CLASS – 12

WORKSHEET- RAY OPTICS AND OPTICAL INSTRUMENTS

A. REFLECTION

(1 Mark Question)

1. When an object is placed between f and 2f of a concave mirror, would the image formed be, (i) real or virtual or (b) diminished or magnified?

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(2 Marks Questions)

2. Use the mirror equation to show that an object placed between f and 2f of a concave mirror produces a real image beyond 2f.

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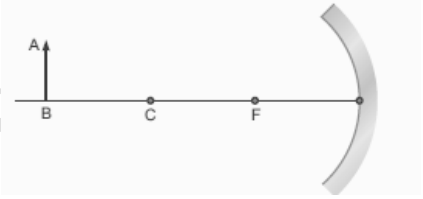
3. An object AB is kept in front of a concave mirror as shown in the figure.



(i) Complete the ray diagram showing the image formation of the object.
(ii) How will the position and intensity of the image be affected if the lower half of the mirror's reflecting surface is painted black?

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4. (a) Draw a ray diagram for a convex mirror showing the image formation of an object placed anywhere in front of the mirror.
(b) Use this ray diagram to obtain the expression for its linear magnification.

(3 Marks Questions)

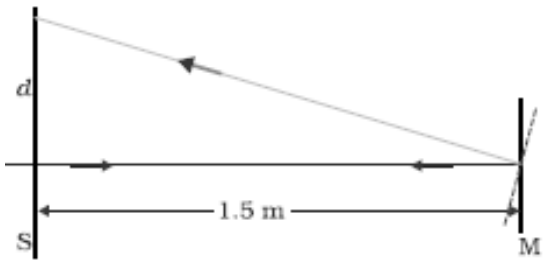
5. A mobile phone lies along the principal axis of a concave mirror. Show, with the help of a suitable diagram, the formation of its image. Explain why magnification is not uniform.

6. A small candle, 2.5 cm in size is placed at 27 cm in front of a concave mirror of radius of curvature 36 cm. At what distance from the mirror should a screen be placed in order to obtain a sharp image? Describe the nature and size of the image. If the candle is moved closer to the mirror, how would the screen have to be moved?
By how much the screen has to be moved if the candle is moved towards the mirror?
[Ans. 5 cm]

7. A 4.5 cm needle is placed 12 cm away from a convex mirror of focal length 15 cm. Give the location of the image and the magnification. Describe what happens as the needle is moved farther from the mirror. [Ans. 2.5 cm]

8. Light incident normally on a plane mirror attached to a galvanometer coil retraces backwards as shown in Fig. A current in the coil produces a deflection of 3.5° of the

mirror. What is the displacement of the reflected spot of light on a screen placed 1.5 m away?



[Ans. 18.4cm]

9. A 5cm long needle is placed 10cm from a convex mirror of focal length 40cm. Find the position, nature and size of the image of the needle. What happens to the size of the image when the needle is moved further away from the mirror? [Ans. 8cm, 4cm]

10. An object is placed at a distance of 40cm on the principal axis of a concave mirror of radius of curvature 30cm. By how much does the image move if the object is shifted towards the mirror through 15cm? [Ans. 24cm, 13.5cm]

11. An object is placed exactly midway between a concave mirror of radius of curvature 40cm and a convex mirror of radius of curvature 30cm. The mirrors face each other and

are 50cm apart. Determine the nature and position of the image formed by successive reflections first at the concave mirror and then at the convex mirror.

[Ans. -100cm, +21.43cm]

12. When the distance of an object from a concave mirror is decreased from 15cm to 9cm, the image gets magnified 3 times than that in first case. Calculate the focal length of the mirror. [Ans. -6cm]

13. A thin rod of length f/3 is placed along the optic axis of a concave mirror of focal length f such that its image which is real and elongated, just touches the rod. What will be the magnification? [Ans. 1.5]

(5 Marks Questions)

14. An object is placed in front of a concave mirror. It is observed that a virtual image is formed. Draw the ray diagram to show the image formation and hence derive the mirror equation: $\frac{1}{f}=\frac{1}{u}+\frac{1}{v}$.

15. Use the mirror equation to deduce that:
(i) an object placed between f and 2f of a concave mirror produces a real image beyond 2f.
(ii) a convex mirror always produces a virtual image independent of the location of the object.
(iii) the virtual image produced by a convex mirror is always diminished in size and is located between the focus and the pole.
(iv) an object placed between the pole and focus of a concave mirror produces a virtual and enlarged image.

