PHYSICS

BOOKS - VIKRAM PUBLICATION (ANDHRA PUBLICATION)

RAY OPTICAL AND INSTRUMENTS

Problems

1. A light wave of frequency $4 \times 10^{14}\mathrm{Hz}$ and a wavelength of $5 \times 10^{-7}m$ passes through a

medium. Estimate the refracetive index of the medium.

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2. A ray of light is incident at an angle of 60° on face of a prism of angle 30° The emergent ray makes an angle of 30° with the incident ray. Calculate the refractive index of the material of the prism.

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3. Two lenses of power $-1.75D$ and $+2.25D$ respectively, are placed in contact. Calculate the focal length of the combination.

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4. Some rays falling on a converging lens are focussed 20 cm from the lens. When a diverging lens is placed in contact with the converging lens, the rays are focussed 30 cm from the combination. What is the focal length of the diverging lens?

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5. A double convex lens of focal length 15 cm is used as a magnifying glass in order to produce an erect image which is 3 times magnified. What is the distance between the object and the lens ?

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6. A compound microscope consists of an object lens of focal length 2 cm and an eyepiece of focal length 5 cm. When an object is placed at 2.2 cm from the object lens, the final image is at 25 cm from the eye lens. What is the distance between the lenses ? What is the total linear magnification ?

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7. Two point surces S_1 and S_2 are 24 cm apart. Where should a convex lens of focal length 9 cm be placed them , so that the images of both sources are formed at the same place ?

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8. Find two positions of an object, placed in front of a concave mirror of focal length 15cm,

so that the image formed is 3 times the size of the object.

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9. Using a certain concave mirror, the magnification is found to be 4 times as great when the object was 25 cm from the mirror as it was with the object at 40 cm from the mirror, the image, being real in each case.Find the focal length of the mirror.

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10. The focal length of the objective and eyepiece of a compound microscope are 4 cm and 6 cm respectively. If an object is placed at a distance of 6cm from the objective, what is the magnification produced by the microscope ?

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11. Draw neat lebelled ray diagram of simple microscope.

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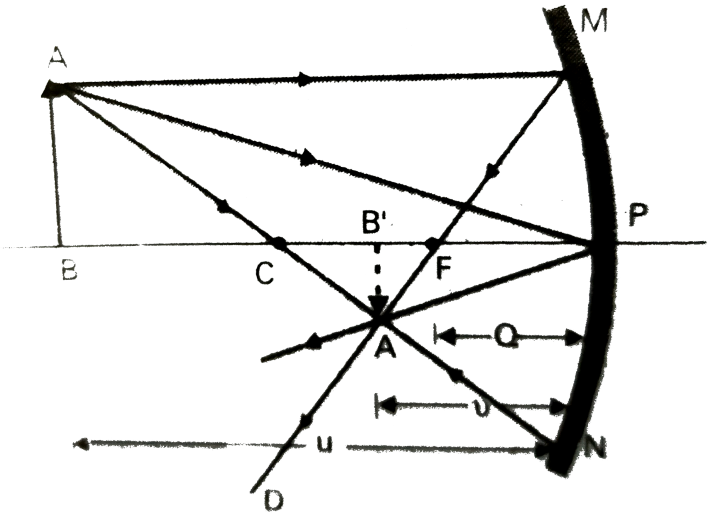
Textual Examples

1. Suppose that the lower half of the concave mirror's reflecting surface in figure 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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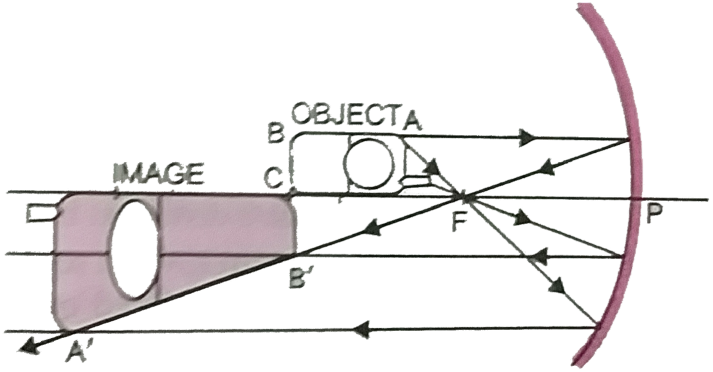
2. A mobile phone lies along the principal axis of a concave mirror as shown in Fig. Show by suitable diagram, the formation of its image.

