



PHYSICS

NCERT - NCERT PHYSICS(GUJRATI)

RAY OPTICS AND OPTICAL INSTRUMENTS

Example

1. Suppose that the lower half of the concave mirror's reflecting surface in Fig. 9.5 is covered

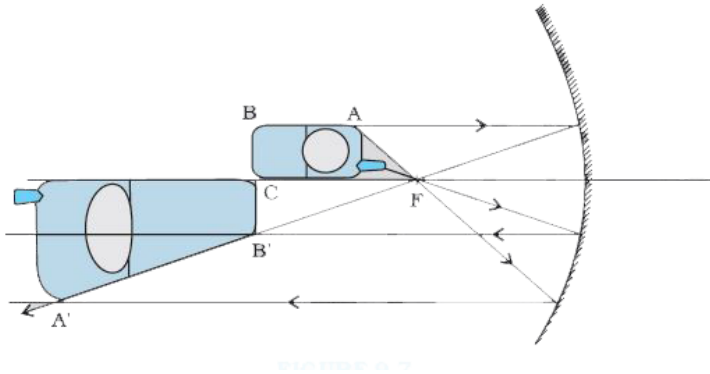
with an opaque (non-reflective) material. What effect will this have on the image of an object placed in front of the mirror?



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2. A mobile phone lies along the principal axis of a concave mirror, as shown in Fig. 9.7. Show by suitable diagram, the formation of its image. Explain why the magnification is not uniform. Will the distortion of image depend on the location of the phone with respect to

the mirror?



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3. An object is placed at (i) 10 cm, (ii) 5 cm in front of a concave mirror of radius of curvature 15 cm. Find the position, nature, and magnification of the image in each case.



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4. Suppose while sitting in a parked car, you notice a jogger approaching towards you in the side view mirror of $R = 2$ m. If the jogger is running at a speed of 5ms^{-1} , how fast the image of the jogger appear to move when the jogger is (a) 39 m, (b) 29 m, (c) 19 m, and (d) 9 m away.



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5. The earth takes 24 h to rotate once about its axis. How much time does the sun take to shift by 1° when viewed from the earth?



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6. Light from a point source in air falls on a spherical glass surface ($n = 1.5$ and radius of curvature = 20 cm). The distance of the light source from the glass surface is 100 cm. At what position the image is formed?





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7. A magician during a show makes a glass lens with $n=1.47$ disappear in the trough of liquid. What is the refractive index of the liquid.



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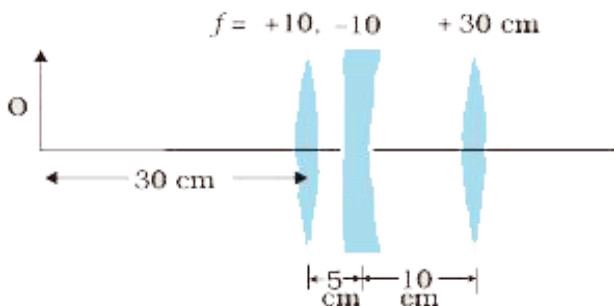
8. (i) If $f = 0.5$ m for a glass lens, what is the power of the lens? (ii) The radii of curvature of the faces of a double convex lens are 10 cm and 15 cm. Its focal length is 12 cm. What is the

refractive index of glass? (iii) A convex lens has 20 cm focal length in air. What is focal length in water? (Refractive index of air-water = 1.33, refractive index for air-glass = 1.5.)



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9. Find the position of the image formed by the lens combination given in the Fig.





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Exercises

1. 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?



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2. 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.



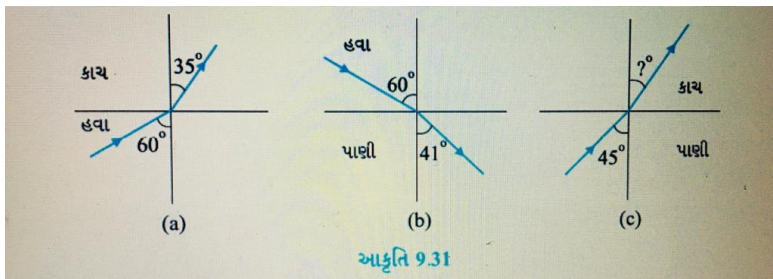
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3. A tank is filled with water to a height of 12.5 cm. The apparent depth of a needle lying at the bottom of the tank is measured by a microscope to be 9.4 cm. What is the refractive index of water? If water is replaced by a liquid of refractive index 1.63 up to the same height, by what distance would the microscope have to be moved to focus on the needle again?



