UNIT- VI OPTICS

CH-9 RAY OPTICS & OPTICAL INSTRUMENTS

GIST

Ray Optics: Reflection of light, spherical mirrors, mirror formula, refraction of light, total internal reflection and optical fibers, refraction at spherical surfaces, lenses, thin lens formula, lens maker‟s formula, magnification, power of a lens, combination of thin lenses in contact, refraction of light through a prism.

Optical instruments: Microscopes and astronomical telescopes (reflecting and refracting) and their magnifying powers.

Reflection of Light

Reflection. When light travelling in a medium strikes a reflecting surface, it goes back into the same medium obeying certain

laws. This phenomenon is known as reflection of light.

Laws of reflection. 1. The incident ray, the normal to the reflecting surface at the point of incidence and the reflected ray all lie in the same plane.

2. The angle of incidence (i) is always equal to the angle of reflection (r).

Spherical mirror. The portion of a reflecting surface, which forms part of a sphere, is called a spherical mirror.

Concave spherical mirror. A spherical mirror, whose reflecting surface is towards the centre of the sphere, of which the mirror forms a part is called concave spherical mirror.

Convex spherical mirror. A spherical mirror, whose reflecting surface is away from the centre of the sphere of which the mirror forms a part is called convex spherical mirror.

Relation between f and R: f =R/2

According to new cartesian sign conventions, both f and R, are taken as negative for a concave mirror and positive for a convex mirror.

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

where u and v denote the object and image distances from the pole of the mirror.

According to new cartesian sign conventions, the distances of the real objects and real images (both lie in front of the mirror) are taken as negative, while those of virtual objects and virtual images (both lie behind the mirror) are taken as positive.

Linear magnification. The ratio of the size of the image (formed by the mirror) to the size of the object is called linear magnification produced by the mirror.

Mathematically- **m** $= \frac{I}{O} = -\frac{v}{u} = \frac{f}{f-u} = \frac{f-v}{f}$

According to new cartesian sign conventions, when the image formed is real (inverted), the magnification produced by the mirror is negative and when the image formed is virtual (erect), the magnification produced by the mirror is positive.

Spherical aberration. The inability of a spherical mirror of large aperture to bring all the rays in a wide beam of light falling on it to focus at a single point is called spherical aberration.

2. Refraction of Light

Refraction. The phenomenon of change in the path of light as it goes from one medium to another is called refraction.

Laws of refraction.

1. The incident ray, the normal to the refracting surface at the point of incidence and the refracted ray all lie in the same plane.

2. The ratio of the sine of the angle of incidence to the sine of the angle of refraction is constant for any two- given media. It is called Snell's law.

Mathematically- $\frac{sin i}{sin r} = \mu_b^a$

Absolute refractive index (μ). The absolute refractive index of a medium is defined as ratio of the velocity of light in vacuum (c) to the velocity of light in that medium(v).

Real and apparent depth. When an object is placed in an optically denser medium, the apparent depth of the object is always less than its real depth.

Mathematically-: 1. $\frac{Real\ depth}{Apparent\ depth} = \mu_b^a$

2. **Normal shift** $\mathbf{d = t\left(1 - \frac{1}{\mu_b^a}\right)}$

Total internal reflection. The phenomenon of reflection of light that takes place when a ray of light travelling in a denser medium gets incident at the interface of the two media at an angle greater than the critical angle for that pair of media.

Mathematically $\mu_b^a = \frac{1}{sin\ C}$

μ_b^a is refractive index of the denser medium £ w.r.t. the rarer medium a and C is the critical angle.

Spherical refracting surface. The portion of a refracting medium, whose curved surface forms the part of a sphere, is called spherical refracting surface.

When object is situated in the rarer medium, the relation is as follows

$$-\frac{\mu_1}{u} + \frac{\pi_2}{v} = \frac{\mu_2 - \mu_1}{R}$$

When the object is situated in denser medium, the relation is as follows

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

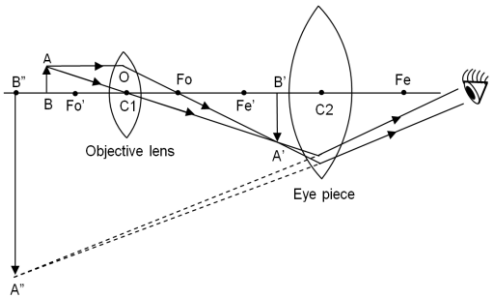
Power of spherical refracting surface: P= $\frac{\mu_2 - \mu_1}{R}$ Here, R is measured in metre.

Lens maker's formula. The relation connecting the focal length of the lens with the radii of curvature of its two surfaces and the refractive index of the material of the lens is called lens maker's formula.

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

The focal length of a convex lens is taken as positive, while that of concave lens is taken as negative.

Lens formula/equation. The relation between the focal length, the object and image distances is called lens equation.



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

Linear magnification. The ratio of the size of the image (formed by the lens) to the size of the object is called linear magnification produced by the lens.

Mathematically- **m** = $\frac{I}{O} = -\frac{v}{u} = \frac{f}{f+u} = \frac{f-v}{f}$

Power of a lens. It is defined as the reciprocal of the focal length of the lens in metre.

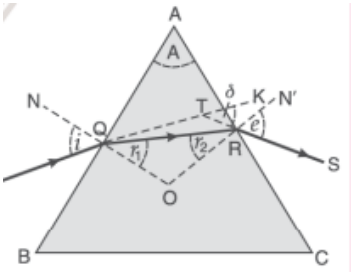
Mathematically **P =** $\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

Two thin lenses placed in contact. When two lenses of focal lengths f_1 and f_2 are placed in contact, the focal

length of the combination is given by $\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$

Power of the equivalent lens: P =P_1 +P_2

Magnification produced by equivalent lens: m = $m_1 \, x \, m_2$



Spherical aberration. The inability of a lens of large aperture to bring all the rays in a wide beam of light falling on it to focus at a single point is called spherical aberration.

DISPERSION OF LIGHT

``Refraction through a prism. A prism is the portion of a transparent refracting medium bound by two plane surfaces meeting each other along a straight edge.

When a ray of light is incident on one face of a prism having angle of prism equal to A at an angle of incidence i, it suffers successive refractions at the two surfaces (angles of refraction at the two surfaces are r, and ry respectively) and then emerges out of it making an angle of emergence equal to e. Due to refraction at the two surfaces, the incident ray deviates from its path through an angle 6, called angle of deviation

Mathematically-

1. A = $r_1 + r_2$ **2. A + δ = I + e 3.** $\mu = \frac{sin\,(A + \delta_m)}{sin\frac{A}{2}}$ **(when the prism is placed in minimum deviation position) 4,** δ **=A (**μ **-1) (when angle of prism is small)**

Dispersion. The phenomenon of splitting up of white light into its constituent colours is called dispersion.

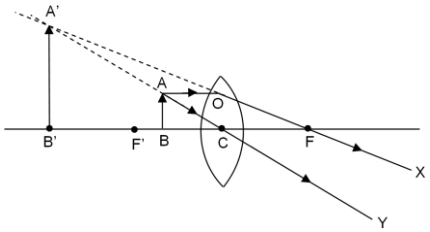
Spectrum. The band of seven colours obtained on the screen is called spectrum.

