PHYSICS

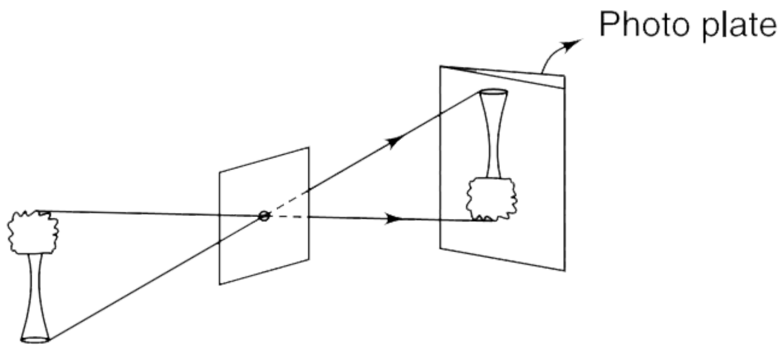
BOOKS - ARIHANT PHYSICS (HINGLISH)

GEOMETRICAL OPTICS

Level 1

1. A man of height 1.8 m is standing in front of a wall. The sun is exactly behind him. His shadow has a length 1.5 m on the ground and 0.75 m on the wall. Find the length of his shadow on the ground if the wall is removed.

2. Light travels in a straight line. This principle is illustrated in a pinhole camera. In this simple device the image of an object is formed on a photographic plate by light passing through a small hole.



In one experiment, 5 cm high image of a tree was obtained on a photo plate placed at a distance of 15 cm from the pin hole. Actual height of the tree is 20 m.

(a) Find the distance of the pinhole from the tree.

(b) How is the size of image affected if the photo plate is moved away from the pinhole?

(c) What will happen if a large hole is made in place of a pin hole?

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3. A point object O is kept in front of a plane mirror AB having length L = 2 m. The line AOM makes an angle $\theta = 60^\circ$ with the mirror. An observer is walking along the line XMX' (perpendicular to AOM). Find the length of his path along XMX' in which he can see the image of the object. Given $AO = d = 1m$ and $AM = 2d$.

]

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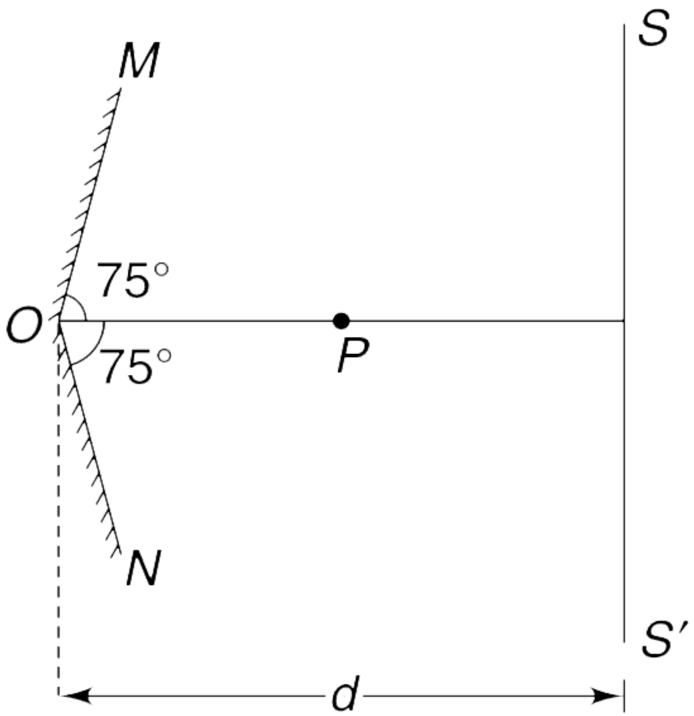
4. Two large plane mirrors OM and ON are arranged at 150° as shown in the figure. P is a point object and SS' is a long line perpendicular to the line OP. Find the length of the part of the line

SS' on which two images of the point object P can be seen.



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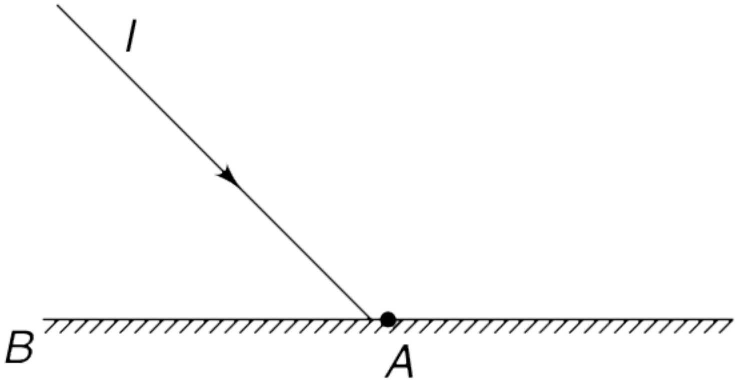
5. I is a ray incident on a plane mirror. Keeping the incident ray fixed, the mirror is rotated by an angle θ about an axis passing through A perpendicular to the plane of the Fig. show that the refracted ray rotates through an angle 2θ. Does your answer differ if the mirror is rotated about an axis passing through B?



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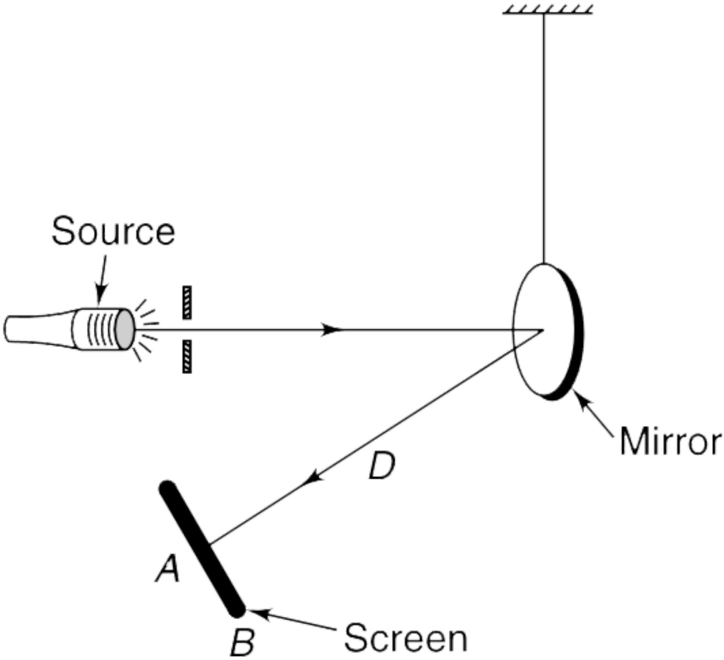
6. The Fig. shows a device used to measure small twist in a thread. A plane mirror is suspended from a twist free thread. A light ray striking the mirror is reflected on to a screen placed at a distance $D = 1m$ from the mirror.



As the thread is twisted by an angle θ (so that mirror rotates by θ), the light spot on the screen moves from A to B such that $AB = 0.5cm$. Find θ.

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7. While looking at her face in a mirror, Hema notes that her face is highly magnified when she is close to the mirror. As she backs away from the mirror, her image first gets blurry, then disappears when she is at a distance of 45 cm from the mirror. Explain the happenings? What will happen if she moves beyond 45 cm distance from the mirror?

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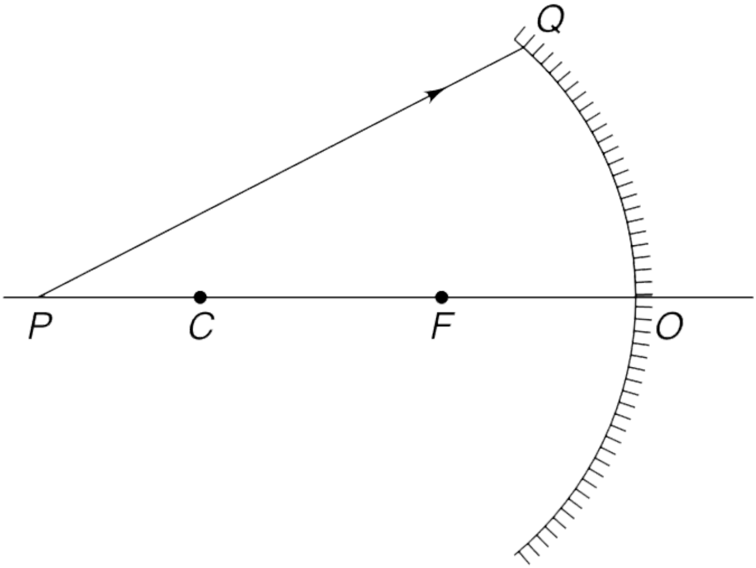
8. We know that parallel light rays which are inclined to the principal axis of a spherical mirror, after reflection converge at a point in the focal plane of the mirror. With this knowledge explain how you will trace the reflected ray for incident ray PQ shown in the

Fig. F is focus and C is centre of curvature of the mirror.



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9. The inner surface of the wall of a sphere is perfectly reflecting. Radius of the sphere is R. A point source S is placed at a distance $R/2$ from the centre of the sphere. Consider the reflection of light from the farthest wall followed by reflection from the nearest wall. Where is the image of the source? Consider paraxial rays only.

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10. A concave mirror forms a real image, on a screen of thrice the linear dimension of a real object placed on its principal axis. The mirror is moved by 10 cm along its principal axis and once again a sharp image of the object is obtained on the screen. This time the image is twice as large as the object. Find the focal length of the mirror.

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11. Plot the graphs of $\left|\frac{1}{V}\right|$ vs $\left|\frac{1}{u}\right|$ where v is image distance and u is object distance for the conditions given below:

A. for concave mirror when image is real

B. for concave mirror when image is virtual

C. for convex mirror when image is virtual

D. for convex mirror when image is real.

Answer: A::B::C::D

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12. A point object O is placed at a distance of 60 cm from a concave mirror of radius of curvature 80 cm.

(a) At what distance from the concave mirror should a plane mirror be kept so that rays converge at O itself after getting reflected from the concave mirror and then from the plane mirror?

(b) Will the position of the point where the rays meet change if they are first reflected from the plane mirror?

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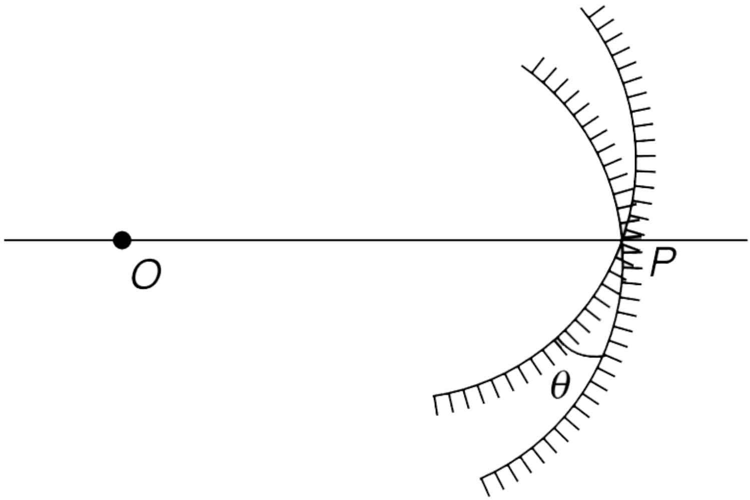
13. A point object (O) is placed at the centre of curvature of a concave mirror. The mirror is rotated by a small angle q about its plole (P). Find the approximate distance between the object and its image. Focal length of the mirror is f.



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14. A one eyed demon has a circular face of radius $a_0 = 10cm$. The eye is located at the centre of the face. At what distance from his face he must hold a convex mirror of 5 cm aperture diameter so as to see his complete face? Focal length of the mirror is 10 cm.

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15. A small insect starts walking away from a concave mirror along its principal axis. At a point (P) 20 cm from the mirror the image flips upside down. (a) What can you say about the size of the image at the instant it flips upside down – it is very large, very small or of the size similar to the insect? (b) Find the distance of the insect from point (P) where its image is thrice as large as the insect.

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16. A piece of metal is cut from a hollow metal sphere of radius R and is polished on both sides. A boy looks at the metal piece and finds his image 13 cm behind the metal piece. His friend flips the mirror, keeping its position unchanged and now the boy finds his image to be 52 cm behind the mirror. Find R.

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17. The aperture diameter of a spherical mirror is $D = \eta R$ where η is a positive number less than 2 and R is radius of curvature of the mirror. Consider a wide parallel beam of light incident on the mirror parallel to its principal axis.

(a) Find minimum value of h for which marginal rays start getting reflected twice.

(b) Find minimum value of h for which marginal rays undergo three reflections.