B. REFRACTION THROUGH PLANE SURFACE

(1 Mark Question)

1. For the same value of angle of incidence, the angles of refraction in three media A, B and C are 15°, 25° and 35° respectively. In which media would the velocity of light be minimum?

2. State the criteria for the phenomenon of total internal reflection of light to take place.

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3. How does focal length of a lens change when red light incident on it is replaced by violet light? Give reason for your answer.

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4. Why does sun appear red at sunrise and sunset?

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5. Why does bluish colour predominate in a clear sky?

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6. Do the frequency and wavelength change when light passes from a rarer to a denser medium?

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7. Does critical angle depend on colour of light? Explain.

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8. During summer noon, why do the trees and houses on the other side of an open ground appear to be shaking?

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9. How is the refractive index of a medium related to the wavelength of incident light?

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10. Eye is more sensitive to yellow colour. Why do then we use traffic light stop signals of red colour?

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11. Why is yellow medium light used for illumination in foggy conditions?

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12. In which direction relative to the normal does a ray of light bend, when it enters obliquely a medium in which its speed is increased?

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(2 Marks Questions)

13. Calculate the speed of light in a medium whose critical angle is 30°.

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14. Find the maximum angle of refraction when a ray of light is refracted from glass ($\mu = 1.5$) to air.

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15. For a ray of light suffering refraction through a combination of thee media, show that: ${}^{1}\mu_{2} \times {}^{2}\mu_{3} \times {}^{3}\mu_{1} = 1$.

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16. Deduce the relation: $\mu = \dfrac{\text{Real Depth}}{\text{Apparent depth}}$

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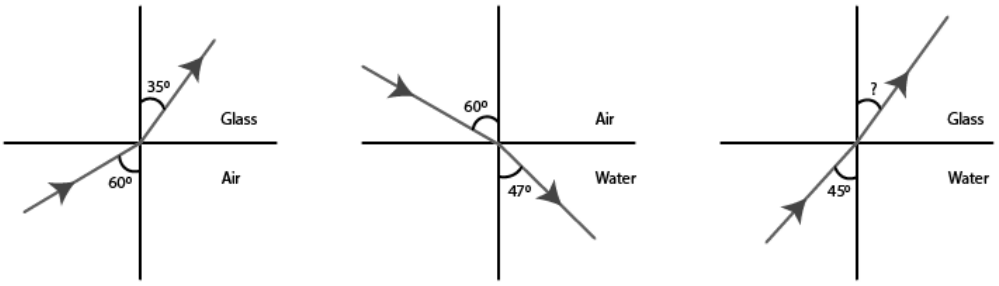
(3 Marks Questions)

17. Refractive index of glass is 1.5. Calculate the velocity of light in glass if velocity of light in vacuum is 3×10^6 ms^{-1}. Also calculate the critical angle for glass-air interface.

18. State the reason for the following observations recorded from the surface of moon: (i) sky appears dark, (ii) rainbow is never formed.

19. The figures show the refraction of a ray in air incident at 60° with the normal to a glass-air and water-air interface, respectively. Predict the angle of refraction in glass when the angle of incidence in water is 45° with the normal to a water-glass interface.

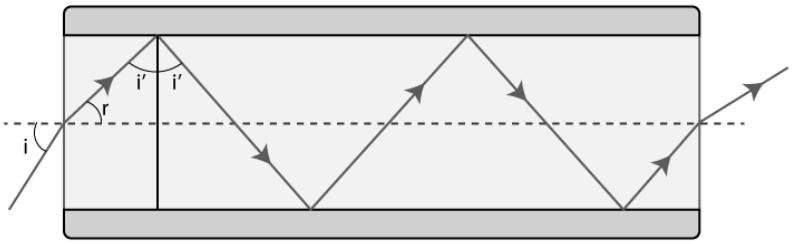


[Ans. 38.2°]

20. A small pin fixed on a tabletop is viewed from above from a distance of 50 cm. By what distance would the pin appear to be raised if it is viewed from the same point

through a 15 cm thick glass slab held parallel to the table? Refractive index of glass = 1.5. Does the answer depend on the location of the slab? [Ans. 5cm]

21. (i) Figure below shows a cross-section of a 'light pipe' made of a glass fiber of refractive index 1.68. The outer covering of the pipe is made of a material of refractive index 1.44. What is the range of the angles of the incident rays with the axis of the pipe for which total reflections inside the pipe take place, as shown in the figure.
(ii) What is the answer if there is no outer covering of the pipe?