Explain why the magnification is not uniform, and distortion will occur depending on the location of the mobile 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 or radius of curvature 15cm. 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. If $\mu = 1.5$, and radius of curvature $= 20cm$, the distance of light source from the glass surface is $100cm$, at what position will the image be formed ? (NCERT Solved Example)

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7. A magician during a show makes a glass lens with n = 1.47 disappear in a trough of liquid.

What is the refractive index of the liquid ?

Could the liquid be water ?

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8. (i) If f = 0.5 m for a glass lens, what is the power of the lens ?

(Refractive index of air-water = 1.33. Refractive index for ar - glass = 1.5.)

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9. (ii) The radii of curvature of the faces of a double convex lens are 10 cm and 15cm. Its focal length is 12 cm. What is the refractive index of glass ?

(Refractive index of air-water = 1.33. Refractive index for ar - glass = 1.5.)

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10. (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 ar - glass = 1.5.)

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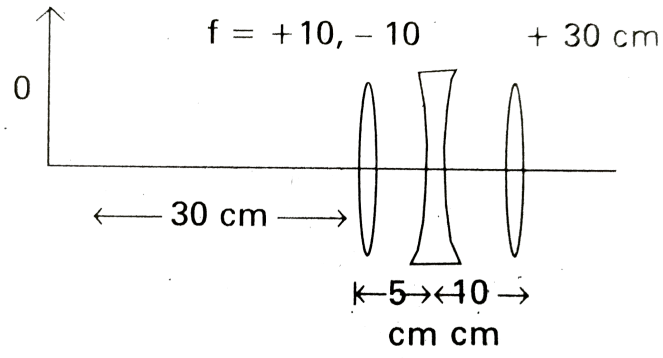
11. Find the position of the image formed by the lens combination given in the fig.



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12. What focal length should the reading spectacles have for a person for whom the least distance of distinct vision is 50 cm ?

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13. The far point of a myopic person is 80 cm in front of the eye . What is the natuure and power of the lens required to correct the defect ?

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14. The far point of a myopic person is 80 cm in front of the eye. What is the power of the lens required to enable his to see very distant objects clearly?

b) In what way does the corrective lens help the above person ? Does the lens magnify very distant objects? Explain carefully.

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15. c) The above person prefers to remove his spectacles while reading a book. Explain why ?

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16. The near point of a hypermetropic person is 75 cm from the eye. What is the power of the lens required to enable the person to read clearly a book held at 25 cm from the eye ?

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17. The near point of a hypermetropic person is 75 cm from the eye. What is the power of the lens required to enable the person to read clearly a book held at 25 cm from the eye ?

In what way does the corrective lens help the above person? Does the lens magnify objects held near the eye ?

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18. The above person prefers to remove the spectacles while looking at the sky. Explain

why?

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Very Short Answer Questions

1. Define focal length and radius of curvature of a concave lens.

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2. What do you understand by the terms 'focus' and 'principal focus' in the context of lenses ?

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3. What is optical density and how is it different from mass density ?

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4. What are the laws of reflection through curved mirrors ?

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5. Define power of a lens and write its unit

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6. A concave mirror of focal length 10 cm is placed at a distance 35 cm from a wall. How far

from the wall should an object be placed so that its real image is formed on the wall ?

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7. A concave mirror produces an image of a long vertical pin, placed 40 cm from the mirror, at the position of the object. Find the focal length of the mirror.

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8. A small angled prism of 4° deviates a ray through 2.48°. Find the refractive index of the prism.

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9. What is 'dispersion' ? Which colour gets relatively more dispersed ?

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10. The focal length of a concave lens is 30 cm. Where should an object be placed so that its image is $1/10$ of its size ?

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11. Example with the help of labelled ray diagram, the defect of vision called myopia and how it is corrected by a lens.

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12. What is hypermetropia ? How can it be corrected ?

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Short Answer Questions

1. A light ray passes through a prism of angle A in a position of minimum deviation. Obtain and expression for (a) the angle of incidence in terms of the angle of the prism and the angle of minimum deviation (b) the angle of

refraction in terms of the refractive index of the prism.