Pure spectrum. A spectrum, in which the constituent colours have sharp boundaries and are distinctly visible, is called the pure spectrum.

Chromatic aberration. The inability of a lens to bring the light of different colours to focus at a single point is called chromatic aberration.

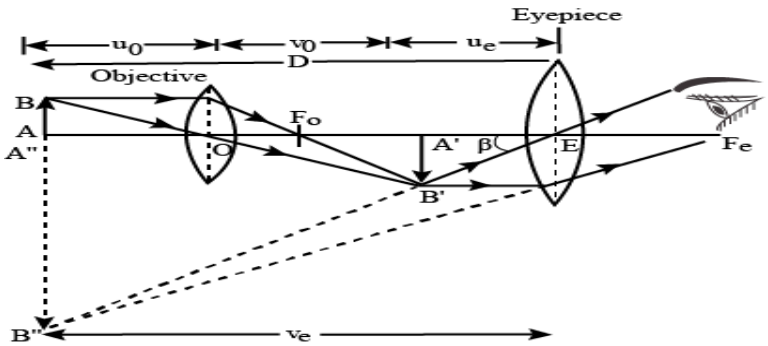
Rayleigh's law of scattering. It states that the intensity of the light of wavelength A in the scattered light varies inversely as the fourth power of its wavelength. **I =** $\frac{1}{\lambda^4}$

Simple microscope. A convex lens of small focal length is called a simple microscope or a magnifying glass. The magnifying power of a microscope 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 lie at the least distance of distinct vision.



$$\mathbf{M = 1 + \frac{D}{f}}$$

Compound microscope. A compound microscope is a two-lens system (object lens and eye lens of focal lengths f, and f,). Its magnifying power is very large, as compared to the simple microscope.

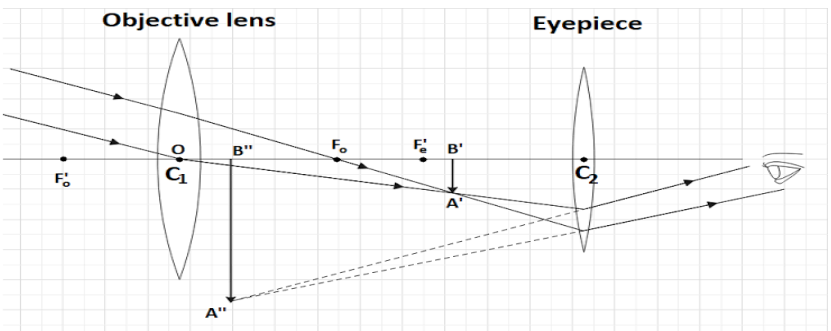


Mathematically- **M =** $\frac{v_o}{u_o}\left(1+\frac{D}{f_e}\right)$ **=** $-\frac{L_o}{f_o}\left(1+\frac{D}{f_e}\right)$

Astronomical telescope. It is a two-lens system and is used to observe distant heavenly objects. It is called refracting type astronomical telescope.

Normal adjustment. When the final image is formed at infinity, the telescope is said to be in normal adjustment. **M = -** $\frac{f_o}{f_e}$

When the final image is formed at the least distance of distinct vision, magnifying power of the telescope, M = - $\frac{f_o}{f_e}\left(1+\frac{f_e}{D}\right)$



CONCEPT MAP

RAY OPTICS

OPTICAL INSTRUMENTS

APPLICATIONS OF TIR

- Fiber optics communication
- Medical endoscopy
- Periscope (Using prism)
- Sparkling of diamond

TOTAL INTERNAL REFLECTION

TIR conditions

- Light must travel from denser to rarer.
- Incident angle $i >$ critical angle i_c

Relation between μ and i_c: $\mu = \frac{1}{\sin i_c}$

REFRACTION OF LIGHT

Snell's law: When light travels from medium a to medium b, ${}^{a}\mu_b = \frac{\mu_b}{\mu_a} = \frac{\sin i}{\sin r}$

Refractive index,

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

Real and apparent depth

$$\mu = \frac{\text{real depth}(x)}{\text{apparent depth}\ (y)}$$

REFLECTION OF LIGHT

According to the laws of reflection, $\angle i = \angle r$

If a plane mirror is rotated by an angle θ, the reflected rays rotates by an angle 2θ.

SIMPLE MICROSCOPE

Magnifying power

For final image is formed at D (least distance) $M = 1 + \frac{D}{f}$

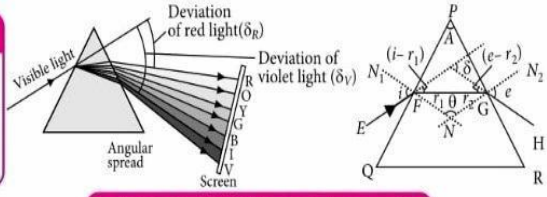
For final image formed at infinity

$$M = \frac{D}{f}$$

REFLECTING TELESCOPE

Magnifying power

$$M = \frac{f_o}{f_e} = \frac{R/2}{f_e}$$



REFRACTION THROUGH PRISM

Relation between μ and δ_m

$$\mu = \frac{\sin\frac{A+\delta_m}{2}}{\sin\frac{A}{2}}$$

where, δ_m = angle of minimum deviation; A = angle of prism

or $\delta = (\mu - 1)A$ (Prism of small angle)

Angular dispersion

$$= \delta_V - \delta_R = (\mu_V - \mu_R)A$$

Dispersive power,

$$\omega = \frac{\delta_V - \delta_R}{\delta} = \frac{\mu_V - \mu_R}{\mu - 1}$$

Mean deviation, $\delta = \frac{\delta_V + \delta_R}{2}$

TELESCOPE

Astronomical telescope

For final image formed at D (least distance) $M = \frac{f_o}{f_e}\left(1 + \frac{f_e}{D}\right)$

In normal adjustment, image formed at infinity $M = f_o / f_e$

POWER OF LENSES

Power of lens: $P = \frac{1}{f\ (\text{in m})}$

Combination of lenses:

Power: $P = P_1 + P_2 - dP_1P_2$

(d = small separation between the lenses)

For $d = 0$ (lenses in contact)

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

THIN SPHERICAL LENS

Thin lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

Magnification: $m = \frac{v}{u} = \frac{h_i}{h_o}$

REFRACTION BY SPHERICAL SURFACE

Relation between object distance (u), image distance (v) and refractive index (μ)

$$\frac{\mu_{\text{denser}}}{v} - \frac{\mu_{\text{rarer}}}{u} = \frac{\mu_{\text{denser}} - \mu_{\text{rarer}}}{R}$$

(Holds for any curved spherical surface.)

Lens maker's formula

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

REFLECTION BY SPHERICAL MIRRORS

Mirror formula, $\frac{1}{u} + \frac{1}{v} = \frac{1}{f} = \frac{2}{R}$

Magnification, $m = -\frac{v}{u} = \frac{h_i}{h_o}$

COMPOUND MICROSCOPE

Magnifying power, $M = m_o \times m_e$

For final image formed at D (least distance) $M = \frac{L}{f_o}\left(1 + \frac{D}{f_e}\right)$

For final image formed at infinity

$$M = \frac{L}{f_o} \cdot \frac{D}{f_e}$$

TERRESTRIAL TELESCOPE

For normal adjustment $M = \frac{f_o}{f_e}$

Distance between objective and eyepiece $d = f_o + 4f + f_e$

LEVEL-1 (MCQ QUESTIONS)

1 A convex lens of power 4D and a concave lens of power 3D are placed in contact. What is the equivalent power of the combination?

a) 7D b) $\frac{4}{3}$D c)1D d) $\frac{3}{4}$D

2 An object approaches a convergent lens from the left of the lens with a uniform speed

5 m/s and stops at the focus. The image

(a) moves away from the lens with a uniform speed 5 m/s.