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4. Figures 9.31(a) and (b) show 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 [Fig. 9.31(c)].



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5. A small bulb is placed at the bottom of a tank containing water to a depth of 80cm. What is the area of the surface of water through which light from the bulb can emerge out? Refractive index of water is 1.33. (Consider the bulb to be a point source.)



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6. A prism is made of glass of unknown refractive index. A parallel beam of light is

incident on a 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



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7. 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?



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8. 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?



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9. 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?



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10. 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 thickness of the lenses.



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11. A compound microscope consists of an objective lens of focal length 2.0 cm and an eyepiece of focal length 6.25 cm separated by a distance of 15cm. 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 (25cm), and (b) at infinity? What is the magnifying power of the microscope in each case?



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12. 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 9.0mm from the objective in sharp focus. What is the separation between the two

lenses? Calculate the magnifying power of the microscope,



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13. A small telescope has an objective lens of focal length 144cm and an eyepiece of focal length 6.0cm. What is the magnifying power of the telescope? What is the separation between the objective and the eyepiece?



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14. (a) A giant refracting telescope at an observatory has an objective lens of focal length 15m. If an eyepiece of focal length 1.0cm is used, what is the angular magnification of the telescope?

(b) 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 $3.48 \times 10^6 m$, and the radius of lunar orbit is $3.8 \times 10^8 m$.



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15. Use the mirror equation to deduce that:

(a) an object placed between f and $2f$ of a concave mirror produces a real image beyond $2f$.

(b) a convex mirror always produces a virtual image independent of the location of the object.

(c) the virtual image produced by a convex mirror is always diminished in size and is located between the focus and the pole.

(d) an object placed between the pole and

focus of a concave mirror produces a virtual and enlarged image.



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16. A small pin fixed on a table top is viewed from above from a distance of 50cm. By what distance would the pin appear to be raised if it is viewed from the same point through a 15cm thick glass slab held parallel to the table? Refractive index of glass = 1.5. Does the answer depend on the location of the slab?



17. (a) Figure 9.32 shows a cross-section of a 'light pipe' made of a glass fibre 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.

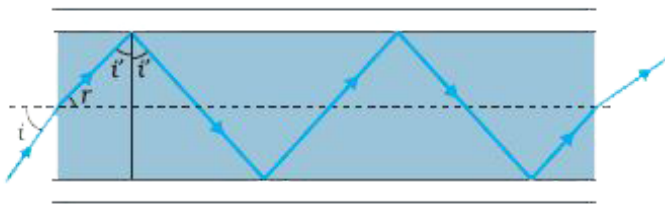


FIGURE 9.32

(b) What is the answer if there is no outer covering of the pipe?



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18. Answer the following questions:

(a) You have learnt that plane and convex mirrors produce virtual images of objects. Can they produce real images under some circumstances? Explain.



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19. Answer the following questions:

(b) 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?



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20. Answer the following questions:

(c) A diver under water, 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?



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21. Answer the following questions:

(d) Does the apparent depth of a tank of water change if viewed obliquely? If so, does the apparent depth increase or decrease?



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22. Answer the following questions:

(e) The refractive index of diamond is much greater than that of ordinary glass. Is this fact of some use to a diamond cutter?



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23. The image of a small electric bulb fixed on the wall of a room is to be obtained on the opposite wall 3m away by means of a large convex lens. What is the maximum possible

focal length of the lens required for the purpose?



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



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25. (a) Determine the 'effective focal length' of the combination of the two lenses in Exercise 9.10, if they are placed 8.0cm 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?

(b) 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.



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26. 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.



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27. A card sheet divided into squares each of size 1mm^2 is being viewed at a distance of 9 cm through a magnifying glass (a converging lens of focal length 10 cm) held close to the eye.