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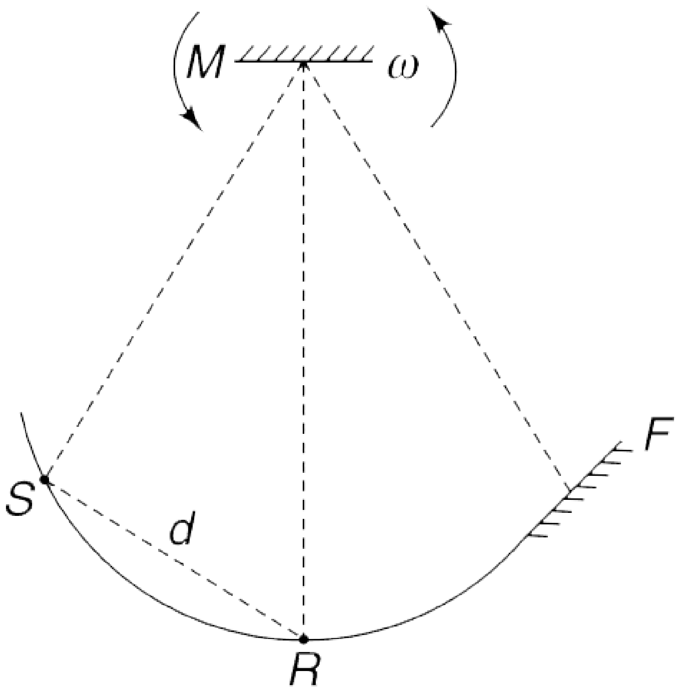
18. A source of laser (S), a receiver (R) and a fixed mir- ror (F) – all lie on an arc of a circle of radius $R = 0.5 km$. The distance between the source and the receiver is $d = 0.5m$. At the centre of the circle there is a small mirror M which is rotating with angular speed ω (see figure). Find smallest value of ω is if it is seen that the source shoots a laser pulse which gets reflected at M, then gets reflected at F and finally gets reflected at M to be received by the receiver.



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19. A real object is kept at a distance a from the focus of a concave mirror on the principal axis. A real image is formed at a distance b from the focus. Plot the variation of b with a. If b versus a graph is given to you, how will you find the focal length of the mirror? Explain

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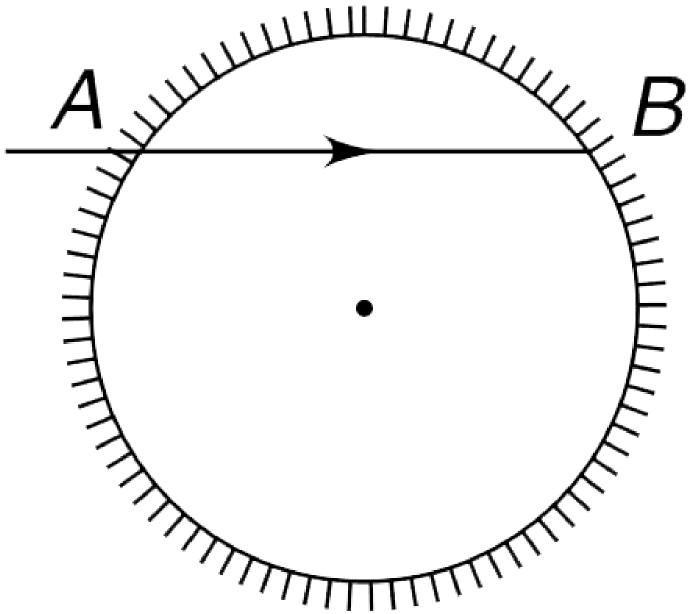
20. A light ray enters horizontally into a vertical cylinder through a small hole at A. The ray is initially travelling along a chord (AB) whose length is $\left(\frac{\sqrt{5}+1}{2}\right)R$ where R is the radius of the cylinder. After how many reflections on the inner wall of the cylinder the light ray will be incident at point A ? [Given $\cos 36^\circ = \frac{\sqrt{5}+1}{4}$]



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21. A ship has a green light $(\lambda = 510nm)$ on its mast. What colour would be observed for this light by a diver deep inside water. Refractive index for water is $\mu = \frac{4}{3}$.

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22. A vertical rod is partially submerged in an aquarium. You look at the aquarium from some distance. Does the underwater part of the rod appear to be closer than, farther than or the same distance as the top of the rod.

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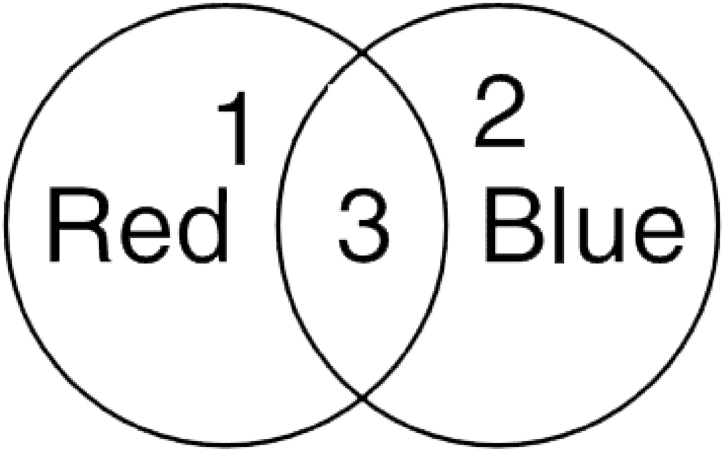
23. Two transparent plastic sheets of red and blue colour overlap as shown in the Fig. An observer looks at a clear sky through the sheets. What can you say about the colour and brightness of light coming through sections 1, 2 and 3 (see Fig.)



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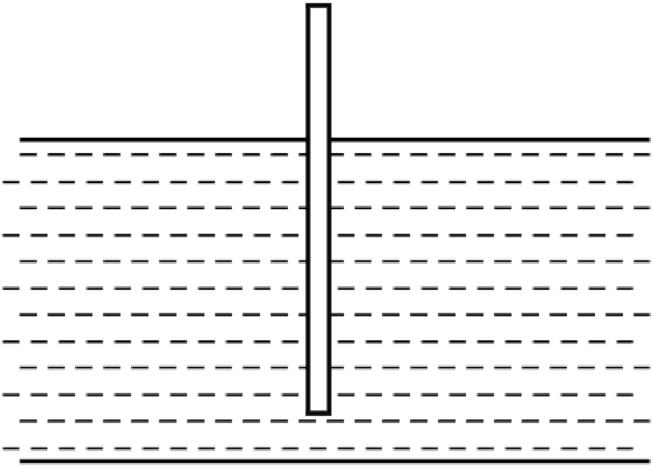
24. A wooden stick of length 100 cm is floating in water while remaining vertical. The relative density of the wood is 0.7. Calculate the apparent length of the stick when viewed from top (close to the vertical line along the stick) Refractive index of wate $= \frac{4}{3}$.



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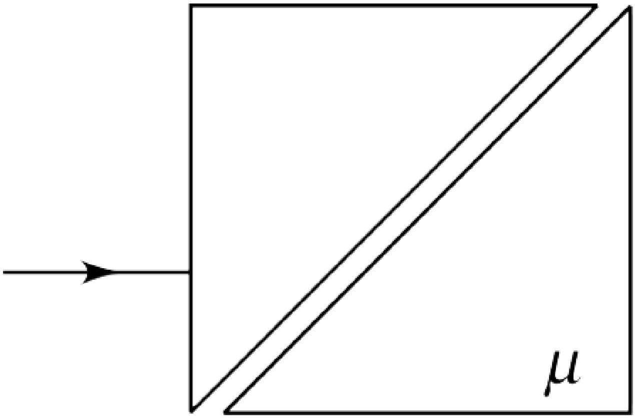
25. A glass cube is cut symmetrically into two halves and the two parts are kept at a small separation between them. Calculate the angular deviation suffered by a light ray incident normally on one of

the faces of the cube.



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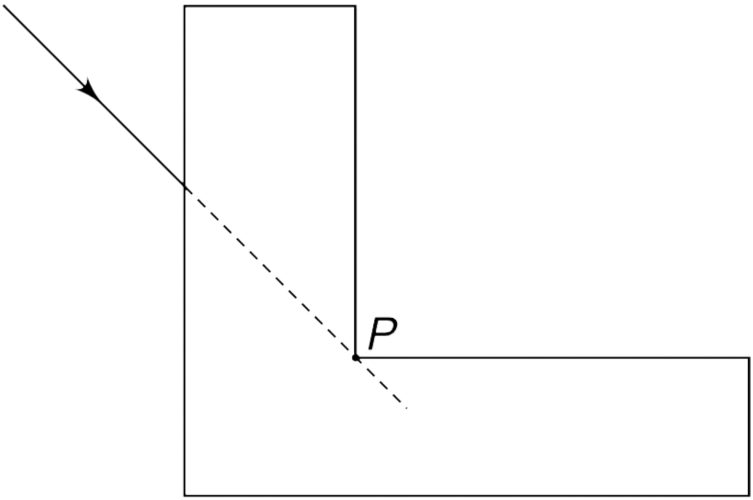
26. A glass block of refractive index $\mu = 1.5$ has an L cross section with both arms identical. A light ray enters the block from left at an angle of incidence of 45°, as shown in the figure. If the block was absent the ray would pass through the point P. Calculate the angle at which the ray will emerge from the bottom face after refraction through the block.



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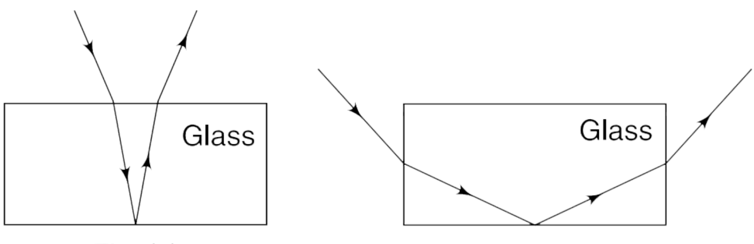
27. A ray of light passes through a rectangular glass block placed in air. Which diagram shows a possible path of a ray?



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28. A ray of light travelling in air is incident on a composite transparent slab at an angle of incidence $i = 45^\circ$. The composite slab consist of 100 parallel faced slices of equal thickness. The refractive index of the n^{th} slice (counting from the one on which light is incident) is given by $\mu_n = 1.0 + 0.01n$. The medium on the other side of the slab has refractive index of $\sqrt{2}$. Calculate the angular deviation suffered by the ray as it comes out of the slab.

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29. Prove that it is impossible to see through adjacent sides of a square block of glass with index of refraction 1.5.

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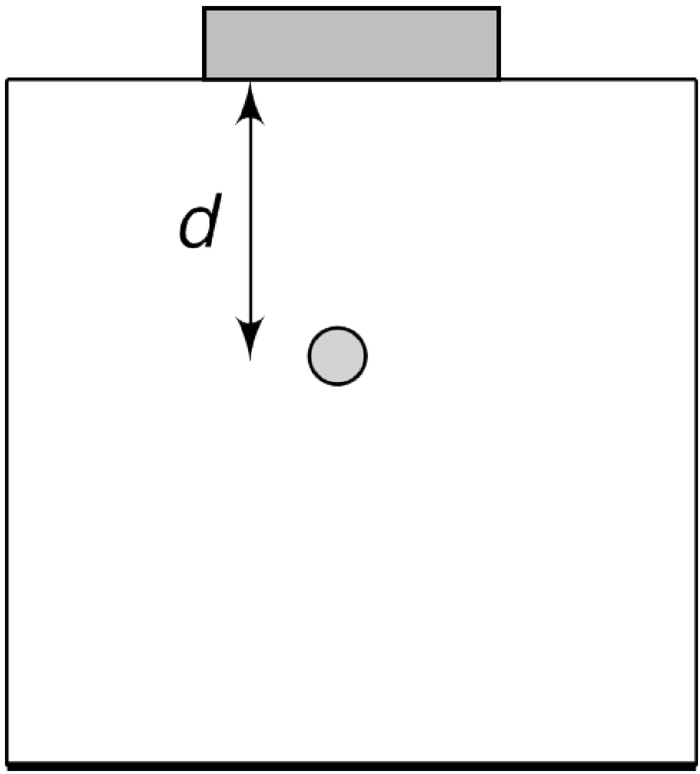
30. A large transparent cube (refractive index = 1.5) has a small air bubble inside it. When a coin (diameter 2 cm) is placed symmetrically above the bubble on the top surface of the cube, the bubble cannot be seen by looking down into the cube at any angle. However, when a smaller coin (diameter 1.5 cm) is placed directly over it, the bubble can be seen by looking down into the cube. What is the range of the possible depths d of the air bubble beneath the top surface ?