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2. Define focal length of a concave mirror. Prove that the radius of curvature of a concave mirror is double its focal length.

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3. A mobile phone lies along the principal axis of a concave mirror longitudinaly. Explain why the magnification is not uniform.

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4. Explain the cartesian sign convention for mirrors.

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5. Define critical angle. Explain total internal reflection using a neat diagram.

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6. Explain the formation of Mirage .

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7. Explain the formation of a rainbow.

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8. Why does the setting sun appear red ?

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9. Draw neat lebelled ray diagram of simple microscope.

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10. What is the position of the object for a simple microscope ? What is the maximum magnification of a simple microscope for a realistic focal length?

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Long Answer Questions

1. What is the cartesian sign convention ? Applying this convention and using a neat

diagram, derive an expression for finding the image distance using the mirror equation.

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2. An object of 5cm height is placed at a distance of 15cm from a concave mirror of radius of curvature 20 cm. Find the size of the image.

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3. Using a neat labelled diagram derive the mirror equation. Define linear magnification.

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4. An object is placed at 5cm from a convex lens of focal length 15cm. What is the position and nature of the image ?

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5. Derive an expression for a thin double convex lens. Can you apply the same to a double concave lens too?

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6. An object is placed at a distance of 20 cm from a thin double convex lens of focal length 15 cm. Find the position and magnification of the image.

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7. Obtain an expression for the combined focal length for two thin convex lenses kept in contact and hence obtain an expression for the combined power of the combination of the lenses.

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8. Define Snell's Law. Using a neat labelled diagram derive an expression for the refractive index of the material of an equilateral prism.

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9. A ray of light, after passing through a medium, meets the surface separating the medium from air at an angle of 45° and is just not refracted. What is the refractive index of the medium?

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10. Draw a neat labelled diagram of a compound microscope and explain its working. Derive an expression for its magnification.

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Textual Exercises

1. A small candal, 2.5 cm in size is placed at 27 cm in front of a concave mirror of radius of

curvature 36 cm. At wht 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 candale 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.

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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 2.54 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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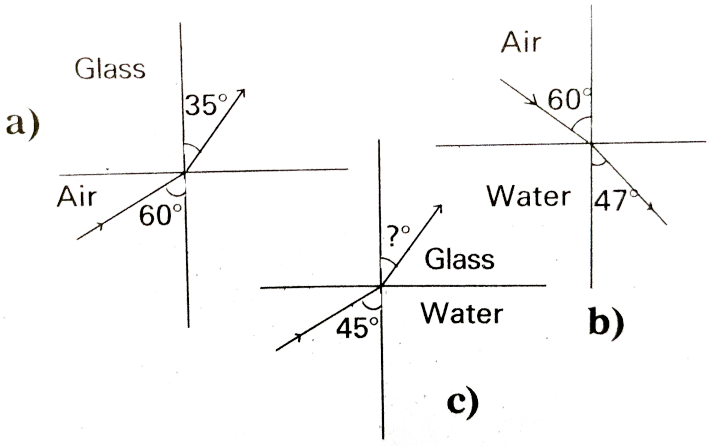

4. The above 3 Figures (a) and (b) show refraction of a ray in air incident at 60° with the normal to a glass - air and water-air figures interface respectively. Predict the angle of refraction in glass when the angle of incidence in water is 45° with the normal to a water - glass interface [Fig. (c)]

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5. A small bulb is placed at the bottom of a tank containing water to a depth of 80 cm. 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 606°. If the prism is placed in water (refractive idex 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 20 cm?

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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 12 cm from P. At what point does the beam converge if the lens is (a) a convex lens

of focal length 20 cm, and (b) a concave lens of focal length 16 cm ?

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9. An object of size 3.0 cm is placed 14 cm in front of a concave lens of focal length 21 cm. 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 30 cm in contact with a concave lens of focal length 20 cm ? 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 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 ?

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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 eyeplece of focal length 2.5 cm can bring an object placed

at 2.0 mm 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 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 ?

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14. 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 ?

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15. 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 ?

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 radius of lunar orbit is $3.8 \times 10^8 m$.

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16. 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.

[Note : The exercise helps you deduce algebraically properties of images that one obtains from explicit ray diagrams.]