[Ans. 60°]

(5 Marks Questions)

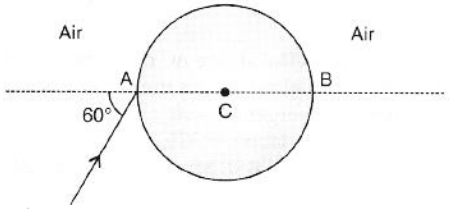
22. Answer the following questions:

(i) You have learnt that plane and convex mirrors produce virtual images of objects. Can they produce real images under some circumstances? Explain.
(ii) A virtual image, we always say, cannot be caught on a screen. Yet when we 'see' a virtual image, we are obviously bringing it on to the 'screen' (i.e., the retina) of our eye. Is there a contradiction?
(iii) A diver underwater, looks obliquely at a fisherman standing on the bank of a lake. Would the fisherman look taller or shorter to the diver than what he actually is?
(iv) Does the apparent depth of a tank of water change if viewed obliquely? If so, does the apparent depth increase or decrease?
(v) The refractive index of diamond is much greater than that of ordinary glass. Is this fact of some use to a diamond cutter?

C. REFRACTION THROUGH CURVED SURFACE

(1 Mark Question)

1. A ray of light falls on a transparent sphere with centre C as shown in the figure. The ray emerges from the sphere parallel to the line AB. Find the angle of refraction at A if refractive index of the material of the sphere is $\sqrt{3}$.



(3 Marks Questions)

2. The diameter of a glass sphere is 15cm. A beam of light strikes the sphere, which converges at point 30cm behind the pole of the spherical surface. Find the position of the image if $\mu = 1.5$.

(5 Marks Questions)

3. Obtain lens makers formula using the expression: $\frac{n_2}{v} - \frac{n_1}{u} = \frac{(n_2 - n_1)}{R}$

Here the ray of light propagating from a rarer medium of refractive index (n_1) to a denser medium of refractive index (n_2) is incident on the convex side of spherical refracting surface of radius of curvature R.

4. Derive the expression for convex surface: $\frac{n_2}{v} - \frac{n_1}{u} = \frac{(n_2 - n_1)}{R}$

where symbols have their usual meanings.

D. LENS

(1 Mark Question)

1. A concave lens of refractive index 1.5 is immersed in medium of refractive index 1.65. What is the nature of the lens?

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2. When does a convex lens behave as a concave lens?

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3. What happens to a focal length of a convex lens, when it is immersed in water?

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4. A lens of glass is immersed in water. What will be its effect on the power of the lens?

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5. How does the focal length of a convex lens change if monochromatic red light is used instead of violet light?

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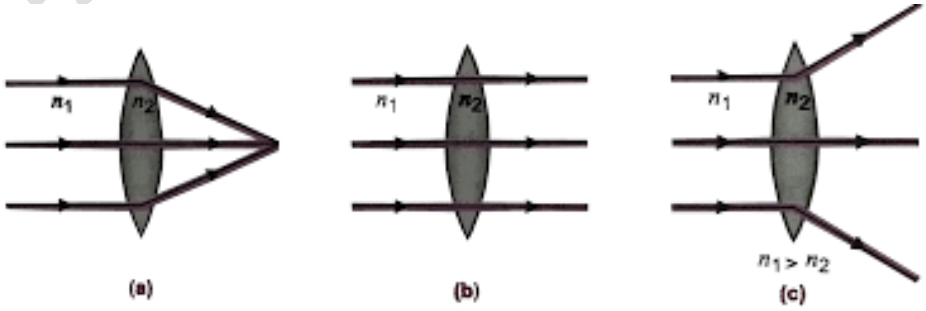
6. In fig path of a parallel beam of light passing through a convex lens of refractive index n_1 kept in medium of refractive index n_2 is shown. (i) $n_1 < n_2$ or (ii) $n_1 = n_2$ or (iii) $n_1 > n_2$?



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

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(2 Marks Questions)

8. The focal length of an equiconcave lens is ¾ times of radius of curvature of its surfaces. Find the refractive index of the material of the lens. Under what condition will this lens behave as a converging lens?