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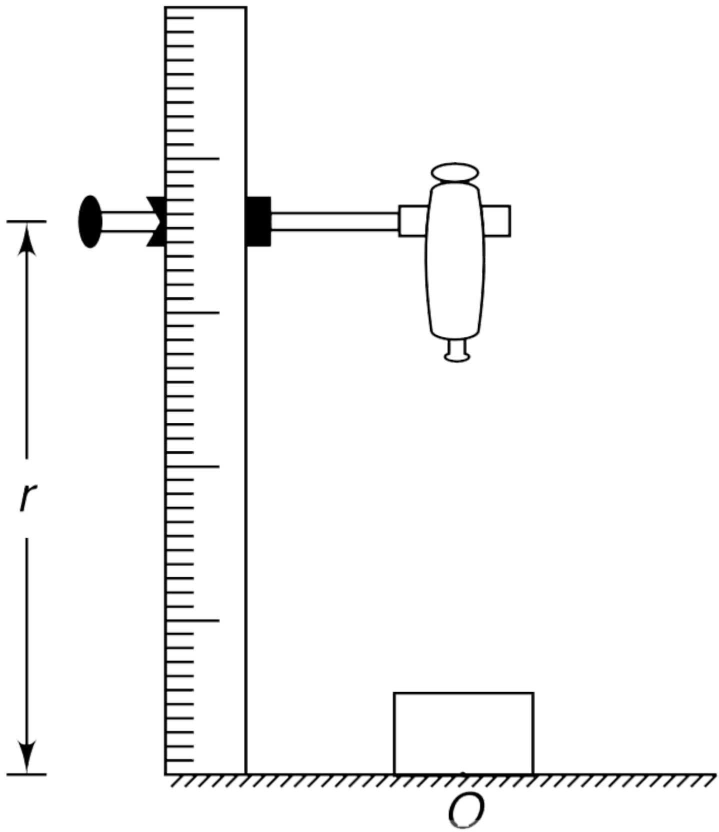
31. A travelling microscope can move vertically along a scale. It is focused at a mark O on the table and the reading on the vertical scale isr_1. Now a glass slab is placed over mark O and the microscope has to be moved up to bring the mark in focus again. This time the scale reads r_2. Lycopodium powder is spread over the top of the glass slab and the microscope is moved up once again to bring the powder particles in sharp focus. This time the vertical scale reads r_3. Find the refractive index of the material of the glass slab.



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32. A vertical beam of light of cross sectional radius $\frac{R}{2}$ is incident symmetrically on the curved surface of a glass hemisphere of refractive index $\mu = \frac{3}{2}$. Radius of the hemisphere is R and its base

is on a horizontal table. Find the radius of luminous spot formed on the table. $\sin 20^\circ = \frac{1}{3}$ and $\sin 80^\circ = 0.98$

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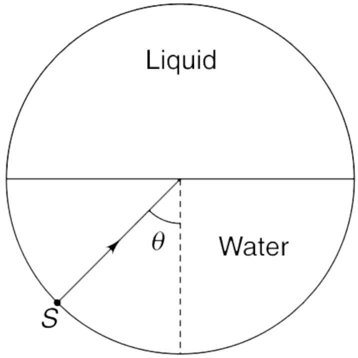
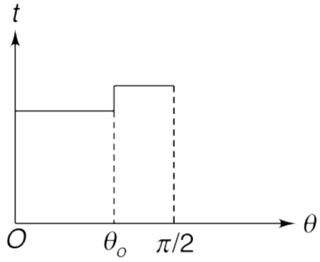
33. A horizontal cylindrical tank is half full of water (refractive index $= \frac{4}{3}$) . The space above the water is filled with a light liquid of unknown refractive index (μ). A small laser source (s) can move along the curved bottom of the cylinder and aims a light beam towards the centre of the cylinder. The time needed by the laser beam to travel from the source to the rim of the cylinder depends on position (θ) of the source as shown in the graph. Find μ, it is given that $\sin \theta_0 = \frac{5}{6}$.





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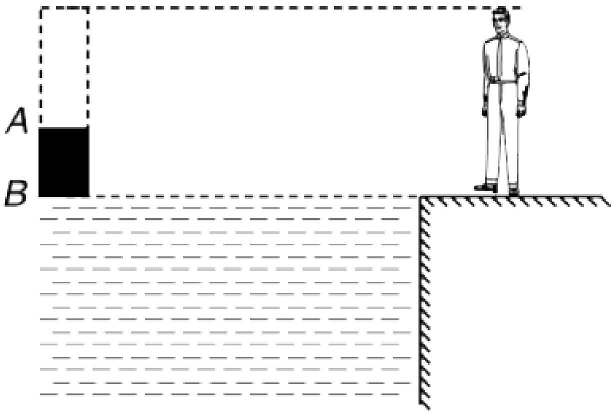
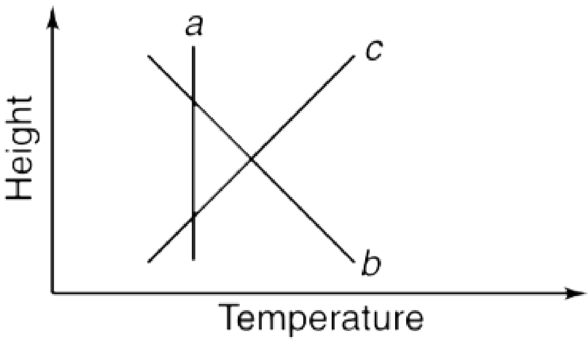
34. A man standing on sea-shore sees an elongated image (shown by dashed line) of a floating object AB. In fact he finds the image to be oscillating due to air turbu- lence. Figure (ii) gives three plots (a, b and c) of height from the water surface vs air temperature. Which one best illustrates the air-temperature condition that can create this image? [Many people have seen sea monsters due to this phenomena!]





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35. The atmosphere of earth extends upto height H and its refractive index varies with depth y from the top as $\mu = 1 + \frac{y}{H}$. Calculate the apparent thickness of the atmosphere as seen by an observer in space.

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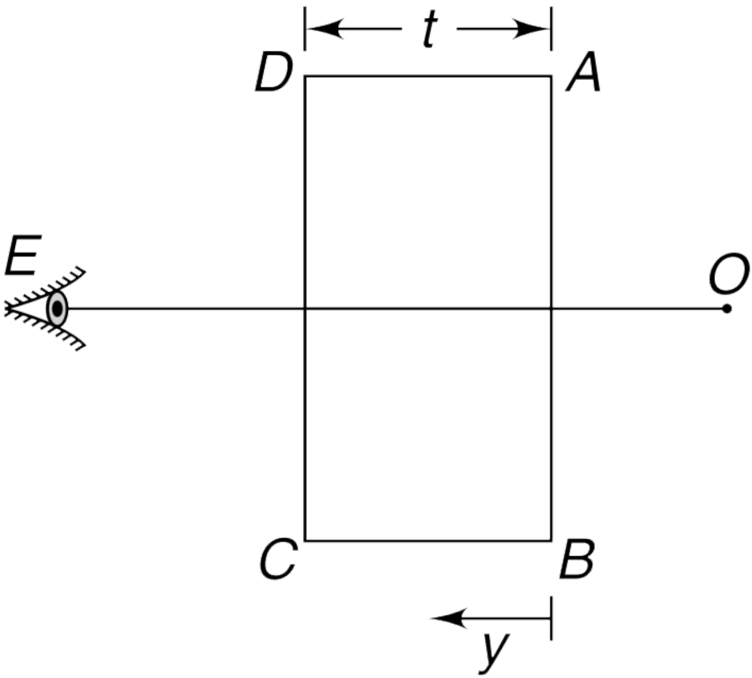
36. A glass slab is placed between an object (O) and an observer (E) with its refracting surfaces AB and CD perpendicular to the line OE. The refractive index of the glass slab changes with distance (y) from the face AB as $\mu = \mu_0(1 + y)$. Thickness of the slab is t. Find how much closer (compared to original distance) the object appears to

the observer. Consider near normal incidence only.



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37. An equilateral prism deviates a ray through 40° for two angles of incidence. The two incidence angels differ by 20°. Find their values.

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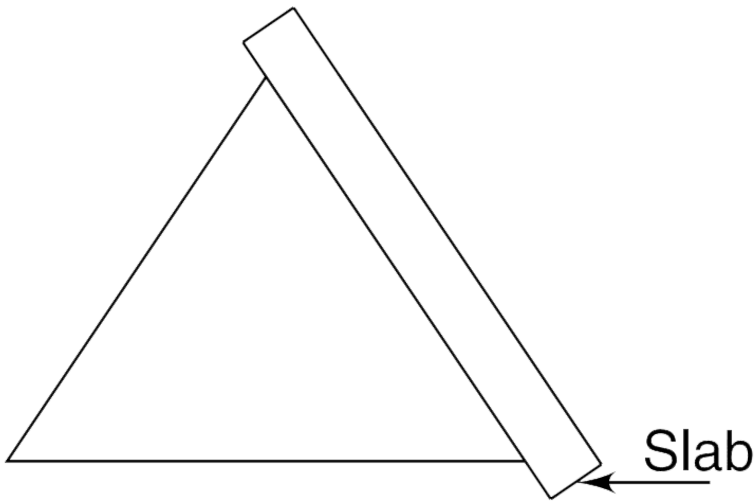
38. An equilateral glass prism can produce a minimum deviation of 30° to the path of an incident ray. A transpar- ent slab of refractive index 1.5 is placed in contact with one of the refracting faces of the prism. Thickness of the slab is 3 cm. Now calculate the minimum possible deviation which can be produced by this prism-slab combination.



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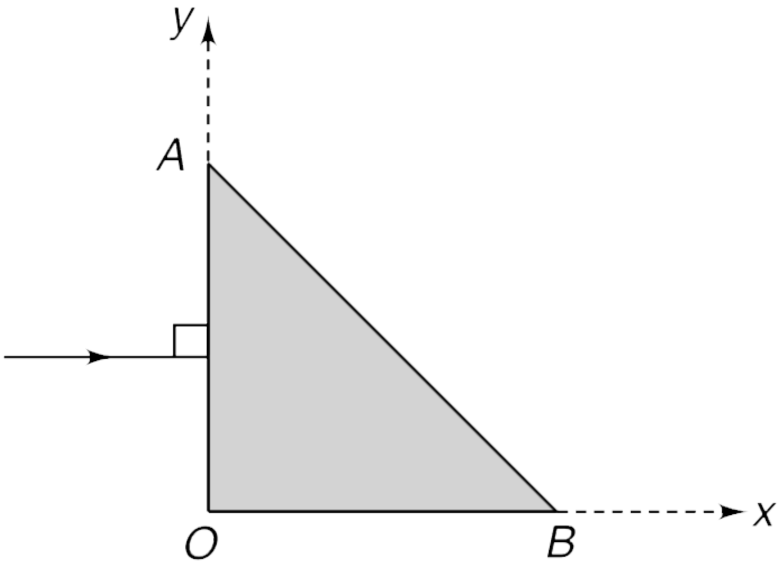
39. A triangular medium has varying refracting index $\mu = \mu_0 + ax$ where x is the distance (in cm) along x-axis from origin and

$m_0 = 4/3$. A ray is incident normally on face OA at the mid-point of OA. Find the range of value of a so that light does not escape through face AB when it falls first time on the face AB.



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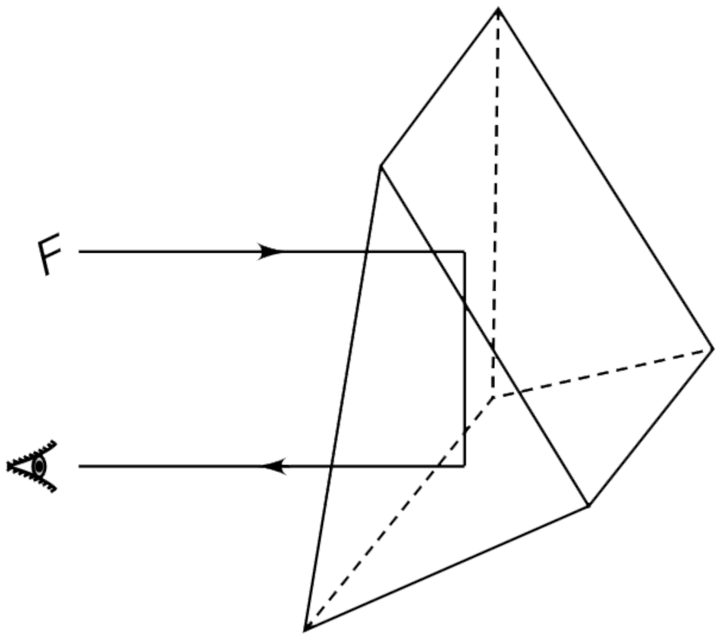
40. Letter F is kept in front of a right triangular psim. The light rays enter perpendicular to the large rectangular face, is reflected twice by small rectangular faces and exits perpendicularly to the large rectangular face (see Fig.). Draw the image of the letter seen by the eye.



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41. A prism (apex angle $A \leq 90^\circ$) produces minimum deviation that is equal to the apex angle. What can be said about the refractive index of the material of the prism.

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42. Limiting angle of a prism is defined as the largest angle of the prism (A) for which no emergent ray is obtained.

(a) Find the limiting angle (A_0) for a glass prism having refractive index μ.

(b) A prism has limiting angle for light of wavelength λ_0. Can there be any emergent ray for light of wave- length $\lambda < \lambda_0$.

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43. An isosceles glass prism has one of its faces silvered. A light ray is incident normally on the other face which is identical in size to the silvered face. The light ray is reflected twice on the same sized faces and emerges through the base of the prism perpendicularly. Find the minimum value of refractive index of the material of the prism.

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44. A parallel beam of light falls normally on the first face of a prism of small refracting angle. At the second refracting face it is partly reflected and partly transmitted. The reflected light strikes the first face again and emerges from it making an angle of 4° with the reversed direction of incident beam. The deviation suffered by refracted ray is 1° from original direction of incident ray. Find the refractive index of glass of the prism and the angle of the prism.

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45. A ray of light is incident upon one face of a prism in a direction perpendicular to the other refracting face. The critical angle for glass – air interface is 30°. Find the angle of the prism (assuming it to be less than 90°) if the ray fails to emerge from the other face.