(b) moves away from the lens with a uniform acceleration.

(c) moves away from the lens with a non-uniform acceleration.

(d) moves towards the lens with a non-uniform acceleration.

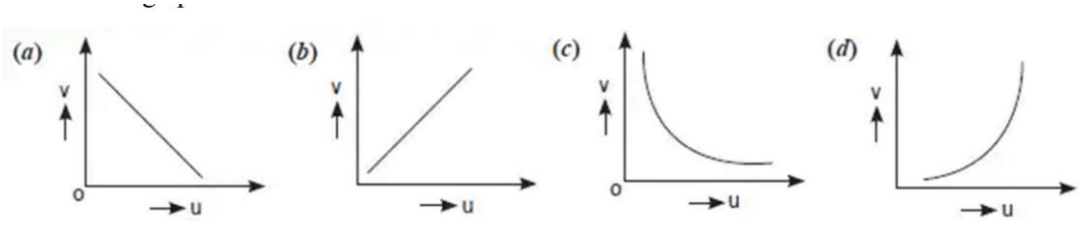
3 The refractive index of the material of an equilateral prism is √3 .What is the angle of Minimum deviation?

(a) 45° (b) 60° (c) 37° (d) 30°

4 An object is placed at the focus of the convex mirror. If its focal length is 20cm, the distance of image from the mirror is

(a)10cm (b)20cm (c)40cm (d)None

5 In an experiment to find focal length of a concave mirror, a graph is drawn between the magnitude of u and v. The graph looks like:



6. Air bubble in water behaves as

(a) sometimes concave, sometimes convex lens

(b) concave lens

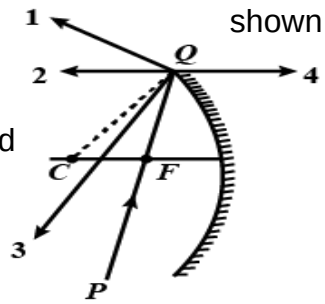
(c) convex lens

(d) always refracting surface

7 A ray of light passes from glass (μ = 1.5) to water (μ = 1.33). The value of the critical angle of glass is _____ .

(a) sin-1 8/9 (b) sin-1√ 8/9 (c) sin-1 ½ (d) sin-1 2/1

8 The direction of ray of light incident on a concave mirror is shown by PQ while directions in which the ray would travel after reflection is shown by four rays marked 1, 2, 3 and 4. Which of the four rays correctly shows the direction of reflected ray?



(a) 1 (b) 2 (c) 3 (d) 4

9 In the formation of a rainbow, the light from the sun on water droplets undergoes

(a) dispersion only. (b) only TIR. (c) dispersion, refraction and TIR.

(d) scattering.

10 An object is placed at a distance of 0.5 m in front of a plane mirror. The distance between object and image will be

(a) 0.25 m (b) 0.5 m (c) 1.0 m (d) 2.0 m

11 The length of an astronomical telescope for normal vision (relaxed eye) will be

(a) fo – fe (b)fo /fe (c) fo × fe (d) fo + fe

12 If a convex lens of focal length 80 cm and a concave lens of focal length 50 cm are combined together, what will be their resulting power?
(a) + 6.5 D (b) – 6.5 D (c) + 7.5 D (d) – 0.75 D

13 A prism has a refractive angle 60°. When a light ray is incident at 50°, then minimum deviation is obtained. What is the value of minimum deviation?
(a) 40° (b) 45° (c) 50° (d) 60°

14 A lens of power 3.5D is placed in contact with a lens of power -2.5D. The combination will behave like

a) A convergent lens of focal length 100cm

b) A divergent lens of focal length 100cm

c) A convergent lens of focal length 200cm

d) A divergent lens of focal length 200cm

15 A ray of light passes through a plane glass slab of thickness t and refractive index μ = 1.5, The angle between the incident ray and the emergent ray will be

(a)0º (b)30 º (c)45º (d) 60º

16 A convex length of focal length is put in contact with a concave lens of same focal length. The equivalent focal length of the combination is

(a)zero (b)f (c)2f (d)Infinity

17 The focal length of plane mirror is

(a)infinity (b)zero (c) 50 cm (d)negative

18 A convex lens is dipped in a liquid, whose refractive index is equal to the refractive index of the lens. Then its focal length will _____ .

(a)become zero (b)remain unchanged (c)become infinite (d)None of these

19 Absolute refractive indices of glass and water are 3/2 and 4/3. The ratio of velocity of light in glass and water will be

(a) 4:3 (b)8:7 (c) 8:9 (d) 3:4

20 Half of the lens is wrapped in black paper. How will it change the image

(a)Size of image is halved

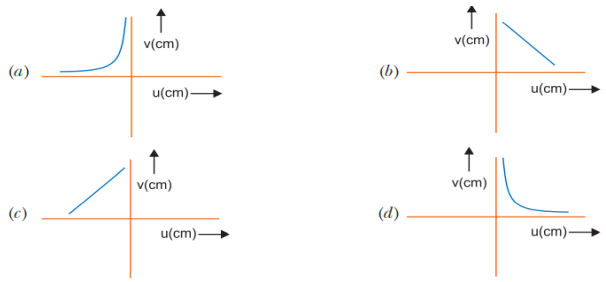
(b)Intensity of image is halved

(c)There is no change in the size of image or intensity

(d)Both size and intensity of the image are changed.

LEVEL-2 (MCQ QUESTIONS)

1 A student measures the focal length of a convex lens by putting an object pin at a distance 'u' from the lens and measuring the distance 'v' of the image pin. The graph between 'u' and 'v' plotted by the student should look like 1

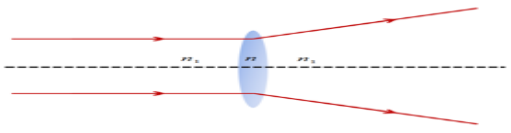


2 What should be increased to increase the angular magnification of a simple microscope?

a)The power of the lens b)The focal length of the lens c)Lens Aperture

d)Object Size

3 What is the correct relationship between refractive indices n,n_1 and n_2 if the behaviour of light is as shown in the figure?



a)n_1>n b)n_1<n c)n_1=n d)None of the above

4 If an equiconvex lens of focal length f and power P is cut into half in thickness, what is the focal length and power of each half?

a)Zero b)f/2 c)f d)2f

5 When a thin convex lens of glass 5D is immersed in a liquid, it behaves as a divergent lens of focal length 100 cm. What is the refractive index of the liquid?

a)1/3 b)2/3 c)3/5 d)5/3

6 incident on a glass plate at an incident angle of 60°. If reflected and refracted rays are mutually perpendicular, then refractrive index of the glass plate is _____ .
(a)$\sqrt{2}$ (b) $\sqrt{3}$ (c)$1/\sqrt{2}$ (d)$1/\sqrt{3}$