(a) What is the magnification produced by the lens? How much is the area of each square in the virtual image?

(b) What is the angular magnification (magnifying power) of the lens?

(c) Is the magnification in (a) equal to the magnifying power in (b)? Explain.



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28. (a) At what distance should the lens be held from the figure in Exercise 9.29 in order to view the squares distinctly with the maximum possible magnifying power?

(b) What is the magnification in this case?

(c) Is the magnification equal to the magnifying power in this case? Explain.



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29. What should be the distance between the object in Exercise 9.24 and the magnifying glass if the virtual image of each square in the figure is to have an area of 6.25mm^2 . Would you be able to see the squares distinctly with your eyes very close to the magnifier?



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30. Answer the following questions:

(a) The angle subtended at the eye by an object is equal to the angle subtended at the

eye by the virtual image produced by a magnifying glass. In what sense then does a magnifying glass provide angular magnification?



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31. Answer the following questions:

(b) In viewing through a magnifying glass, one usually positions one's eyes very close to the lens. Does angular magnification change if the eye is moved back?



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32. Answer the following questions:

(c) Magnifying power of a simple microscope is inversely proportional to the focal length of the lens. What then stops us from using a convex lens of smaller and smaller focal length and achieving greater and greater magnifying power?



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33. Answer the following questions:

(d) Why must both the objective and the eyepiece of a compound microscope have short focal lengths?



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34. Answer the following questions:

(e) When viewing through a compound microscope, our eyes should be positioned not on the eyepiece but a short distance away

from it for best viewing. Why? How much should be that short distance between the eye and eyepiece?



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



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36. A small telescope has an objective lens of focal length 140cm and an eyepiece of focal length 5.0cm. 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 (25cm)?



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37. (a) For the telescope described in Exercise 9.28 (a), 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 25cm?



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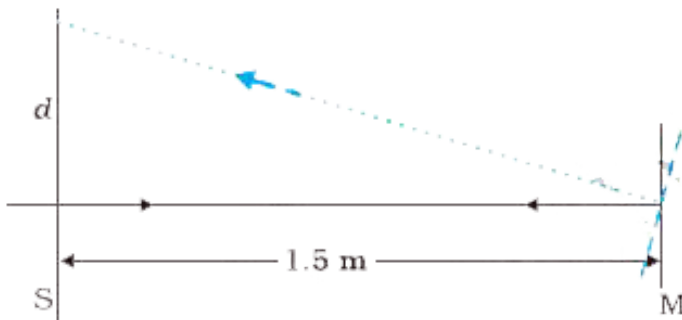
38. A Cassegrain telescope uses two mirrors as shown in Fig. 9.30. Such a telescope is built with the mirrors 20mm apart. If the radius of curvature of the large mirror is 220mm and the small mirror is 140mm, where will the final image of an object at infinity be?



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39. Light incident normally on a plane mirror attached to a galvanometer coil retraces backwards as shown in Fig. 9.33. 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?

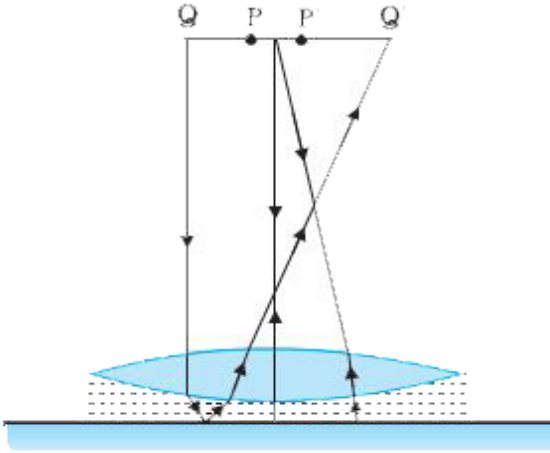


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40. Figure 9.34 shows an equiconvex lens (of refractive index 1.50) in contact with a liquid

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 45.0cm. The liquid is removed and the experiment is repeated. The new distance is measured to be 30.0cm. What is the refractive

index of the liquid?



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