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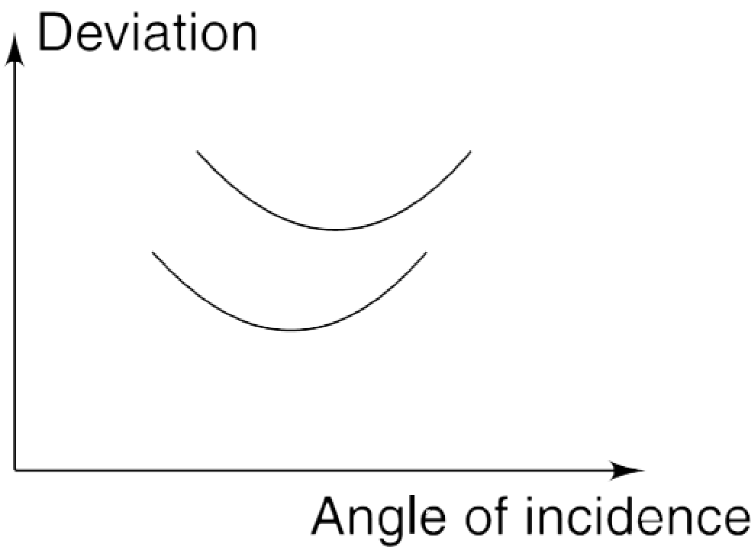
46. The plot of deviation versus angle of incidence for two prisms made of same material has been shown in the Figure. Which of the two graph corresponds to the prism of higher refracting angle (A)?



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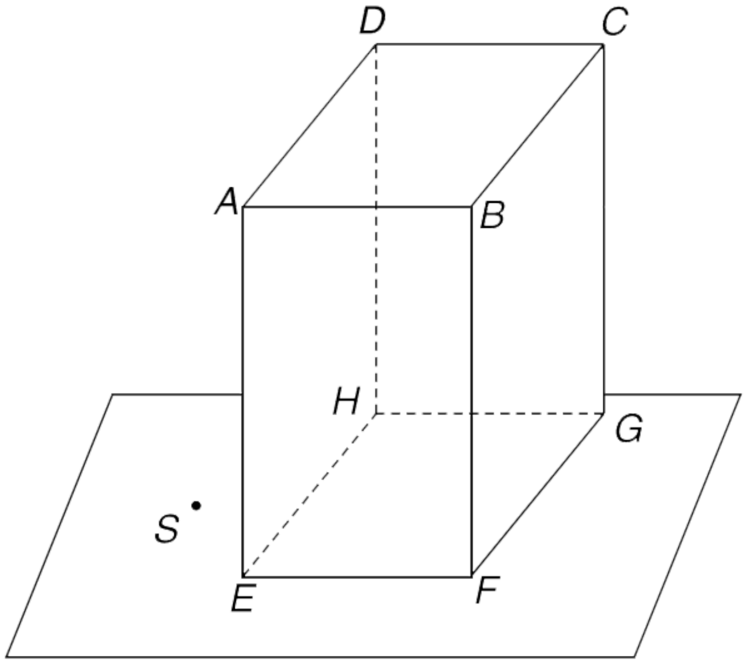
47. A large rectangular glass block of refractive index μ is lying on a horizontal surface as shown in Figure. Find the minimum value of μ so that the spot S on the surface cannot be seen through top plane

'ABCD' of the block.



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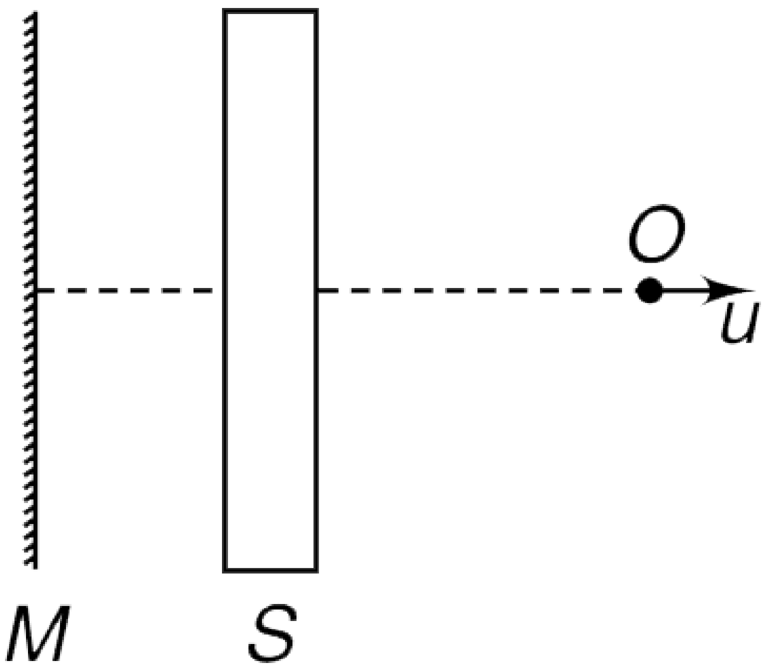
48. Object O is placed in front of a plane mirror M. A glass slab S having thickness t = 3 cm and refractive index $\mu = 1.8$ is placed between the object and the mirror. The refracting faces of the slab are parallel to the mirror surface. The object is made to move with a velocity of $u = 2m / s$ perpendicular to the mirror surface. Find the speed of the image formed after

(a) refraction from the slab followed by reflection from the mirror.

(b) refraction from the slab followed by reflection from the mirror followed by the refraction from the slab.



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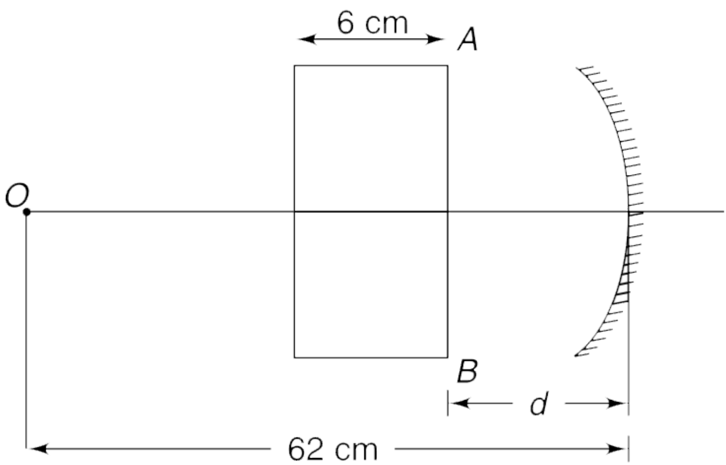
49. A point object O is placed at a distance of 62 cm in front of a concave mirror of focal length $f = 20 cm$. A glass slab of refractive index $\mu = \frac{3}{2}$ and thickness 6 cm is inserted between the object and the mirror. Let's define final image as image formed after the light ray originating from O passes through the slab, gets reflected from the mirror and then again passes through the slab. At what distance d from the mirror, the face AB of the slab can be placed so that the final image is formed inside the slab itself?



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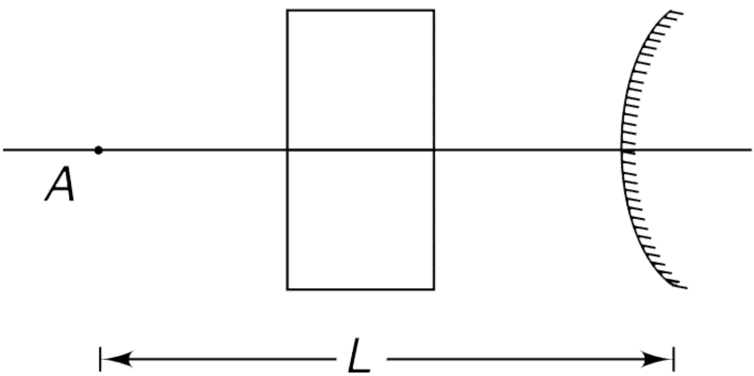
50. A point object (A) is kept at a distance (L) from a convex mirror on its principal axis. A glass slab is inserted between the object and the mirror with its refracting surfaces perpendicular to the principal axis of the mirror. The thickness of the slab is 6 cm and its refractive index is $\frac{3}{2}$. The image formed after refraction through the slab, reflection from the mirror followed by refraction through the slab is a virtual image at a distance of 10 cm from the pole of the mirror (on its principal axis). Consider paraxial rays only and calculate the distance (L) of the object from the mirror. Focal length of the mirror is $f = 20cm$.



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51. The two perpendicular faces of a right angled isosceles prism are silvered. Prove that a light ray incident on the third face (hypotenuse face) will emerge from the prism parallel to the initial direction.

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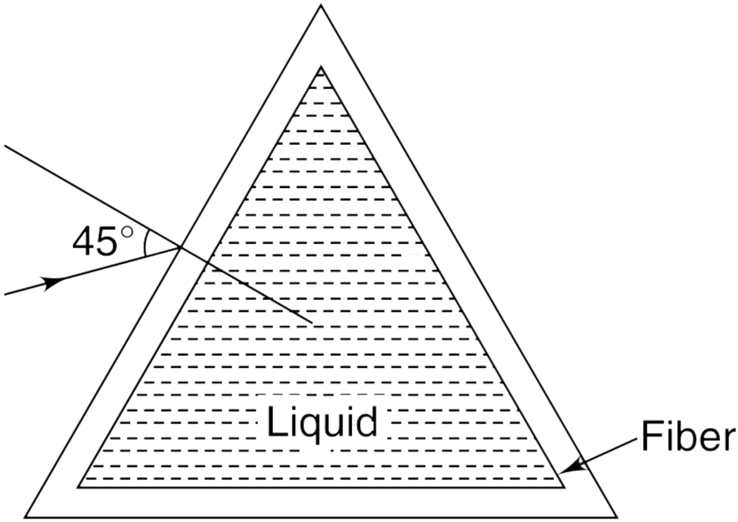
52. An equilateral prism has its faces made of a transparent fiber sheet (having refractive index = 1.25) having thickness of 1 mm. The fibre prism is filled with a liquid of refractive index $\sqrt{2}$. Find the deviation of a light ray incident on one face of such a prism at an angle of 45°.



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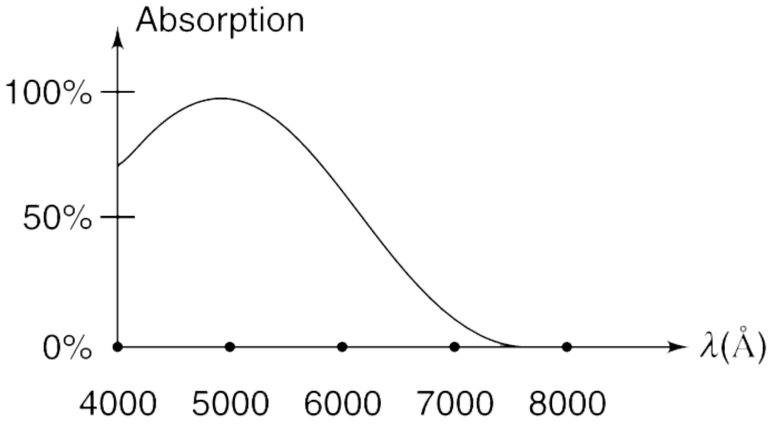
53. The Figure shows the absorption spectrum for a body. What is the colour of the body?



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54. Two thin prisms are combined such that they neither produce any average deviation nor do they cause any dispersion when white light is incident on the combination. Angle of one prism is $A = 2^\circ$ and refractive index of its glass for red, yellow and violet lights are 1.49, 1.50 and 1.51 respectively. Find the dispersive power of the glass of the other prism.

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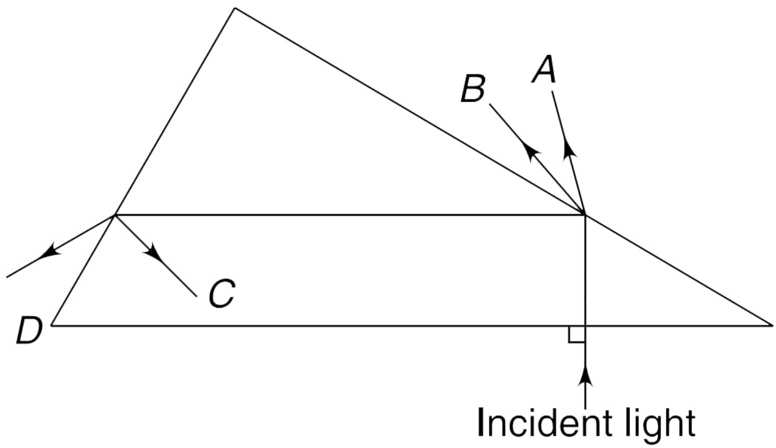
55. White light is incident on a glass prism as shown. Four easily identifiable colors – red, green, yellow and blue get separated as A, B, C and D. Which of the rays (A, B, C and D) correspond to which color?



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56. A concave spherical surface of radius of curvature $R = 20cm$ separates two media A and B having refractive indices $\mu_A = \frac{4}{3}$ and $\mu_B = \frac{3}{2}$ respectively. A point object is placed on the principal axis. Find the distance of the object from the surface so that its image is virtual when

(a) the object is in medium A.

(b) the object is in medium B.