7 Light of certain colour has 2000 waves in a millimeter in air. What will be the wavelength of this light in medium of refractive index 1.25 ?
(a) 1000 (b) 2000 (c) 3000 (d) 4000

8 A convex lens of glass (n = 1.5) has focal length of 20 cm. The lens is immersed in water of refractive index 1.33. The change in the focal length of convex lens is
(a) 1.86 cm (b) 58.2 cm (c) 4.62 cm (d) 6.44 cm

9 For a thin lens when the heights of the object and the image are equal, object distance and image distance are equal to _____ .
(a)f (b) 4f (c) 3f (d) 2f

10 the refractive index of an equilateral prism when light is incident at grazing incidence and emerges at grazing emergence:

a)1.5 b) 1.8 c) 1.33 d) 2

LEVEL 3 (MCQ QUESTIONS)

1 A biconcave lens of power P vertically splits into two identical plano-concave parts. The power of each part will be
(a) 2P (b) P/2 (c) P (d) $P/\sqrt{2}$

2 An incident light ray falls on a glass prism at an angle of 60^o and emerges with an angle of 30 with its initial incident direction.

If the angle of the prism is 30^o, then which of the following is an INCORRECT statement?

A. Refractive index of the prism is $\sqrt{3}$.

B. The light undergoes minimum deviation through the prism (i.e., r1 = r2).

C. The emergent ray is perpendicular to the face from which it emerges.

D. Angle of refraction r1 at the incident face is same as angle of the prism.

3 Which of the following actions will lead to an increase in the magnifying power of an astronomical telescope?

A. Increase in the length of the telescope tube.

B. Interchange the objective and the eyepiece of the telescope.

C. A small piece of paper on the objective of the telescope pointed towards the moon.

D. Increase in the focal length of the objective and decrease in the focal length of the eye piece.

4 A real image of size p times the size of an object is formed by a concave mirror of focal length f.

What is the object distance from the mirror?

A. (p+1)*f/p B. (p-1)*f/p C. p*f/(p+1) D. p*f/(p-1)

5 Read the following statements carefully:

I. A drop of an oil in water or in a glass, both behave as convergent lens.

II. A water drop in air and a glass sphere in water, both behave as convergent lens.

III. An air bubble in water and a water bubble in glass, both behave as a divergent lens.

IV. A frozen ice crystal inside a glass sphere and a bromine liquid drop inside a glass sphere, behave as divergent lens.

[Reference values of refractive indices of common substances: Air = 1.001; Water = 1.33; ice = 1.31; Glass = 1.51; Oil = 1.4; Bromine = 1.66]

Select the correct option.

A. Statements I and II are correct.

B. Statements I and III are correct.

C. Statements II and III are correct.

D. Statements II and IV are correct

6 An object is moved towards a concave mirror at a constant speed, from infinity to its focus. Which of the following statements correctly describe the corresponding motion in the image formed by the concave mirror?

A. The image moves slower initially and faster later on, away from the mirror.

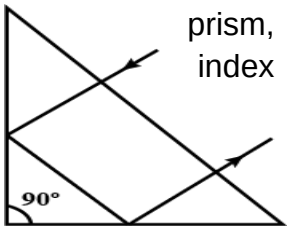
B. The image moves faster initially and slower later on, towards the mirror.

C. The image moves at a constant speed, faster than the object, away from the mirror.

D. The image moves at a constant speed, slower than the object, towards the mirror.

7 A ray of light is incident normally on an isosceles right-angled prism, travels as shown in figure. The least value of the refractive index of the prism must be:

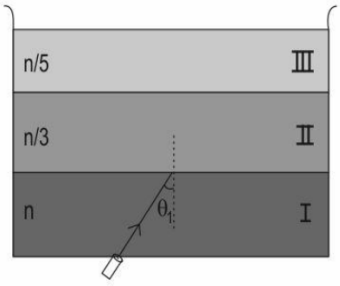
a)√2 b)√3 c)2.0 d)1.5



8 A transparent container contains layers of 3 immiscible transparent liquids of different refractive indices. A laser beam is pointed at the layer I as shown in the figure.

What minimum angle of θ1 will ensure that laser beam does not enter region III at all?

a)θ= $\sin^{-1}$ (1/5) b) $\sin^{-1}$ (1/15) c) $\sin^{-1}$ (2/5)
d)_ $\sin^{-1}$ (3/5)



9 Two statements are given below. One is labelled Assertion (A) and the other is labelled Reason (R). Read the statements carefully and choose the option that correctly describes statements A and R.

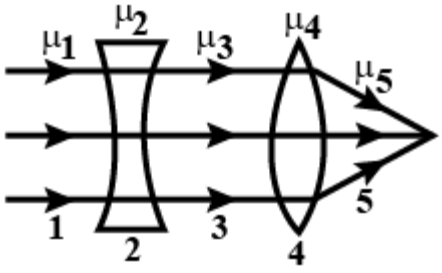
Assertion(A): A ray of light travelling from one media to another always changes its path.

Reason(R): The speed of light changes when it travels from one medium to another.

10 In the figure shown μ1, μ2, μ3, μ4 and μ5 are the refractive indices of the mediums 1, 2, 3, 4 and 5 respectively. Consider the following

a. μ1 = μ2
b. μ3 = μ4 = μ5
c. μ2 < μ3
d. μ4 > μ5

Which of the relations of refractive indices are correct?



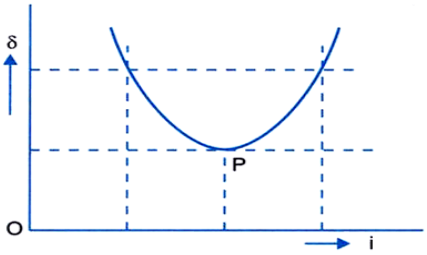
LEVEL 1 (2 M QUESTIONS)

1 What is total internal reflection and what are the conditions under which it occurs? Obtain relation between critical angle between & refractive index.

2 a)A convex mirror is immersed in water of refractive index 1.33. Will the lens behave as a converging or a diverging lens? Give reason.
b) When monochromatic light travels from one medium to another its wavelength changes but frequency remains the same. Explain.

3 Draw a ray diagram to show the image formation by a concave mirror when the object is placed between its focus and pole.
Write the value and sign of magnification in this case.

4 A plot, between the angle of deviation (δ) and angle of incidence (i), for a triangular prism is shown in figure:



Explain why any given value of 'δ' corresponds to two values of angle of incidence. State the significance of point P on the graph. ?

5 a)Write two differences between linear and angular magnification.

b) Three lenses with magnifications 2, 3 and 10 form a combination. What is its total magnification?

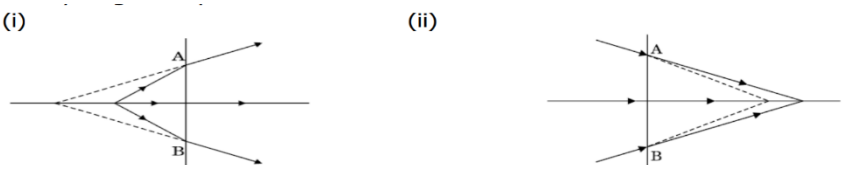
6 With the help of a ray diagram, obtain the relation between its focal length and radius of curvature.