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9. The radius of curvature of each surface of a convex lens of refractive index 1.5 is 40cm. Calculate its power. [Ans. 2.5D]

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10. Two thin lenses of focal lengths +10cm and – 5cm are kept in contact. What is the (i) focal length and (ii) power of the combination? [Ans. 10cm, - 10D]

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11. Derive the lens formula $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$, for a concave lens, using necessary ray diagram.

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12. Double-convex lenses are to be manufactured from a glass of refractive index 1.55, with both faces of the same radius of curvature. What is the radius of curvature required if the focal length is to be 20cm? [Ans. 22.0 cm]

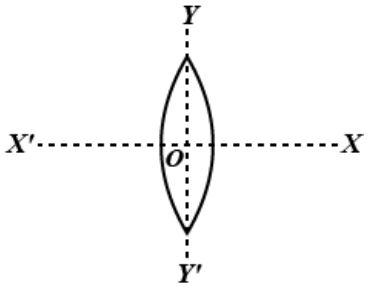
13. The image of a small electric bulb fixed on the wall of a room is to be obtained on the opposite wall 3 m away by means of a large convex lens. What is the maximum possible focal length of the lens required for the purpose? [Ans. 0.75m]

14. A screen is placed 90 cm from an object. The image of the object on the screen is formed by a convex lens at two different locations separated by 20 cm. Determine the focal length of the lens. [Ans. 21.4cm]

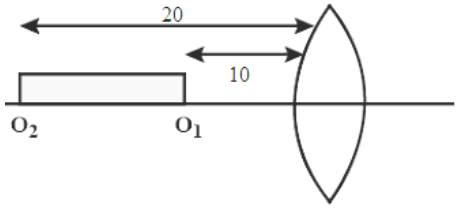
(3 Marks Questions)

15. A convex lens of focal length 0.2m and made of glass ($\mu = 1.50$) is immersed in water ($\mu = 1.33$). Find the change in focal length of the lens. [Ans. 0.58m]

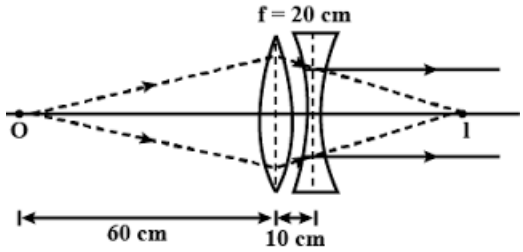
16. An equiconvex lens of focal length 15cm is cut into two equal halves as shown in fig. What is the focal length of each half? [Ans. 30cm]



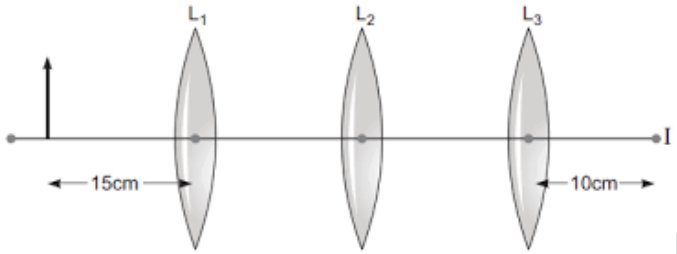
17. A needle 10cm long is placed along the axis of a convex lens of focal length 10cm such that the middle point of the needle is at a distance of 20cm from the lens. Find the length of the image of the needle. [Ans. 13.33cm]



18. From the ray diagram shown below, calculate the focal length of the concave lens.
[Ans. 20cm]



19. You are given three lenses L_1, L_2 and L_3 each of focal length 10cm. An object is kept at 15cm in front of L_3 as shown. The final real image is formed at the focus I of L_3. Find the separations between L_1, L_2 and L_3.



20. A beam of light converges at a point P. Now 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, and (b) a concave lens of focal length 16cm? [Ans. 48cm]

21. An object of size 3.0cm is placed 14cm in front of a concave lens of focal length 21cm. Describe the image produced by the lens. What happens if the object is moved further away from the lens? [Ans. 1.8 cm]

22. What is the focal length of a convex lens of focal length 30cm in contact with a concave lens of focal length 20cm? Is the system a converging or a diverging lens? Ignore the thickness of the lenses, Ignore the thickness of the lenses. [Ans. -60 cm]