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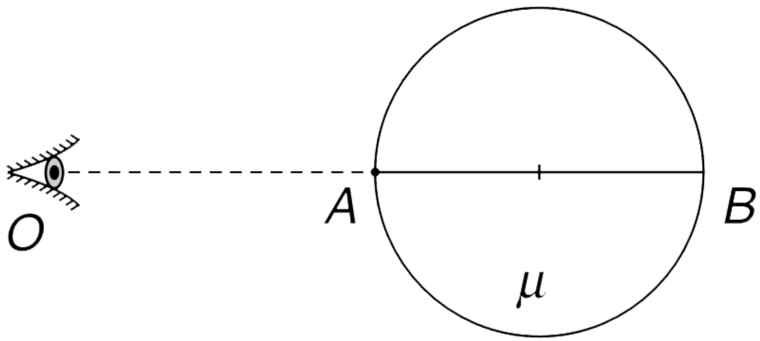
57. A transparent ball of radius R is viewed by an observe O along its diameter AB. The observe O sees the distance AB to be infinitely large. Find the refractive index of the material of the ball.



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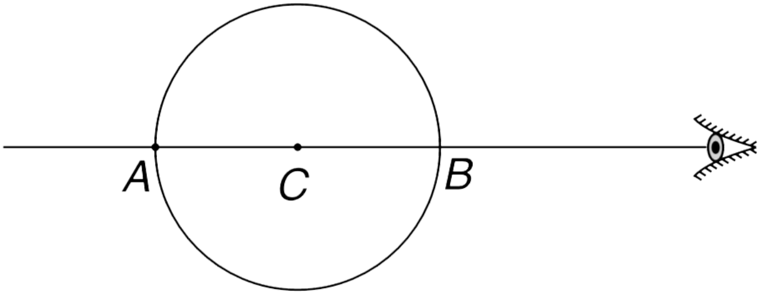
58. A glass $(\mu = 1.5)$ sphere of radius R is viewed from outside along a diameter. Calculate the distance between two points (say P and Q) lying on the line AB whose images are seen at centre C and point A respectively.



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59. A concave spherical surface of radius of curvature $10cm$ separates two mediums X and Y of refractive indices $4/3$ and $3/2$ respectively. Centre of curvature of the surfaces lies in the medium X. An object is placed in medium X.

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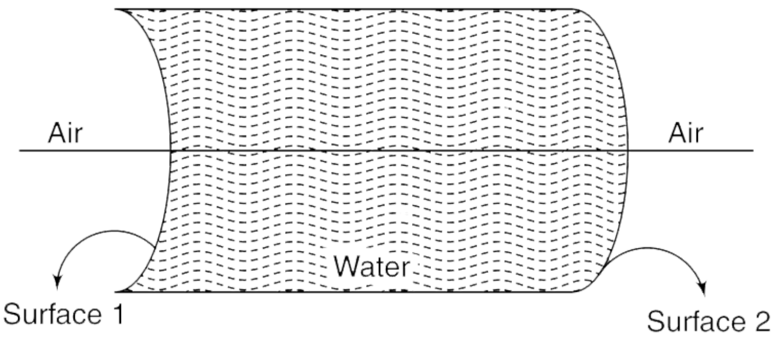
60. A region bounding water has air on two sides. Tell the nature (real or virtual) of the image for following cases- (The object is real and lies on the principal axis (see fig) in all cases.)

(a) The object is to the left of surface 1 and the image to be considered is formed after the first refraction.

(b) The object is to the left of surface 1 and the image to be considered is formed after two refractions.

(c) The object is to the right of second surface and the image to be considered is formed after one refraction.



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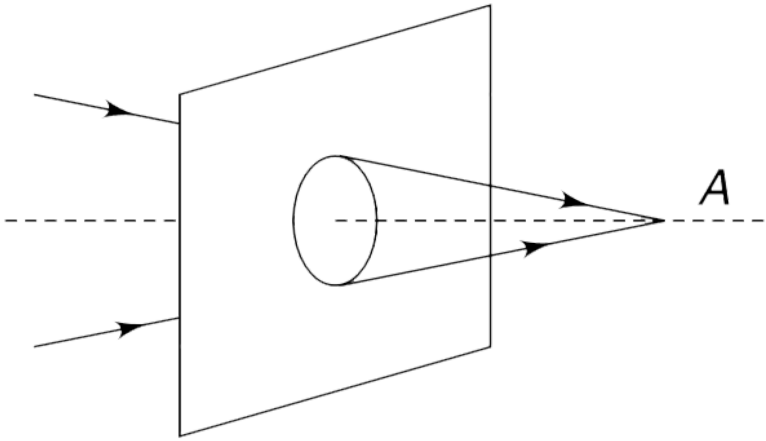
61. A converging beam of light rays passes through a round opening in a screen. The beam converges at a point A which is at a perpendicular distance of 15 cm from the screen and lies slightly above the central axis of the circular opening. A convex lens of focal length 30 cm is inserted in the opening. At what distance from the screen do the rays converge now ?



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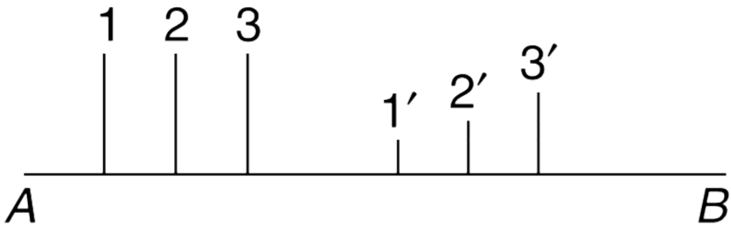
62. In the Figure AB is the principal axis of an optical element (a lens or a mirror). For position 1, 2 and 3 of a real object, the corresponding position of images are 1', 2' and 3' respectively. Size of image at 3' is largest and that at 1' is smallest. Identify the optical element and indicate its position.



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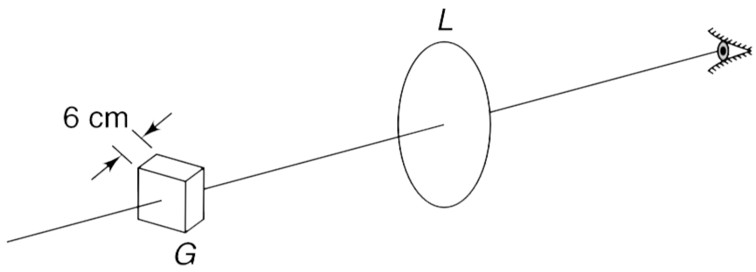
63. A transparent glass slab (G) of thickness 6 cm is held perpendicular to the principal axis of a convex lens (L) as shown in the Figure. The refractive index of the material of the glass is $\frac{3}{2}$ and its nearer face is at a distance 40 cm from the lens. Focal length of the lens is 20 cm. Find the thickness of the glass slab as observed through the lens.



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64. An object 240 cm in front of a lens forms a sharp image on a screen 12 cm behind the lens. A glass slab 1 cm thick, having refractive index 1.50 is placed between the lens and the screen with its refracting faces perpendicular to the principal axis of the lens.

(a) By how much distance the object must be moved so as to again cast a sharp image on the screen?

(b) Another identical glass slab is interposed between the object and the lens. How much further the object shall be moved so as to form a sharp image on the screen.

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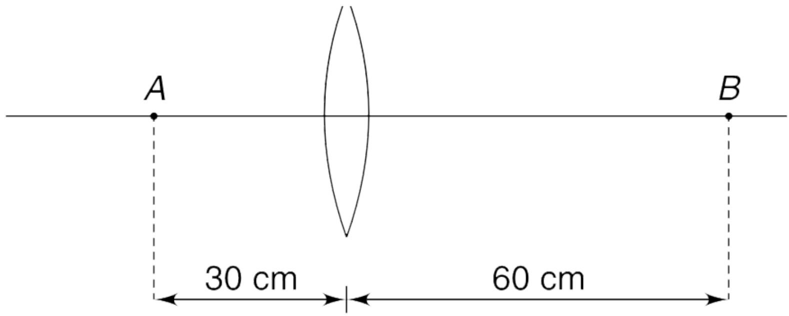
65. Two point objects A and B are kept on the principal axis of a convex lens as shown. Image of both the objects is formed at same position. Find the focal length of the lens.



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66. In which case does a light ray pass through the centre of a thin lens without deviation?

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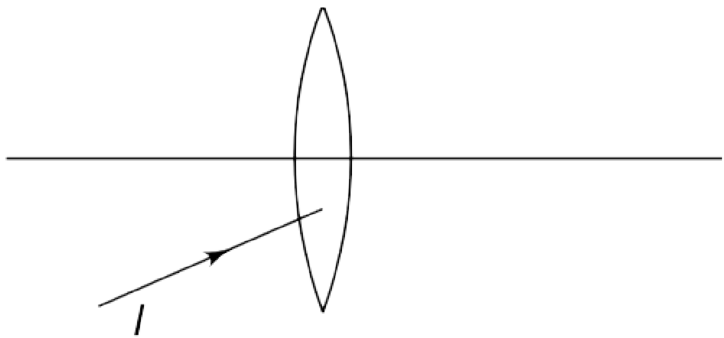
67. The medium on both sides of a convex lens is same. A light ray (I) is incident on it as shown. Draw the path of the ray after it emerges from the lens. Write each step of your construction. The focal length of the lens is known.



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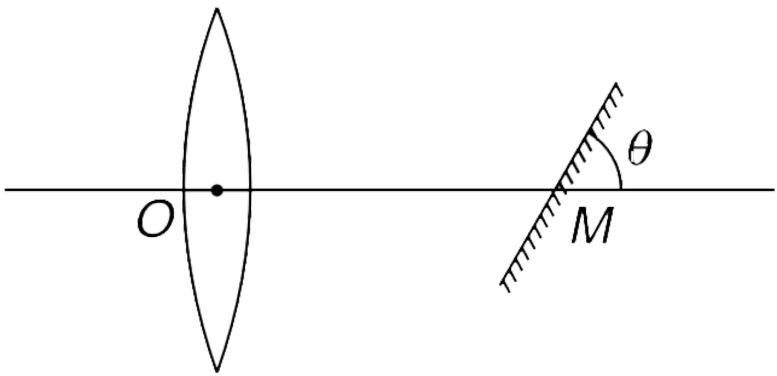
68. A horizontal parallel beam of light passes though a vertical convex lens of focal length 40 cm. Behind the lens there is a plane mirror making an angle θ with the principal axis of the lens. The mirror intersects the principal axis at M. Distance between the optical centre of the lens and point M is $OM = 20cm$. The light beam reflected by the mirror converges at a point P. Distance OP is 20 cm. Find θ.



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69. A cylindrical tube has a length of 60 cm. Three identical convex lenses, each of focal length $f = 10$ cm are fixed inside the tube, one at each of the ends and one at the centre. One end of the tube is placed 10 cm away from a point source. The device casts an image of the object. How much does the image shift when the tube is moved away from the source by 10 cm.

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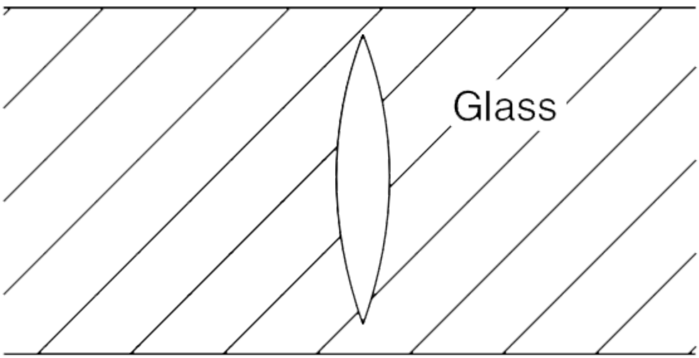
70. There is an air lens in an extended glass medium. The radius of curvature of both the curved surfaces is R, and refractive index of the glass is $\frac{3}{2}$. Power of this air lens is P. Find the refractive index of the material to be filled inside the lens so that its power becomes – P.



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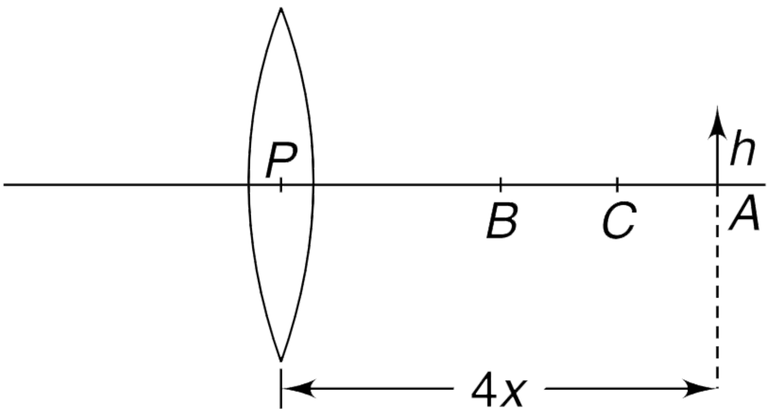
71. A thin converging lens forms a real image of an object located far away from the lens. The image is formed at A at a distance 4x from the lens and height of the image is h. A thin diverging lens of focal length x is placed at $B[PB = 2x]$ and a converging lens of focal length 2x is placed at $C[PC = 3x]$. The principal axes of all lenses coincide. Find the height of the final image formed.