LEVEL-2 (2 M QUESTIONS)

1. How does the power & focal length of a convex lens vary, if the incident red light is replaced by violet light?
2. A right angled isosceles glass prism is made from glass of refractive index 1.5. Show that a ray of light incident normally on (i) one of the equal sides of this prism is deviated through 90° (ii) the hypotenuse of this prism is deviated through 180°.
3. a)When monochromatic light is incident on a surface separating two media, the reflected and refracted light both have the same frequency as the incident frequency. Explain why?
   b) What are benefits of Lens Combination and making equivalent lens?
4. An object is placed 10 cm from a lens of focal length 5 cm. Draw the ray diagrams to show the formation of image if the lens is (i) converging, and (ii) diverging.

5 The line AB in the ray diagram represents a lens. State whether the lens is convex or concave ?

(i) (ii)



LEVEL-3 (2 M QUESTIONS)

1 (a) The bluish colour predominates in the clear sky. Why?

(b) Violet colour is seen at the bottom of the spectrum when white light is dispersed by a prism. State reasons to explain these observations.

2 Write 4 advantages of reflecting type telescope over refracting type?

3 A concave lens made of material of refractive index ‘n2’is held in a reference medium of refractive index ‘n1’. Trace the path of parallel beam of light passing through the lens when: i)n1 = n2 (ii) n1 < n2 (iii) n1 > n2 . In which case the lens will behave as plain glass?

LEVEL-1 (3 M QUESTIONS)

1 An equi-convex lens of radius of curvature R is cut into two equal parts by a vertical plane, so it becomes a Plano convex lens. If f is the focal length of the equi-convex lens, then what will be focal length of Plano convex lens?

2 Derive mirror equation for a convex mirror for real image.

3 a)A biconvex lens made of a transparent material of refractive index 1.25 is immersed in water of refractive index 1.33. Will the lens behave as a converging or a diverging lens? Give a reason.

b) A convex lens is placed in contact with a plane mirror. A point object at a distance of 20 cm on the axis of this combination has its image coinciding with itself. What is the focal length of the lens? Draw related Ray Diagram.

4 Using the ray diagram for a system of two lenses of focal lengths f1 and f2 in contact with each other, show that two lens system can be regarded as equivalent to a single lens of focal length f, where

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

Also write the relation for the equivalent power of the lens combination.

5 Derive thin prism formula

LEVEL-2 (3 M QUESTIONS)

1 Produce a relation between real depth and apparent depth.

2 Using MIRROR FORMULA , show that a convex mirror always produces a virtual image, independent of the location of the object & draw the related ray diagram.

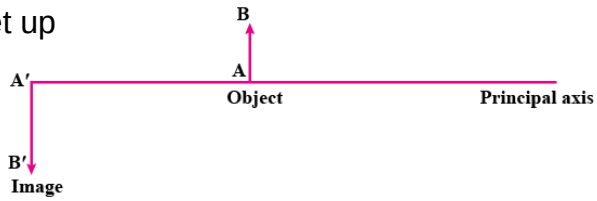
3 a)How does the angle of minimum deviation produced by a prism change with increase in (i) the wavelength of incident light, and (ii) the refracting angle of prism?

b) A glass prism is held in water. How is the angle of minimum deviation affected?

c) When does a ray passing through a prism deviate away from its base?

LEVEL - 3 (3 M QUESTIONS)

1 i)Redraw the diagram below and mark the position of the centre of curvature of the spherical mirror used in the given set up



ii) State the principle of reversibility of light.

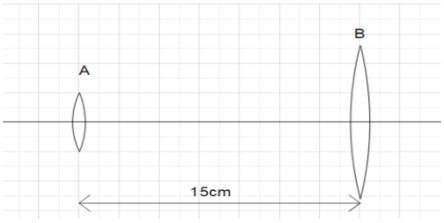
2 Which two of the following lenses L1, L2 and L3 will you select as objective and eyepiece for constructing the best possible (i) telescope (ii) microscope? Give reason to support your answer. iii)the aperture of the objective of …….. is preferred to be large?

Lenses	Power (P)	Aperture(A)
L_1	3 D	8cm
L_2	6 D	1 cm
L_3	10 D	1 cm

3 a) Write the two important factors considered to increase the magnifying power of a refracting type telescope.

b)Two convex lenses A and B of an astronomical telescope having focal lengths 5cm and 20 cm respectively, are arranged as shown in the

i)Which one of two lenses you will select to use as objective lens and why?



(ii) What should be the change in the distance between the lenses to have the telescope in its normal adjustment position?

(iii) Calculate magnifying power of telescope in the normal adjustment position

LEVEL-1 (5 M QUESTIONS)

1. a) Derive expression for the lens maker's formula, i.e.,

$\frac{1}{F} = (\mu - 1)\left[\frac{1}{R1} - \frac{1}{R2}\right]$ where the symbols have their usual meanings. Why is it known as Lens Maker's formula.

b) Write the basic assumptions in the derivation of lens maker's formula .

LEVEL 2 (5 M QUESTIONS)

1 Deduce the expression for the magnifying power of the microscope with a ray diagram for the formation of image by a compound microscope.

Explain, i)Why must both the object and the eyepiece of a compound microscope have short focal lengths?-

ii)While viewing through a compound microscope, why should our eyes be positioned not on the eyepiece but a short distance away from it for best viewing?

LEVEL 3 (5 M QUESTIONS)

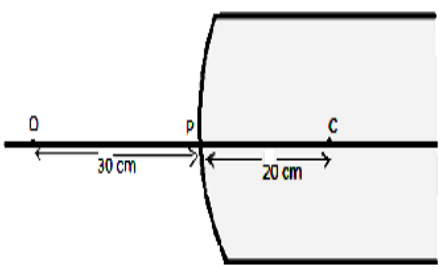
1. i)Draw a ray diagram showing the formation of the image by a point object on the principal axis of a spherical concave surface separating two media of refractive indices n1 and n2, when a point source is kept in the rarer medium of refractive index n1. Derive the relation between object and image distance in terms of refractive index of the medium and radius of curvature of the surface.

ii)Light from a point source in air falls on a convex spherical glass surface of refractive index 1.5 and radius of curvature 20 cm. The distance of light source from the glass surface is 100 cm. At what position is the image formed?