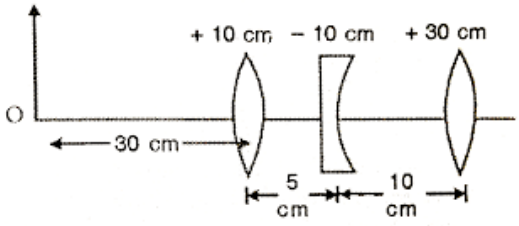
23. (i) Determine the 'effective focal length' of the combination of the two lenses in previous Question, if they are placed 8.0 cm apart with their principal axes coincident. Does the answer depend on which side of the combination a beam of parallel light is incident? Is the notion of effective focal length of this system useful at all?
(ii) An object 1.5 cm in size is placed on the side of the convex lens in the arrangement (a) above. The distance between the object and the convex lens is 40 cm. Determine the magnification produced by the two-lens system, and the size of the image.
[Ans. -220 cm, 0.98cm]

24. A large card divided into squares each of size 1 mm^2 is being viewed from a distance of 9 cm through a magnifying glass (converging lens has a focal length of 9 cm) held close to the eye. Determine:
(a) the magnification produced by the lens? How much is the area of each square in the virtual image?
(b) the angular magnification (magnifying power) of the lens?
(c) Is the magnification in (a) equal to the magnifying power in (b)? Explain.
[Ans. (a) 1cm^2 (b) 2.8]

25. Derive the formula of effective focal length of two lenses having focal lengths f_1 and f_2 placed in contact with each other.

(5 Marks Questions)

26. Three lenses of focal lengths +10cm, - 10cm and +30cm are arranged coaxially as in the figure given below. Find the position of the final image formed by the combination.



E. PRISM

(2 Marks Questions)

1. Calculate the refractive index of the material of an equilateral prism for which the angle of minimum deviation is 60°. [Ans. √3]

2. Calculate the angle of minimum deviation for an equilateral prism of refractive index √3. [Ans. 60°]

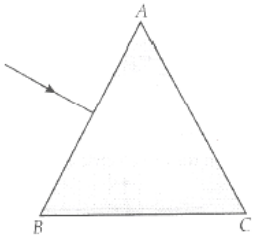
3. Show that in case of a prism: $A + \delta = i + i'$ where the symbols have their usual meanings.

4. At what angle should a ray of light be incident on the face of a prism of refracting angle 60° so that it just suffers total internal reflection at the other face? The refractive index of the material of the prism is 1.524. [Ans. 30°]

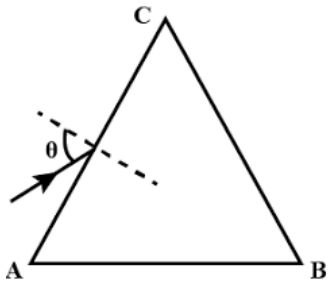
5. You are given prisms made of crown glass and flint glass with a wide variety of angles. Suggest a combination of prisms which will
(i) deviate a pencil of white light without much dispersion,
(ii) disperse (and displace) a pencil of white light without much deviation.

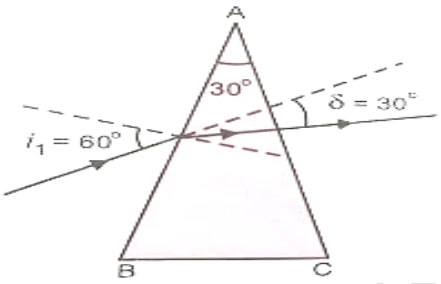
(3 Marks Questions)

6. The figure shows a light falling normally on the face AB of an equilateral glass prism having refractive index 3/2, placed in water of refractive index 4/3. Will this ray suffer total internal reflection on striking the face AC? Justify your answer.



7. A ray of light PQ is incident at an angle of 60° on the face AB of a prism of angle 30°, as shown in figure. The ray emerging out of the prism makes an angle of 30° with the incident ray. Show that the emergent ray is perpendicular to the face BC through which it emerges. Also calculate the refractive index of the prism material

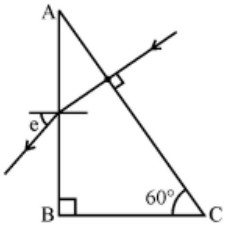




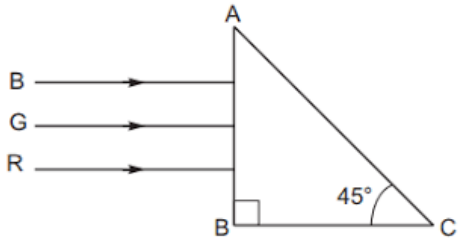
8. A prism is made of glass of unknown refractive index. A parallel beam of light is incident on the face of the prism. The angle of minimum deviation is measured to be 40°. What is the refractive index of the material of the prism? The refracting angle of the prism is 60°. If the prism is placed in water (refractive index 1.33), predict the new angle of minimum deviation of a parallel beam of light. [Ans. 10°20']

(5 Marks Questions)

9. Calculate the angle of emergence (e) of the ray of light incident normally on the face AC of a glass prism ABC of refractive index √3. How will the angle of emergence change qualitatively, if the ray of light emerges from the prism into a liquid of refractive index 1.3 instead of air?