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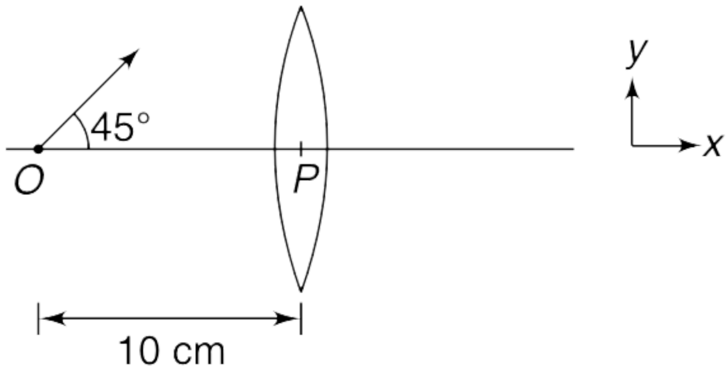
72. A point object (O) lies at a distance of 20 cm on the principal axis of a convex lens of focal length $f = 10cm$. The object begins to move in a direction making an angle of 45° with the principal axis. At what angle with the principal axis does the image beings to move?



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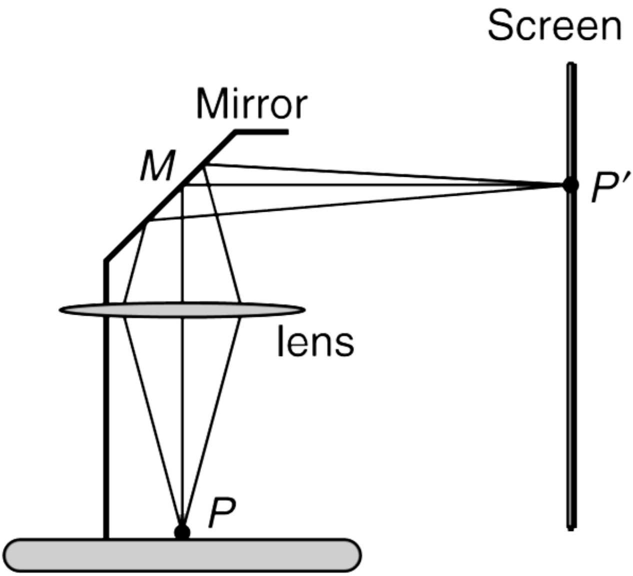
73. The lens in an overhead projector forms an image P’ of a point P on a transparency. If the screen is moved away from the projector, how should we move the lens to keep the image on the screen in focus?



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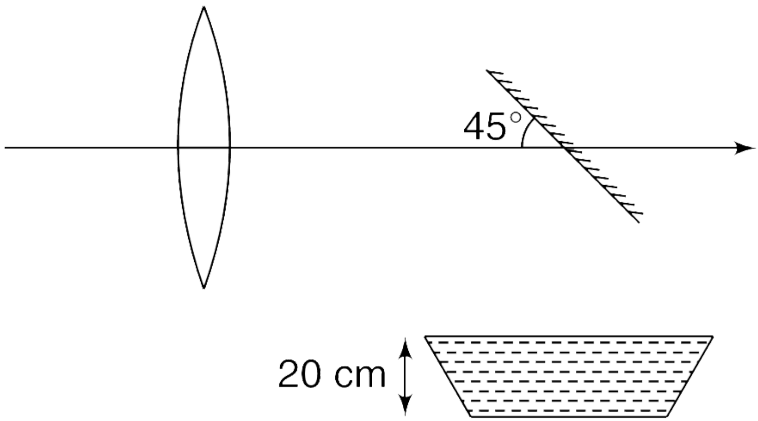
74. A small object is at the bottom of a container which has water filled up to a height of 20 cm. There is a plane mirror inclined at 45° to the horizontal above the container. A convex lens having focal length 15 cm is at a distance of 50 cm from the mirror. The horizontal principal axis of the lens is at a distance of 45 cm from the bottom of the container. Find the distance of the image (from the lens) of the object as seen by an observer to the left of the lens.

Light rays from the object hit the lens only after they are reflected from the mirror. (use $\mu_{\text{water}} = 4/3$)



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75. The principal axis of a thin equi-convex lens is the x-axis. The co-ordinate of a point object and its image are $(-20cm, 1mm)$ and $(25cm, 2mm)$ respectively. Find the focal length of the lens.

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Level 2

1. Sunrays pass through a pinhole in the roof of a hut and produce an elliptical spot on the floor. The minor and major axes of the spot are 6 cm and 12 cm respectively. The angle subtended by the diameter of the sun at our eye is 0.5°. Calculate the height of the roof.

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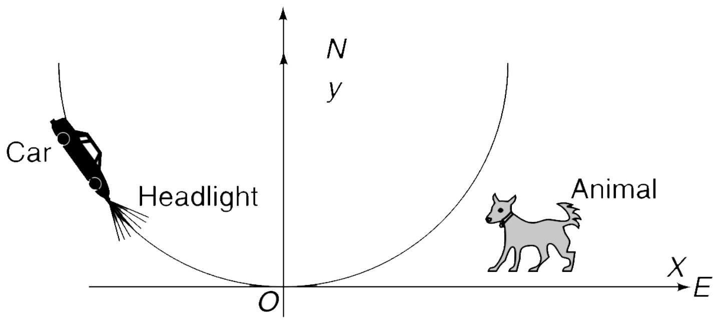
2. A car is travelling at night along a highway shaped like a parabola with its vertex at the origin of the co-ordinate system. The car starts at a point 200 m West and 200 m North of the origin and travels in easterly direction. There is an animal standing 200 m East and 100 m North of the origin. At what point on the highway will the car's headlight illuminate the animal?



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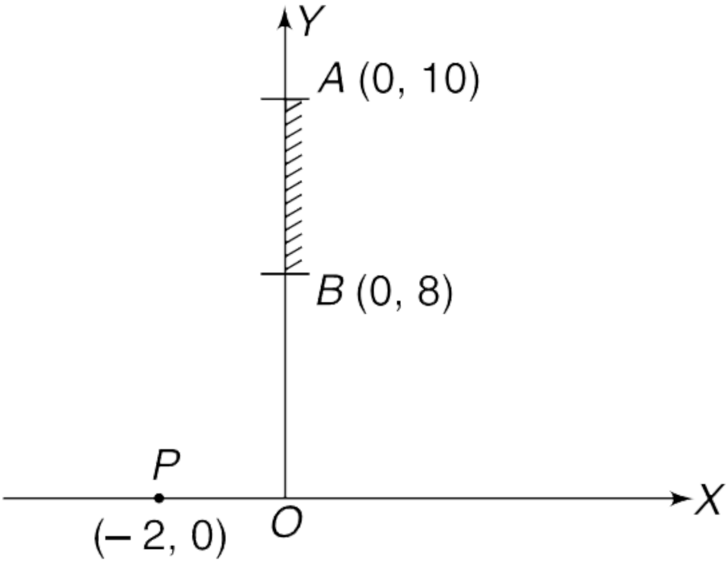
3. Consider the situation shown in the Figure. The mirror AB forms image of point object P. Co-ordinates of A, B and P are (0, 10) m, (0, 8) m and $(-2, 0)m$ respectively. Two observers O1 and O2 are located at $(-2, 10)m$ and $(-1, 13)m$ respectively.

(a) One of the two observers cannot see the image of point P. Identify the observer.

(b) To ensure that both the observers are able to see the image, it was decided to use a longer mirror. Keeping the upper end of the mirror fixed at A (0, 10) m, what is the minimum length of mirror required so that both observers can see the image of point P?



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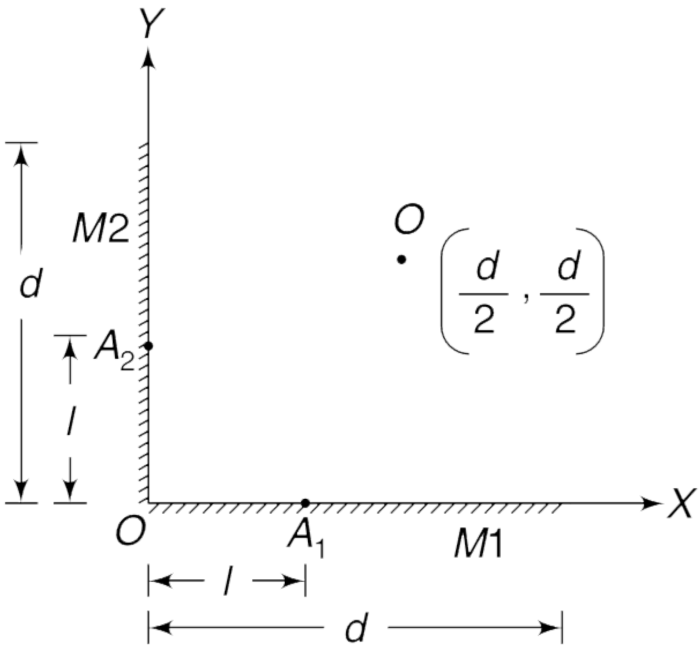
4. Two plane mirrors M1 and M2 of length d each are placed at right angle as shown. A point object O is placed symmetrically with respect to the mirrors at co-ordinates $\left(\frac{d}{2}, \frac{d}{2}\right)$

(a) How many images of O will be seen?

(b) Show that all the images lie on a circle.

(c) Length $l(= OA_1 = OA_2)$ of both the mirrors is cut and removed. Find least value of l such that only two images of the object are formed.



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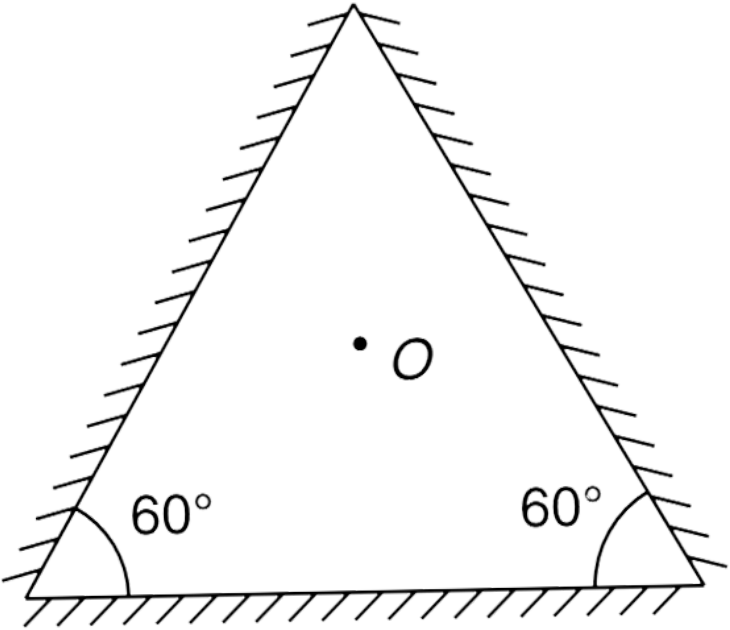
5. Three plane mirrors are kept as shown in the Figure A point object (O) is kept at the centroid of the triangle seen in the Figure.

How many images will be formed?



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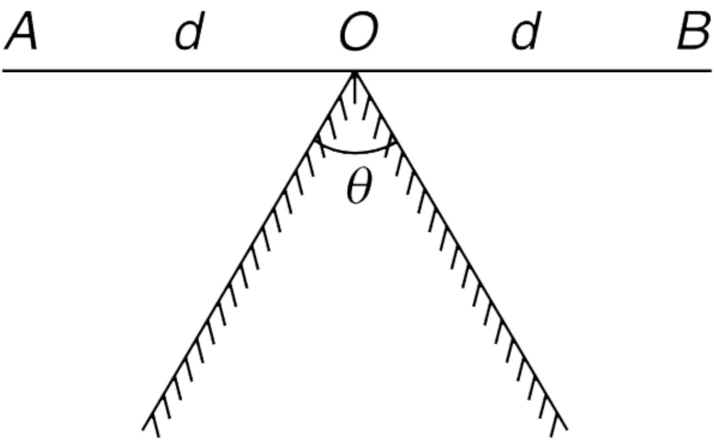
6. Two plane mirrors are joined together as shown. Two point objects A and B are placed symmetrically such that $OA = OB = d$. [AOB is a straight line]

(a) If the images of A and B coincide find θ (call it θ_0).

(b) Keeping the position of objects unchanged the angle between the two mirrors is increased to $\theta = \frac{4}{3}\theta_0$. Now find the distance between the images of A and B.



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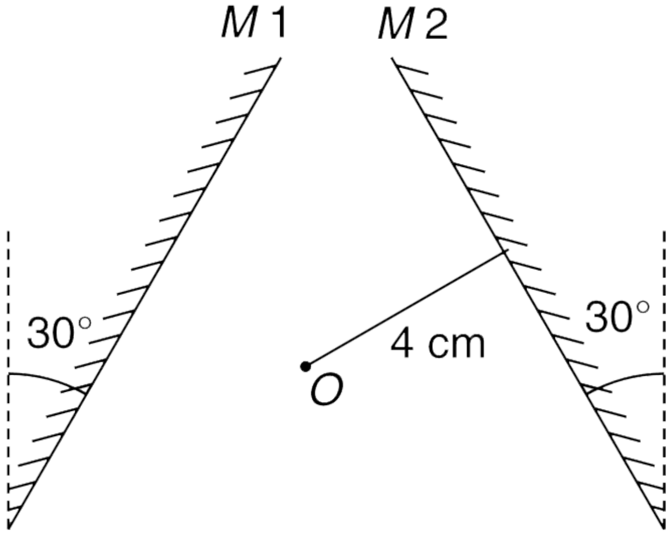
7. Two plane mirrors M1 and M2 are inclined at 30° to the vertical. A point object (O) is placed symmetrically between them at a distance of 4 cm from each mirror. Find the distance of the object from the second image formed in mirror M1.