LEVEL-1 (NUMERICALS)

1	A ray of light incident on a equilateral prism propagates parallel to the baseline of the prism inside it. Find the angle of incidence of this ray, given the refractive index of the material of the prism is $\sqrt{3}$?	2
2	What is the focal length of a combination of a convex lens of focal length 30 cm and a concave lens of focal length 20 cm in contact? Is the system a converging or a diverging lens? Ignore thickness of lenses.	2
3	Calculate the speed of light in a medium whose critical angle is 45°. Does critical angle for a given pair of media depend on wave length of incident light? Give reason.	2
4	The radii of curvature of the faces of a double convex lens are 10cm and 15cm. If the focal length of the lens is 12cm, find the refractive index of the material of the lens?	2

LEVEL-2 (NUMERICALS)

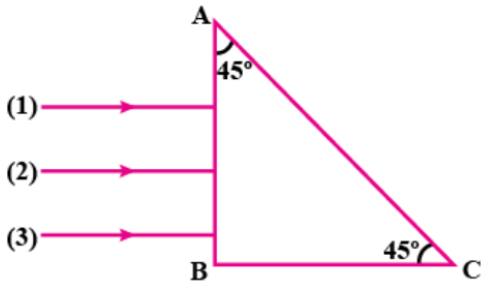


1 A spherical convex surface of radius of curvature 20cm made of glass of refractive index 1.5 is placed in air. Find the position of the image formed if a point object is placed 30cm in front of a convex surface on the principal axis? 2

2 A ray of monochromatic light is incident on the refracting face of a prism angle 75°. It passes through the prism and is incident on the other face at the critical angle. If refractive index of the prism is $\sqrt{2}$, what is the angle of incidence on the first face of the prism? 3

LEVEL-3 (NUMERICALS)

1 Three rays 1,2, 3 of different colours fall normally on one of the sides of an isosceles right angled prism as shown in fig. The refractive indices of prism for these rays are 1.39, 1.47 and 1.52 respectively. Find which of these rays get normally reflected and which get only refracted from AC. Trace the path of rays. Justify your answer with the necessary calculations ? 3



2 An angular magnification of 30X is desired for a compound microscope using an objective of focal length 1.25 cm and eyepiece of focal length 5cm. How will you set up the compound microscope? 5

3 i)A small telescope has an objective lens of focal length 140cm and an eyepiece of focal length 5.0cm. If this telescope is used to view a100m tall tower 3km away, what is the height of the image of the tower formed by the objective lens? 5

ii)An astronomical telescope has focal lengths 100 & 10 cm of objective and eyepiece lens respectively when final image is formed at least distance of distinct vision, magnification power of telescope will be?

CASE STUDY QUESTIONS (4-Marks)

A telescope is a device used to observe distant objects by their emission, absorption, or reflection of electromagnetic radiation. Originally, it was an optical instrument using lenses, curved mirrors, or a combination of both to observe distant objects – an optical telescope. Nowadays, the word "telescope" is defined as a wide range of instruments capable of detecting different regions of the electromagnetic spectrum, and in some cases other types of detectors

The first known practical telescopes were refracting telescopes with glass lenses and were invented in the Netherlands at the beginning of the 17th century. They were used for both terrestrial applications and astronomy.

1

The reflecting telescope, which uses mirrors to collect and focus light, was invented within a few decades of the first refracting telescope.
In the 20th century, many new types of telescopes were invented, including radio telescopes in the 1930s and infrared telescopes in the 1960s..

i) The magnifying power of an astronomical telescope in normal adjustment is 100. What is the focal length of the objectives and eyepiece of the distance between them is 101 cm?

a. 1 cm and 10 cm respectively
b. 1 cm and 100 cm respectively
c. 10 cm and 1 cm respectively
d. 100 cm and 1 cm respectively

ii) If the focal length of the objective lens is increased then
a)Magnifying power of microscope will increase but that of telescope will decrease
b)Magnifying power of microscope and telescope both will increase
c)Magnifying power of microscope and telescope both will decrease
d)The magnifying power of microscope will decrease but that of the telescope will increase

.iii) The magnifying power of a telescope is 9. When it is adjusted for parallel rays, the distance between the objective and the eye-piece is found to be 20 cm. The focal lengths of the lenses are

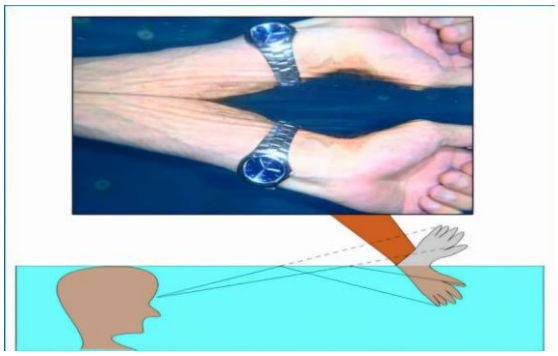
a) 18 cm, 2 cm b) 11 cm, 9 cm c)10 cm, 10 cm d) 15 cm, 5 cm

iv)) In a compound microscope, magnifying power is 95 and the distance of the object from the objective lens is 1/38 cm. The focal length of the objective lens ¼ cm. What is the magnification of eyepiece?

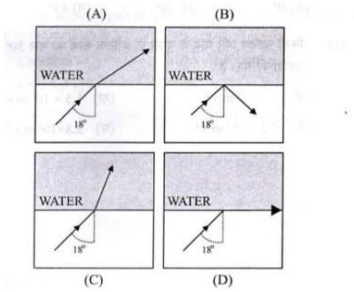
a) 5 b) 10 c) 100 d) 200

COMPETENCY BASED QUESTIONS

1. A ray of light travels from a denser to a rarer medium. After refraction, it bends away from the normal. When we keep increasing the angle of incidence, the angle of refraction also increases till the refracted ray grazes along the interface of two media. The angle of incidence for which it happens is called critical angle. If the angle of incidence is increased further the ray will not emerge and it will be reflected back in the denser medium. This phenomenon is called total internal reflection of light.



i)A ray of light travels from a medium into the water at an angle of incidence of 18°. The refractive index of the medium is more than that of water and the critical angle for the interface between the two media is 20°. Which one of the following figures best represents the correct path of the ray of light?



ii) A point source of light is placed at the bottom of a tank filled with water, of refractive index μ, to a depth h. The area of the surface of water through which light from the source can emerge is:

a)$\pi h^2/2(\mu^2-1)$ b) $\pi h^2/(\mu^2-1)$

c) $\pi h^2/(\sqrt{2}\sqrt{(\mu^2-1)})$ d) $2\pi h^2/(\mu^2-1)$

iii) Is the formula "Real depth/Apparent depth =μ" valid if viewed from a position quite away from the normal?

iv) A diver in a swimming pool wants to signal his distress to a person lying on the edge of the pool by flashing his water proof flash light

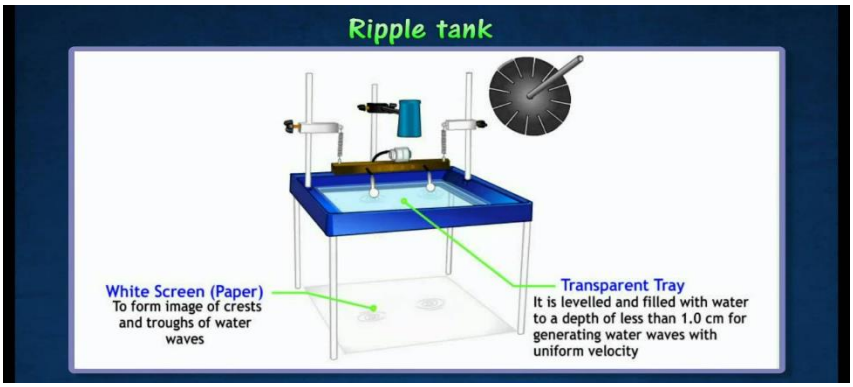
a) He must direct the beam vertically upwards

b) He has to direct the beam horizontally

c) He has to direct the beam at an angle to the vertical which is slightly less than the critical angle of incidence for total internal reflection

d) He has to direction the beam at an angle to the vertical which is slightly more than the critical angle of incidence for the total internal reflection

2. The study of waves in two dimensions is often done using a ripple tank. A ripple tank is a large glass-bottomed tank of water that is used to study the behavior of water waves. A light typically shines upon the water from above and illuminates a white sheet of paper placed directly below the tank. Light interacts differently with the varying curvature of the water's surface, resulting in the projection of bright and dark regions onto a sheet of paper below the tank. As the water waves move through the ripple tank, the dark and bright spots move as well. As the waves encounter obstacles in their path, their behavior can be observed by watching the movement of the dark and bright spots on the sheet of paper. Ripple tank demonstrations are commonly done in a Physics class in order to discuss the principles underlying the reflection, refraction, and diffraction of waves.



