... (1)

Also $m = f_0 / f_e = 10$ ∴ $f_0 = 10f_e$

Now (1) becomes $10f_e + f_e = 20$.

∴ $11f_e = 20$ or $f_e = \frac{20}{11}$ = **1.82 cm**

From (1) $f_0 + 1.82 = 20$ or

$f_0 = 20 - 1.82$ = **18.18 cm**

Problem 47: What is the angular magnification of a refracting telescope with objective focal length 10m and eyepiece focal length 1cm. Find the diameter (d) of the moon's image formed by the telescope if the diameter of moon is 3.5× 10⁶m and the distance between moon and earth is 3.8×10⁸m.

Ans: Angular magnification,

$$m = \frac{f_0}{f_e} = \frac{10}{0.01} = \mathbf{1000.}$$

If d is the diameter of moon's image,

then, $$\frac{d}{f_0} = \frac{3.5 \times 10^6}{3.8 \times 10^8}$$

$$\therefore \quad d = \frac{3.5 \times 10^6}{3.8 \times 10^8} \times 10 = \mathbf{0.0921\ m}$$

Problem 48: A telescope has an objective lens of focal length 150cm and an eye piece of focal length 5cm. What is the magnifying power of the telescope for viewing distant when (i) the final image is at infinity and (ii) it is formed at the least distance of distinct vision (25cm)?

Ans: **i)** When the final image is at infinity, magnification $m = f_0 / f_e = 150/5 = \mathbf{30}$

ii) When the final image is formed at the least distance of distinct vision, magnification,

$$m = \frac{f_0}{f_e}\left(1 + \frac{f_e}{D}\right) = \frac{150}{5}\left(1 + \frac{5}{25}\right)$$

$= 30 \times 1.2 = \mathbf{36}$

Problem 49: For a refractive telescope, the magnifying power when image is formed at infinity, is 25 and that when image is formed at the least distance of distinct vision is 30. Find the focal length of the eyepiece and objective.

Ans: For the image formed at infinity, magnification, $m_1 = 25 = f_0 / f_e$ ... (1)

For the image at the least distance,

$$m_2 = 30 = \frac{f_0}{f_e}\left(1 + \frac{f_e}{D}\right) \quad \text{... (2)}$$

(2) ÷ (1) gives $\left(1 + \frac{f_e}{D}\right) = \frac{m_2}{m_1}$.

i.e., $1 + \frac{f_e}{25} = \frac{30}{25}$.

∴ $f_e = 25\left(\frac{30}{25} - 1\right)$ = **5 cm**

From (1) $f_0 / f_e = 25$ or

$f_0 = f_e \times 25 = 5 \times 25$ = **125 cm**