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17. Use the mirror equation to deduce that :

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

[Note : The exercise helps you deduce algebraically properties of images that one obtains from explicit ray diagrams.]

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18. Use the mirror equation to deduce that :

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

[Note : The exercise helps you deduce algebraically properties of images that one obtains from explicit ray diagrams.]

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19. Use the mirror equation to deduce that :

d) an object placed between the pole and focus of a concave mirror produces a virtual and enlarged image.

[Note : The exercise helps you deduce algebraically properties of images that one obtains from explicit ray diagrams.]

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20. A small pin fixed on a table top is viewed from above from a adistance 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 ?

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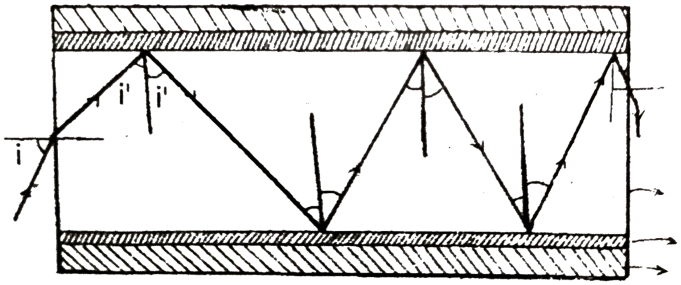
21. a) Figure shows a cross - section of a light pipe made of a glass fibre of refractive inde 1.68. The outer covering of the pipe is made of a material of refracitive index 1.44. What is the range of the angles of the incident rays with the axis of the pipe for which total reflections inside the pipe take place, as shown in the figures.

b) What is the answer if there is no outer

covering of the pipe?



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22. 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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23. b) A virtual image, we always say, can-not 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 contradication ?

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24. 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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25. 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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26. 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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27. 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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28. 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.

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29. a) Determine the 'eefective focal length' of the combination of the two lenses in Exercise 10, 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 ?

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30. a) Determine the 'eefective focal length' of the combination of the two lenses in Exercise 10, 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 ?

b) A 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 is 40 cm.

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31. 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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32. You are given prisms made of crown glass and flint glass with a wide variety of anlges. Suggest a combination of prisms will

a) deviate a pencil of white light without much dispersion.

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33. You are given prisms made of crown glass and flint glass with a wide variety of anlges. Suggest a combination of prisms will

b) disperse (and displace) a pencil of white light without much deviation.

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34. For a norma eye, the far point is at infinity and the near point of distinct vision is about 25 cm in front of the eye. The cornea of the eye provides a converging power of about 40 diopters, and the least converging power of the eyelens behind the cornea is about 20 diopters. From this rough data estimate the

range of accommodation (i.e., the range of converging power of the eyelens) of a normal eye.

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35. Does short-sightedness (myopia) or long-sightedness (hypermetropia) imply necessarily that the eye has partially lost its ability of accommodation? If not, what might cause these defects of vision ?

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36. A myopic person has been using spectacles of power -1.0 dioptre for distant vision. During old age he also needs to use separate reading glass of power $+0.2$ dioptres. Explain what may have happened.

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37. A person looking at a person wearing a shirt with a pattern comprising 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 ?

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38. A man with normal near point (25 cm) reads a book with small print using a magnifying glass: a thin convex lens of focal length 5 cm.

a) What is the closest and the farthest distance at which he should keep the lens

from the page so that he can read the book when viewing through the magnifying glass ?

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39. A man with normal near point (25 cm) reads a book with small print using a magnifying glass: a thin convex lens of focal length 5 cm.

b) What is the maximum and the minimum angular magnification (magnifying power) possible using the above simple microscope?

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

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

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41. A card sheet divided into squares each of size $1\ \mathrm{mm}^2$ is being viewed at a distance of 9 cm through a magnifying glass (a converging lens of focal length 9 cm) held close to the eye. What is the angular magnification (magnifying power) of the lens ?

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42. A card sheet divided into squares each of size$1\ \mathrm{mm}^2$ is being viewed at a distance of 9

cm through a magnifying glass (a converging lens of focal length 9 cm) held close to the eye. Is the magnification in (a) equal to the magnifying power in (b) ? Explain.

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43. a) At what distance should the lens be held from the figure in Exercise 2.29 in order to view the sequares distinctly with the maximum possible magnifying power?