1.Assertion : Plane mirror may form real image.

Reason : Plane mirror forms virtual image, if object is real.

ii) A biconvex lens made of a transparent material of refractive index 1.25 is immersed in water of refractive index 1.33. Will the lens behave as a converging lens? Give a reason.

iii) A transparent cube contains a small air bubble. Its apparent distance is 2 cm when seen through one face and 5 cm when seen through other face. If the refractive index of the material of the cube is 1.5, the real length of the edge of cube must be:

a) 7 cm b) 7.5 cm c) 10.5 cm d) 20 cm

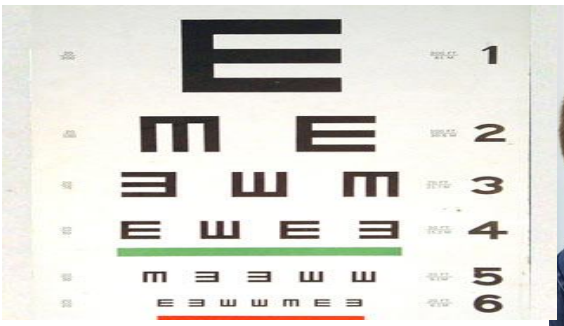
iv)A body is located on a wall. Its image of equal size is to be obtained on a parallel wall with the help of a convex lens. The lens is placed at a distance d ahead of second wall, then the required focal length will be:

A) only d/4 B) only d/2 C) more than d/4 but less than d/2 D)less than d/4

CCT BASED QUESTIONS

1 A comprehensive eye exam is simple and comfortable. It shouldn't take more than 45 to 90 minutes. Here is what the exam should include: 4

This is the part of an eye exam people are most familiar with. You will read an eye chart to determine how well you see at various distances. You cover one eye while the other is being tested. This exam will determine whether you have 20/20 vision or not.



Your doctor will ask you to look at an eye chart through a device called a phoroptor. The phoroptor contains different lenses. Your doctor may check how your pupils respond to light by shining a bright beam of light into your eye. Pupils usually respond by getting smaller. If your pupils widen or don't respond, this may reveal an underlying problem.

Loss of side vision (peripheral vision) may be a symptom of glaucoma. This test can find eye problems you aren't aware of because you can lose side vision without noticing.A test called ocular motility evaluates the movement of your eyes. Your ophthalmologist looks to see if your eyes are aligned. They also check that your eye muscles are working properly.

Eye pressure testing, called tonometry, measures intraocular eye pressure, or IOP. Elevated IOP is one sign of glaucoma. Your ophthalmologist uses a slit-lamp microscope to light up the front part of the eye. This includes the eyelids, cornea, iris and lens. This test checks for cataracts or any scars or scratches on your cornea.

i) The maximum magnification that can be obtained with a convex lens of focal length 2.5 cm is (the least distance of distinct vision is 25 cm)

a) 10 b) 0.1 c) 62.5 d)11

ii) The magnifying power of a magnifying glass is 6. The focal length of its lens in metres will be, if least distance of distinct vision is 25 *cm*

a) 0.05 b) 0.06 c) 0.25 d) 0.12

iii) Resolving power of human eye is:

a) 0.1 mm b) 1 mm c) 2 mm d)None of the above

iv) In a simple microscope, if the final image is located at infinity then its magnifying power is

a) 25/f b) D/25 c) f/25 d) f/D^{+1}

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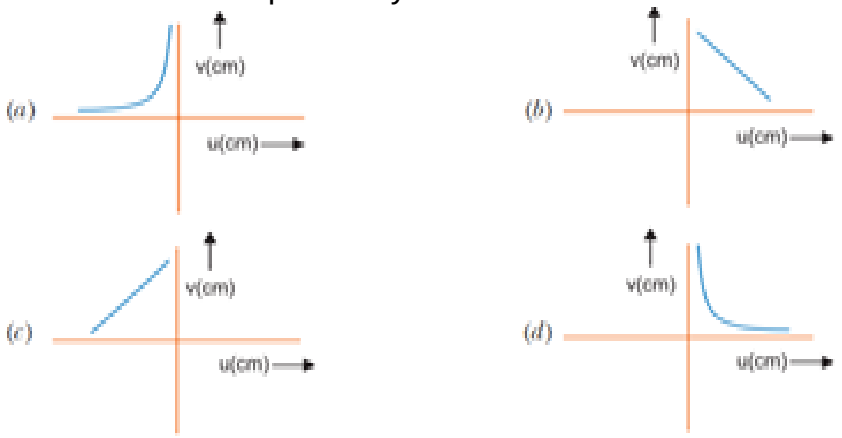
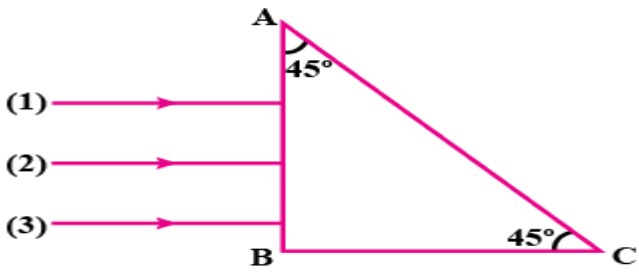
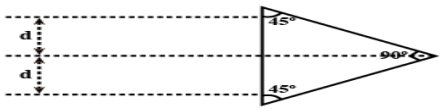
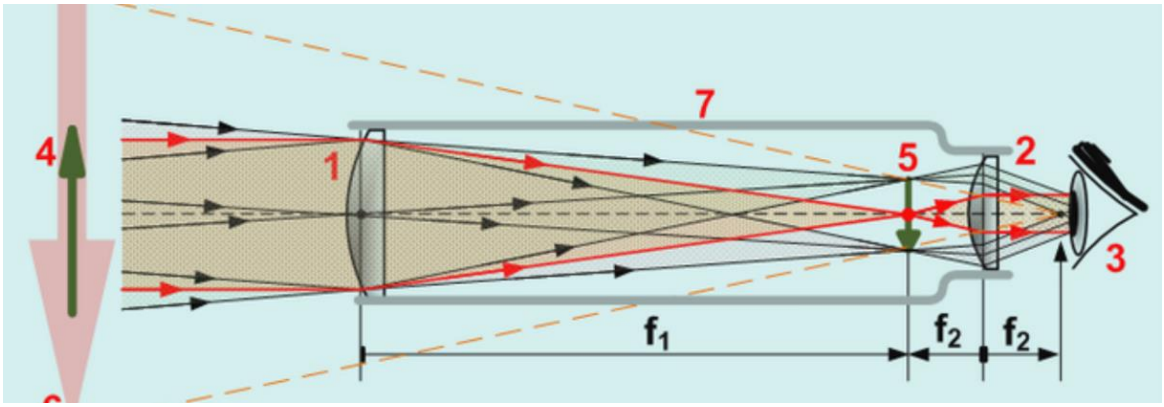
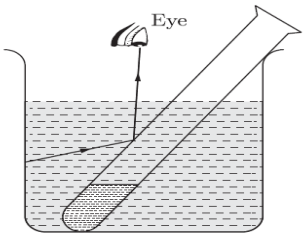
SELF ASSESMENT TEST

Note: Q. No. 1-4 is of 01 mark each, Q. No. 5-6 is of 02 marks each, Q.No.7 is of 03 marks, Q. No. 8 is a case study based and is of 04 marks, Q. No. 11 is of 5 marks.