10. (i) A ray of monochromatic light is incident on one of the faces of an equilateral triangular prism of refracting angle A. Trace the path of ray passing through the prism. Hence, derive an expression for the refractive index of the material of the prism in terms of the angle of minimum deviation and its refracting angle. (ii) Three light rays red (R), green (G) and blue (B) are incident on the right angled prism abc. The refractive indices of the material of the prism for red, green and blue wavelengths are respectively 1.39, 1.44 and 1.47. Trace the paths of these rays reasoning out the difference in their behavior.



11. Draw a graph to show the variation of the angle of deviation 'δ' with that the angle of incidence 'i' for a monochromatic ray of light passing through a glass prism of refracting angle 'A'. Hence deduce the relation: $\mu = \dfrac{\sin\left(\dfrac{\delta_m + A}{2}\right)}{\sin\left(\dfrac{A}{2}\right)}$

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F. OPTICAL INSTRUMENTS

(1 Mark Question)

1. A compound microscope is used because a realistic simple microscope does not have _____ magnification.

(2 Marks Questions)

2. For a normal eye, the far point is at infinity and the near point of distinct vision is about 25cm in front of the eye. The cornea of the eye provides a converging power of about 40 dioptres, and the least converging power of the eye-lens behind the cornea is about 20 dioptres. From this rough data estimate the range of accommodation (i.e., the range of converging power of the eye-lens) of a normal eye. [Ans. 24 D]

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3. Does the human eye partially lose its ability of accommodation when it undergoes short-sightedness (myopia) or long-sightedness (hypermetropia)? If not, what might cause these defects of vision?

4. Spectacles of power −1.0 dioptre is being used by a person suffering from myopia for distant vision. He also needs to use separate reading glass of power + 2.0 dioptres when he turns old. Explain what may have happened.

5. A person looking at a cloth with a pattern consisting of vertical and horizontal lines is able to see the vertical lines more distinctly than the horizontal ones. What is this defect due to? How is such a defect of vision corrected?

(3 Marks Questions)

6. (a) Draw a ray diagram depicting the formation of the image by an astronomical telescope in normal adjustment.

(b) You are given the following three lenses. Which two lenses will you use as an eyepiece and as an object to construct an astronomical telescope? Give reason.

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

7. Which two of the following lenses L_1, L_2 and L_3 will you select as objective and eyepiece for constructing best possible (i) telescope (ii) microscope? Give reason to support your answer.

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

8. A person wears glasses of power – 2.5D, Is the person far sighted or near sighted? What is the far point of the person without glasses? (Ans. – 40cm)

9. A simple microscope is rated 5X for a normal relaxed eye. What will be its magnifying power for a relaxed farsighted eye whose near point is 40cm? [Ans. 8]

10. A reflecting type telescope has a concave reflector of radius of curvature 120cm. Calculate focal length of eyepiece to secure a magnification of 20. [Ans. 3cm]

11. Draw a ray diagram of simple microscope. Deduce the formula for its angular magnification when the image is formed at the least distance of distinct vision.

12. Draw a labeled diagram to show the formation of an image by a compound microscope. Write the expression for its magnifying power.

13. Draw a labeled ray diagram to show the image formation in a refracting type astronomical telescope. Why should the diameter of the objective of a telescope be large?