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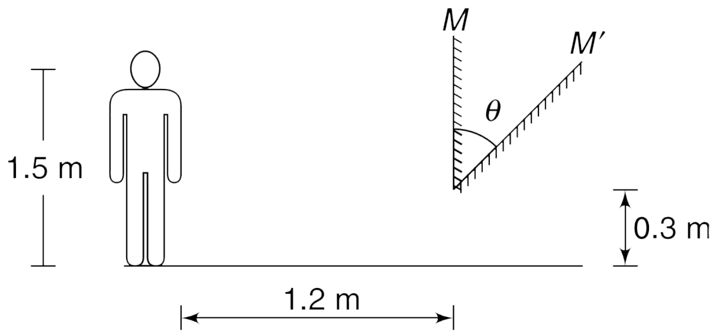
8. The distance between the eye and the feet of a boy is 1.5 m. He is standing on a flat ground and a vertical plane mirror M is placed at a distance of 1.2 m from the boy, with its lower edge at a height of 0.3 m from the ground. Now the mirror is tilted about is lower edge as shown in the Figure. Find maximum value of angle θ for which the image of feet remains visible to the boy. [Take $\sin 15^\circ = \frac{1}{4}$]



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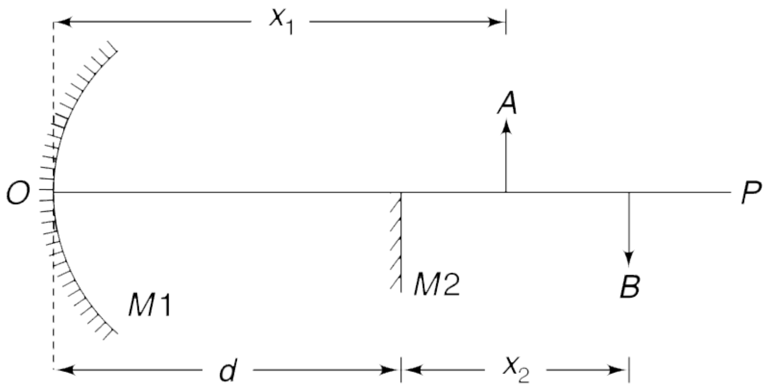
9. OP is the principal axis of a concave mirror M1. Just below the axis a plane mirror M2 is placed at a distance d from the concave mirror. Two small pins A and B are placed on the principal axis as shown. By moving M2 and changing d, the virtual image of A formed in mirror M1 and the virtual image of B formed in mirror M2 were made to coincide.

(a) Calculate the focal length of the concave mirror if it was found that the images coincide when separation between the mirrors was

d_0.

(b) Can the two virtual images be observed by the eye simultaneously?



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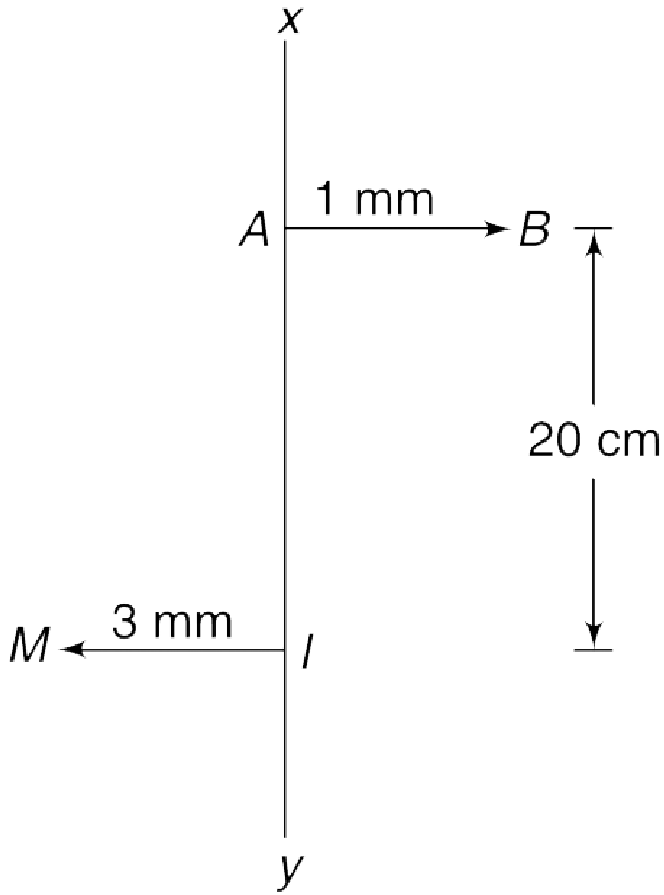
10. A real object AB has its image as IM when placed in front of a spherical mirror. XY is the principal axis of the mirror.

(a) Draw a ray diagram to locate the position of the mirror and its focus.

(b) Find the focal length of the mirror.



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11. Two spherical concave mirrors of equal focal length are put against each other with their reflecting surfaces facing each other.

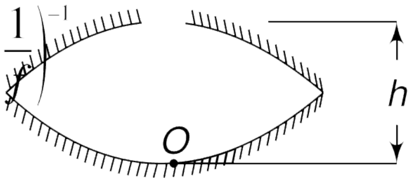
The upper mirror has an opening at its centre. A small object (O) is kept at the bottom of the cavity so formed (see Figure). The top mirror produces a virtual image of the object and the lower mirror then creates a real image of the virtual image. The second image is created just outside the cavity mouth. This creates an optical illusion as if the object is raised above its original position.

(a) Prove that the height h shown in the Figure is related to focal length of the mirror as

$$\frac{1}{f} = \frac{1}{h} + \frac{1}{h + \left(\frac{1}{h} - \frac{1}{f}\right)^{-1}}$$

(b) Rewrite the above equation in terms of $x = \frac{h}{f}$ and solve if for x.

$$\frac{1}{f} = \frac{1}{h} + \frac{1}{h + \left(\frac{1}{h} - \frac{1}{f}\right)^{-1}}$$



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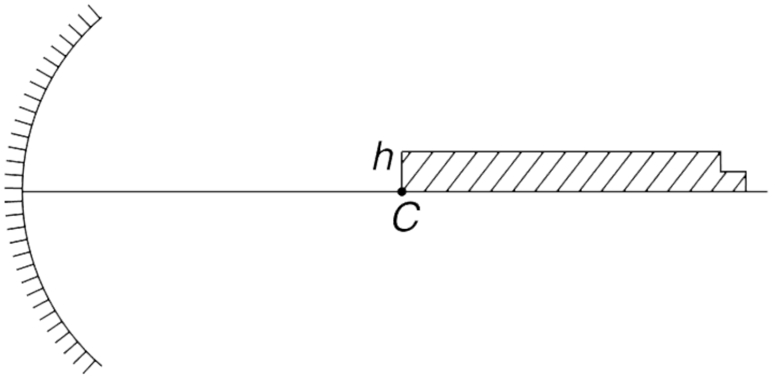
12. A long rectangular strip is placed on the principal axis of a concave mirror with its one end coinciding with the centre of curvature of the mirror (see Figure). The width (h) of the object is very small compared to the focal length (f) of the mirror. Calculate the area of the image formed.



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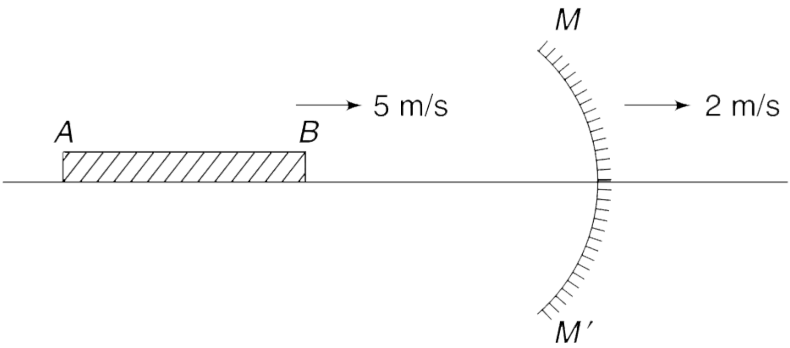
13. A pencil (AB) of length 20 cm is moving along the principal axis of a concave mirror MM', with a velocity $5m/s$ approaching the mirror. The mirror itself is moving away from the pencil at a speed of 2 m/s. Find the rate of change of length of the image of the pencil at the instant end A is at a distance of 60 cm from the mirror.



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14. A small object of height h is placed perpendicular to the principal axis of a convex mirror of focal length f at a distance x from the pole of the mirror. An observer is located on the principal axis at a distance L from the pole of the mirror. (Take $x, f, L > \; > h]$.

(a) Calculate the angle α formed by the image at the eye of the observer

(b) If the convex mirror is replaced by a plane mirror, with all other things remaining unchanged, calculate the angle β formed by the image at the eye.

(c) Justify the statement "objects are closer than they appear" written on the rear view mirror of your car.

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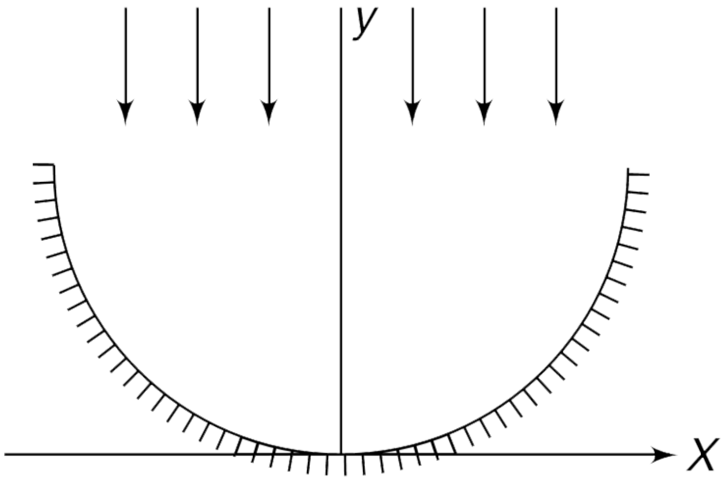
15. Consider a large parabolic mirror whose section can be represented by $y = kx^2$, where k is a positive number. Show that a parallel beam of light travelling in negative y direction, after reflection from the mirror, gets focused at a point $\left(0, \frac{1}{4k}\right)$. If you need a parallel beam of light, will you prefer a parabolic reflector over a spherical one?



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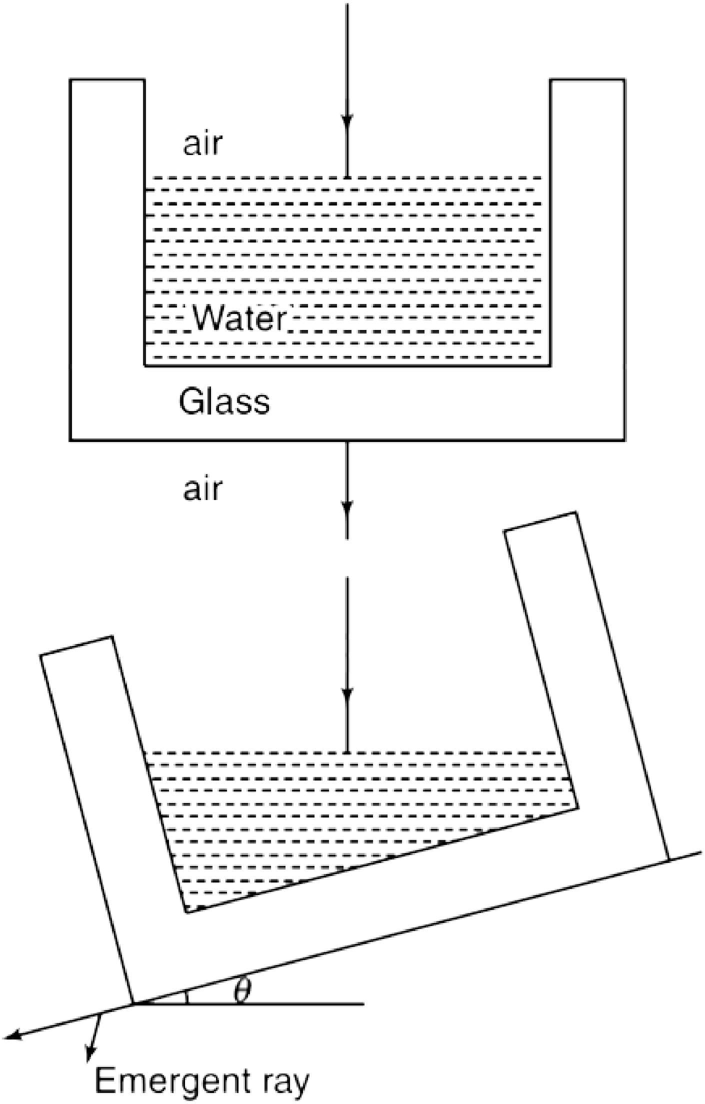
16. Figure shows a glass $(\mu_g = 1.5)$ vessel, partly filled with water $\left(\mu_w = \frac{4}{3}\right)$. A ray of light is incident normally on the water surface and passes straight through. The vessel is tilted slowly till angle θ such that the light ray is emergent grazing the lower surface of the glass. Find θ.