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44. b) What is the magnificiation in this case ?

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

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46. What should be the distance between the object in Exercise 30 and the magnifying glass if the virtual image of each square in the figure is to have an area of $6.25\ \mathrm{mm}^2$. Would you be able to see the squares distinctly with your eyes very close to the magnifier ?

[Note : Exercises 29 to 31 will help you clearly understand the difference between magnification in absolute size and the angular magnification (or magnifying power) of an instrument.'

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47. 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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48. 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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49. 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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50. d) Why must both the objective and the eyepiece of a compound microscope have short focal lengths ?

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51. 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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52. An angular magnification (magnifying power) of 30 X is desired using an objective of

focal length 1.25 cm and an eyepiece of focal length 5cm. How will you set up the compound microscope ?

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53. 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) ?

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54. 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 b) the final image is formed at the least distance of distinct vision (25 cm) ?

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55. a) For the telescope described in Exercise 34 (a), what is the separation between the objective lens and the eyepiece ?

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56. 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?

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57. c) What is the height of the final image of the tower if it is formed at 25 cm?

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58. A cassegrain telescope is built with the mirrors 20 mm apart. If the radius of curvature of the larger mirror is 220 mm and the small mirror is 140 mm. where will the final image of an object at infinity be ?

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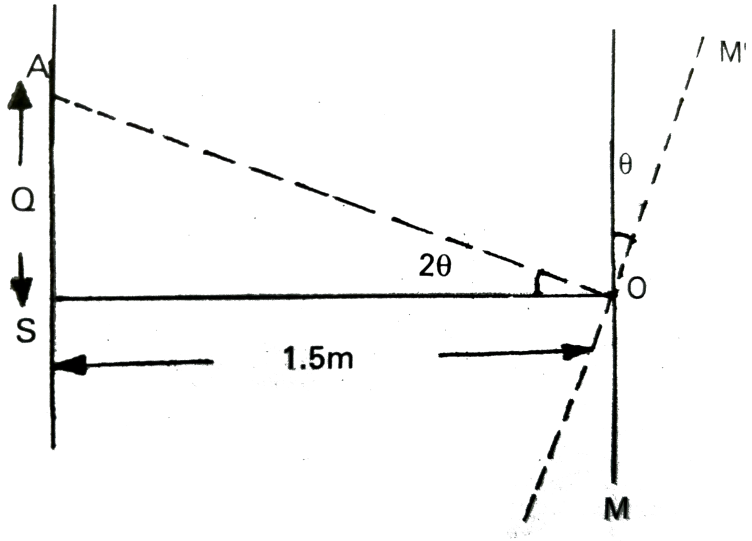
59. Light incident normally on a plane mirror attached to a galvanometer coil retraces backwards as shown in Fig. A current in the coil produceds a deflection of 3.5° of the mirror. What is the displacement of the reflected spot of light on a screen placed 1.5 m

away ?



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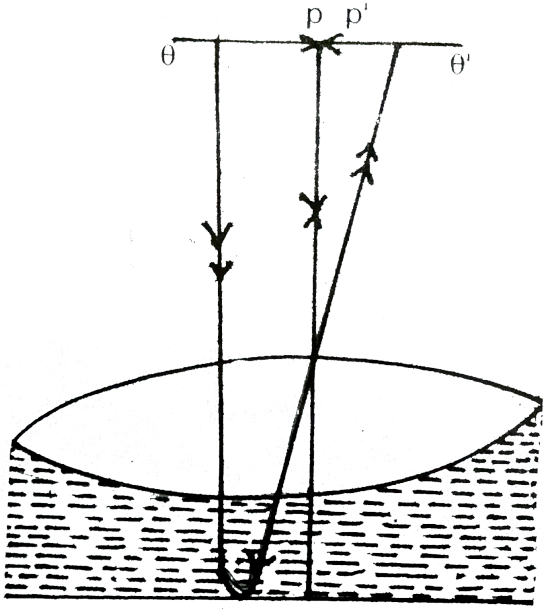
60. Figure shows an equiconvex lens (of refractive index 1.50) in contact with a liquid layer on top of a plane mirror. A small needle

with its tip on the principal axis is moved along the axis unit 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 ?



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