14. A compound microscope consists of an objective lens of focal length 2.0cm and an eyepiece of focal length 6.25cm separated by a distance of 15 cm. How far from the objective should an object be placed in order to obtain the final image at (a) the least distance of distinct vision (25 cm), and (b) at infinity? What is the magnifying power of the microscope in each case? [Ans. (a) 2.5cm, 20 (b) 2.59cm, 13.5]

15. A person with a normal near point (25 cm) using a compound microscope with objective of focal length 8.0 mm and an eyepiece of focal length 2.5cm can bring an object placed at 9.0 mm from the objective in sharp focus. What is the separation between the two lenses? Calculate the magnifying power of the microscope. [Ans. 88]

16. A small telescope has an objective lens of focal length 144 cm and an eyepiece of focal length 6.0 cm. What is the magnifying power of the telescope? What is the separation between the objective and the eyepiece? [Ans. 24, 150cm]

17. (i) A giant refracting telescope at an observatory has an objective lens of focal length 15 m. If an eyepiece of focal length 1.0 cm is used, what is the angular magnification of the telescope?
(ii)If this telescope is used to view the moon, what is the diameter of the image of the moon formed by the objective lens? The diameter of the moon is 3.48×10^6 m and the radius of lunar orbit is 3.8×10^8m. [Ans. (i) 1500 (ii) 13.73cm]

18. A child with normal near point (25 cm) reads a book with small size print using a magnifying glass: a thin convex lens of focal length 5 cm.
(a) What would be the shortest and the longest distance at which the lens should be placed from the page so that the book can be read easily when viewing through the magnifying glass?
(b) What is the maximum and the minimum angular magnification (magnifying power) possible using the above given simple microscope? [Ans. (a) 5cm (b) 5]

19. The virtual image of each square in the figure is to have an area of 6.25 mm^2. Find out, what should be the distance between the object in Exercise 86 and the magnifying glass? If the eyes are too close to the magnifier, would you be able to see the squares distinctly?
[Ans. – 15cm]

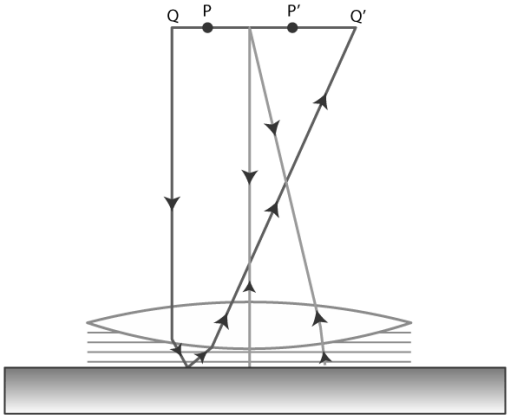
20. An angular magnification (magnifying power) of 30X is desired using an objective of focal length 1.25 cm and an eyepiece of focal length 5 cm. How will you set up the compound microscope? [Ans. 11.67 cm]

21. A small telescope has an objective lens of focal length 140 cm and an eyepiece of focal length 5.0 cm. What is the magnifying power of the telescope for viewing distant objects when
(a) the telescope is in normal adjustment (i.e., when the final image is at infinity)?
(b) the final image is formed at the least distance of distinct vision (25 cm)?
[Ans. 28, 33.6]

22. (a)For a telescope, what is the separation between the objective lens and the eyepiece?
(b) If this telescope is used to view a 100 m tall tower 3 km away, what is the height of the image of the tower formed by the objective lens?
(c)What is the height of the final image of the tower if it is formed at 25 cm?
[Ans. (a) 145cm (b) 4.67cm (c) 28cm]

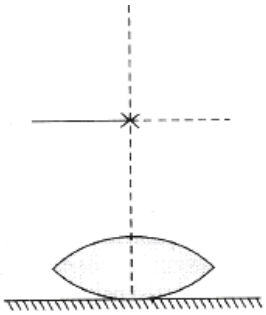
G. CHALLENGING PROBLEMS

1. Figure shows a biconvex lens (of refractive index 1.50) in contact with a liquid layer on top of a plane mirror. A small needle with its tip on the principal axis is moved along the axis until its inverted image is found at the position of the needle. The distance of the needle from the lens is measured to be 45.0 cm. The liquid is removed and the experiment is repeated. The new distance is measured to be 30.0 cm. What is the refractive index of the liquid?



[Ans. 1.33]

2. A symmetric biconvex lens of radius of curvature R and made of refractive index 1.5, is placed on a layer of liquid placed on top of a plane mirror as shown in the figure. An optical needle with its tip on the principal axis of the lens is moved along the axis until its real, inverted image coincides with the needle itself. The distance of the needle from the lens is measured to be x. On removing the liquid layer and repeating the experiment, the distance is found to be y. Obtain the expression for the refractive index of the liquid in terms of x and y.



SPACE FOR ROUGH WORK

SPACE FOR NOTES