SN	Question	Marks
1.	Half of the lens is wrapped in black paper. How will it change the image? a)Size of image is halved b)Intensity of image is halved c)There is no change in the size of image or intensity d) intensity of the image is reduced	1
2.	A student measures the focal length of a convex lens by putting an object pin at a distance 'u' from the lens and measuring the distance 'v' of the image pin. The graph between 'u' and 'v' plotted by the student should look like 	1
3.	**Assertion (A):** Refractive index of glass with respect to air is different for red light and violet light. **Reason (R):** Refractive index of a pair of media does not depends on the wavelength of light used. a- Both assertion and reason are correct and the reason is the correct explanation of assertion. b- Both assertion and reason are correct and the reason is not a correct explanation of assertion. c- Assertion is correct but the reason is incorrect d- Assertion is incorrect but the reason is correct.	1
4.	Assertion: The focal length of the convex mirror will increase, if the mirror is placed inwater. Reason: The focal length of a convex mirror of radius R is equal to , f = R/2	1

5.	A biconcave lens of power P vertically splits into two identical plano-concave parts. The power of each part will be (a) 2P (b) P/2 (c) P (d) P/$\sqrt{2}$	1
6.	A prism has refractive angle 60°. When a light ray is incident at 50°, then minimum deviation is obtained. What is the value of minimum deviation? (a) 40° (b) 45° (c) 50° (d) 60°	1
7.	An object is placed in front of a concave mirror of focal length 20 cm. The image formed is three times the size of the object. Calculate two possible distances of the object from the mirror?	2
8.	A ray of light passing from air through an equilateral glass prism undergoes minimum deviation when the angle of incidence is 3/4 of the angle of prism. Calculate the speed of light in the prism.	2
9.	Three rays 1,2, 3 of different colours fall normally on one of the sides of an isosceles right angled prism as shown in fig. The refractive indices of prism for these rays are 1.39, 1.47 and 1.52 respectively. Find which of these rays get normally reflected and which get only refracted from AC. Trace the path of rays. Justify your answer with the necessary calculations ?  	3
10	Two parallel light rays pass through an isosceles prism of refractive index √3/2 as shown in the figure. The angle between the two emergent rays is :  	3
11	**CASE BASED QUESTION** Lens maker's formula relates to the focal length (f) of a lens to the refractive index of the lens and the radii of the curvature of its two surfaces. The focal length of the lens depends upon the refractive index of the material used for making the lens and the radius of curvature. This formula is used by the manufacturers for making the desired lens; that's it is called the lens maker's formula. Limitations of the lens maker's formula. The lens should not be thick so that the space between the 2 refracting surfaces can be small. The medium used on both sides of the lens should always be the same. An array of simple lenses with a common axis can be used to multiply the magnification of an image. The real image formed by one lens can be used as the object for another lens, combining magnifications. Two lenses at this separation form the simplest	4

	type of optical telescope. A schematic of a simple telescope is a good example of the use of two lenses to focus the image of one lens:  i)In Ramsden eyepiece, the two plano-convex lenses each of focal length are separated by a distance 12 cm. The equivalent focal length (in cm) of the eyepiece is a)10.5 b) 12.0 c) 13.5 d) 15.5 ii)The sun's diameter is 1.4×10^{9}m and its distance from the earth is 10^{11}m. The diameter of its image, formed by a convex lens of focal length 2m will be a)0.7 cm b)1.4 cm c)2.8 cm d)Zero (i.e. point image) iii) If aperture of lens is halved then image will be a) No effect on size b) Intensity of image decreases c) Both (a) and (b) d) None of these iv)A diver in a swimming pool wants to signal his distress to a person lying on the edge of the pool by flashing his water proof flash light a) He must direct the beam vertically upwards b) He has to direct the beam horizontally c) He has to direct the beam at an angle to the vertical which is slightly less than the critical angle of incidence for total internal reflection d) He has to direction the beam at an angle to the vertical which is slightly more than the critical angle of incidence for the total internal reflection	
12	(i) Draw a labelled ray diagram to obtain the real image formed by an astronomical telescope in normal adjustment position. Define its magnifying power. Deduce expression . (ii) You are given three lenses of power 0.5 D, 4 D and 10 D to design a telescope. (a) Which lenses should be used as objective and eyepiece? Justify your answer. (b) Why is the aperture of the objective preferred to be large?	5

	CASE STUDY	
13.	How are rainbows formed? The properties and behaviour of light, and how it interacts with droplets of water, give rise to one of nature's most colourful meteorological events - the rainbow. It's all in the geometry... Rainbows are formed when sunlight is scattered from raindrops into the eyes of an observer.Most raindrops are spherical rather than the often depicted 'teardrop' shape and it is this spherical shape that provides the conditions for a rainbow to be seen.The position of the sun and the raindrops in relation to the observer need to be just right for a rainbow to form: The sun needs to be behind the viewerThe sun needs to be low in the sky, at an angle of less than 42° above the horizon. The lower the sun in the sky the more of an arc of a rainbow the viewer will see Rain, fog or some other source of water droplets must be in front of the viewer The size of the raindrops does not directly affect the geometry of a rainbow, but mist or fog tends to disperse the effect more (see fogbows). Rainbows only appear semi-circular over level ground at sunrise or sunset, when the sun is exactly on the horizon, the majority of the time a smaller segment of an arc is seen. If the angles at which the light enters the droplet are correct, some of the light that enters the droplet will be internally reflected from the inside edge of the drop and will exit the drop, undergoing refraction again as it passes back from water to air. Reflection by mirrors, Refraction by lenses, water give rise to many such wonderful phenomenon in atmosphere. i) An empty test tube is placed slanting in the water and viewed from above. What will you observe?  ii) If an equiconvex lens of focal length f and power P is cut into half in thickness, what is the focal length and power of each half? a)Zero b)f/2 c)f d)2f iii) A prism has an angle 600 and refractive index $\sqrt{2}$, what is the angle of minimum deviation? a)90^0 b)60^0 c)45^0 d) 30^0 iv) When a thin convex lens of glass 5D is immersed in a liquid, it behaves as a divergent lens of focal length 100 cm. What is the refractive index of the liquid? a)1/3 b) 2/3 c) 3/5 d) 5/3	4

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