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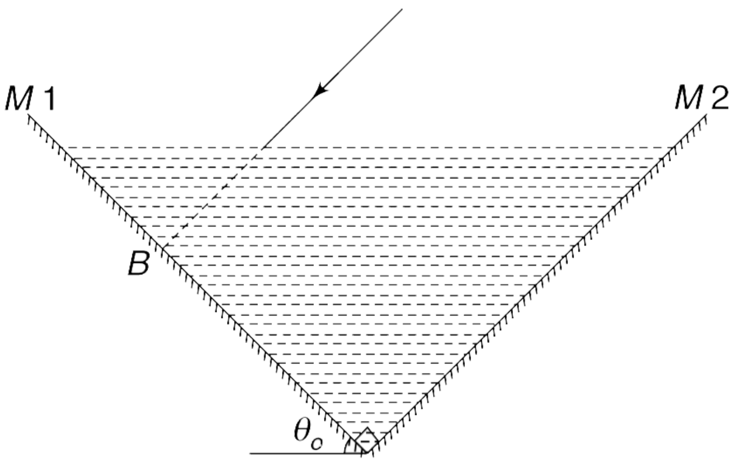
17. Two plane mirrors $M1$ and $M2$, placed at right angles, form two sides of a container. Mirror $M1$ is inclined at an angle θ_0 to the horizontal. A light ray AB is incident normally on $M1$. Now the container is filled with a liquid of refractive index μ so that the ray is first refracted, then reflected at $M1$. The ray is next reflected at $M2$ and then comes out of the liquid surface making an angle θ with the normal to the liquid surface. Find θ.



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18. When the sun appears to be just on horizon, it is in fact below the horizon. This is because the light from the sun bends when it enters the earth's atmosphere. Let us assume that atmosphere is uniform and has index of refraction equal to μ. It extends upto a height $h(< < R =$ radius of earth) above the earth's surface. In absence of atmosphere how late would we see the sunrise compared to what we see now? Take time period of rotation of earth to be T. Calculate this time for following data

$R = 6400km, \mu = 1.0003, h = 20km, T = 24hr.$

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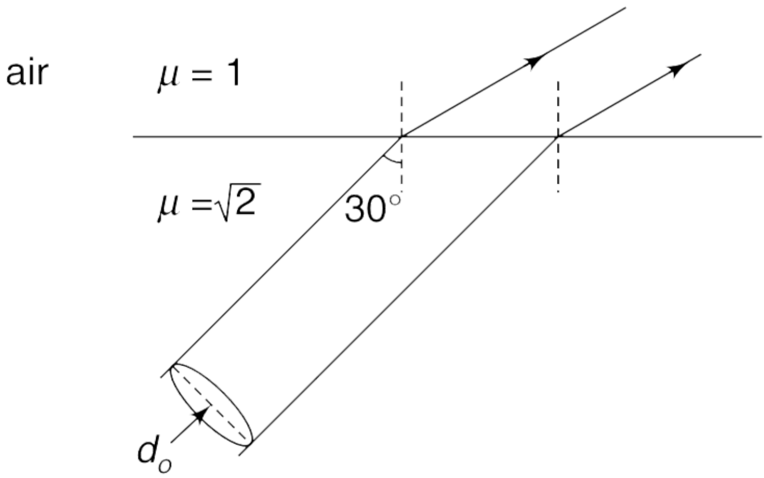
19. Intensity of a light beam can be defined as amount of light energy incident in unit time on a unit area held normal to the direction of beam. A light beam of intensity I_0 has a circular cross section of diameter d_0. This beam is travelling in a medium of refractive index $\mu = \sqrt{2}$and gets incident on the medium – air boundary at an angle of incidence $i = 30^{\circ}$. Assume that entire light energy gets transmitted into air. Find the intensity (I) of transmitted light beam.



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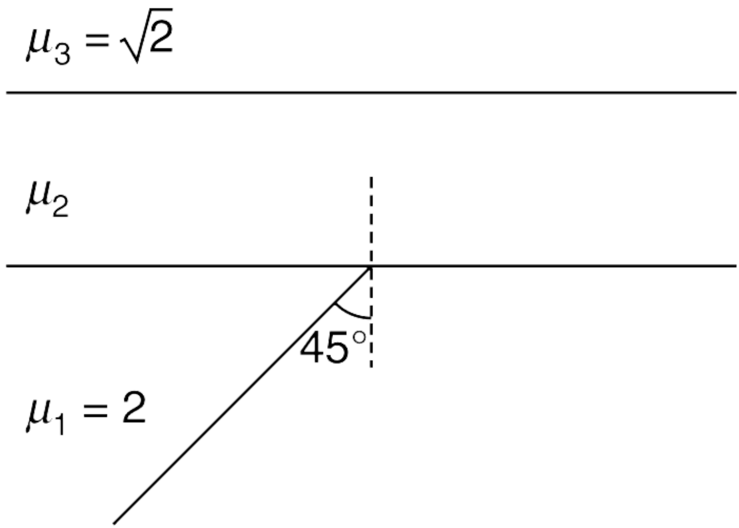
20. In the diagram shown, a light ray is incident on the lower medium boundary at an angle 45° with the normal. Find the deviation suffered by the light ray if–

(a) $\mu_2 > \sqrt{2}$ (b) $\mu_2 < \sqrt{2}$



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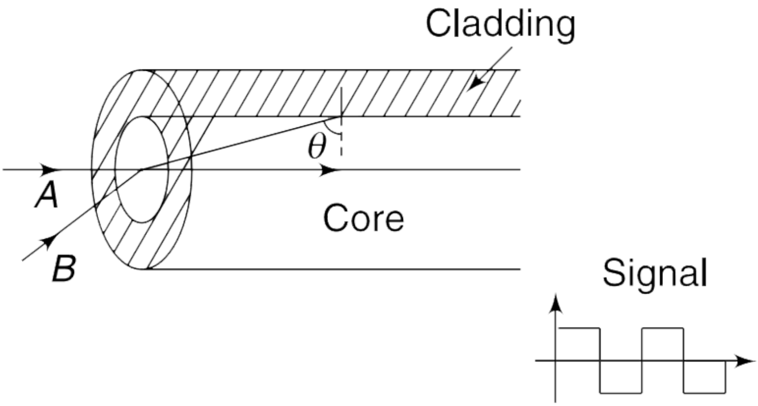
21. A fibre optic cable has a transparent core of refractive index 1.6 and the cladding has a refractive index of 1.5. An optical signal travels along path A and another signal travels along path B such that it strikes the core – cladding interface at an angle of incidence θ that is just greater than the critical angle. Length of the cable is 1500 m.

(a) Find the time difference between the two signals reaching the other end of the cable.

(b) A digital signal shown in the Figure. is transmitted through the cable. Find maximum frequency so that the crest from path A never arrives with a trough from path B at the receiving end of the cable.



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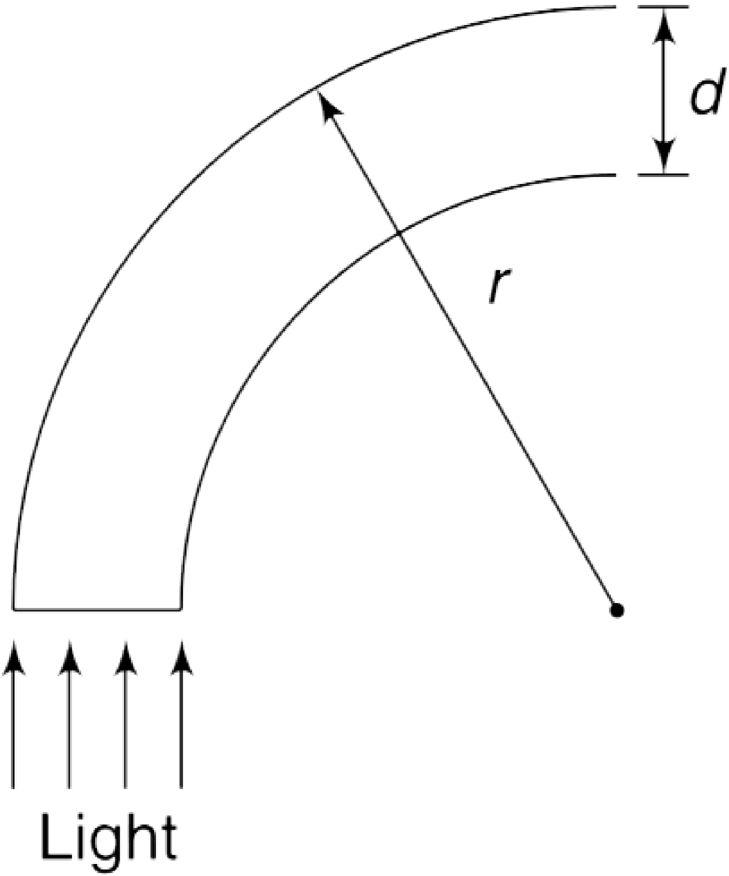
22. An optical fibre has diameter d and is made of material of refractive indeed μ. It is surrounded by air. Light is made to enter through one end of the fibre as shown. The fiber is in the shape of a circular bend of outer radius r.

(a) Find least value of $r(=r_o)$ for which no light can escape out of the fibre. Calculate r_o for $d = 200 \mu m$ and $\mu = 1.4$.

(b) How is value of r_o affected as d is made smaller?

(c) For sharper bends, shall we have higher μ or smaller μ ?



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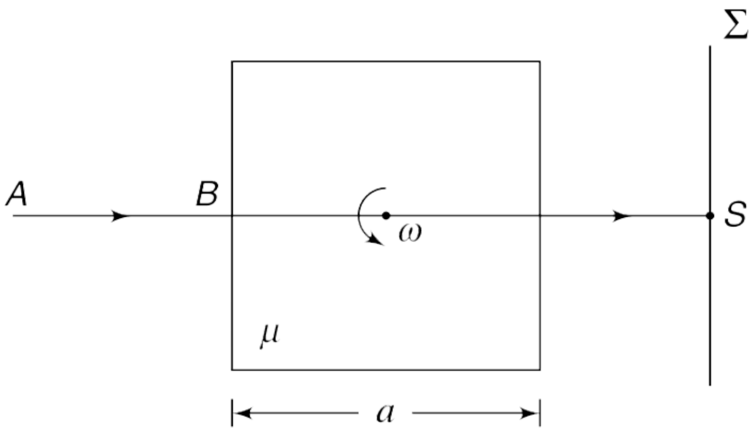
23. A glass cube has side length a and its refractive index is $\mu = \frac{3}{2}$.

A ray of light (AB) is incident normally on one of its face and after passing through the cube it forms a spot S on screen σ. The cube begins to rotate with angular speed ω about its central axis as shown in the Figure. Immediately after the cube begins to rotate, find the speed of the spot S on the screen.



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24. A single ray traverses a glass plate (thickness = t) with plane surfaces that are parallel to each other. The emergent ray is parallel to the incident ray but suffers a lateral displacement d. Assuming that glass plate (refractive index μ) is placed in air, find the dependence of d on angle of incidence i. Plot the variation of d with i (changing from 0° to 90°)

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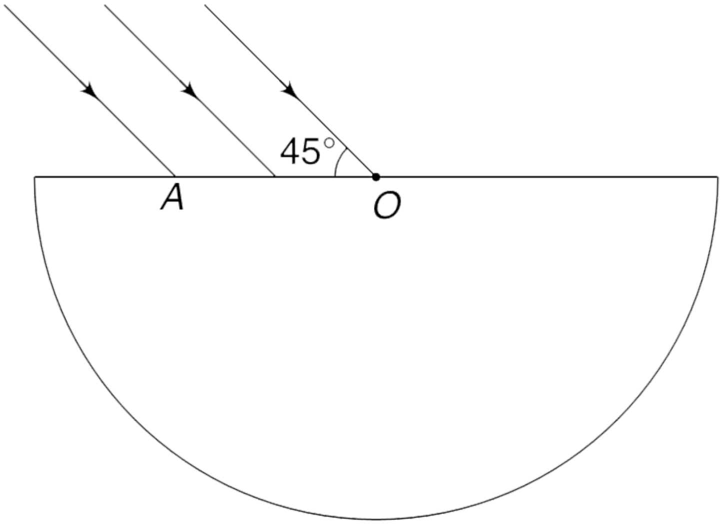
25. A transparent semicylinder has refractive index $\mu = \sqrt{2}$. A parallel beam of light is incident on its plane surface making an angle of 45° with the surface. The incident beam extends from O to A on the plane surface. Find the maximum width OA (in terms of radius R of the cylinder) so that no ray suffers total internal reflection at the curved surface. [O is the centre of the circular cross section of the cylinder]



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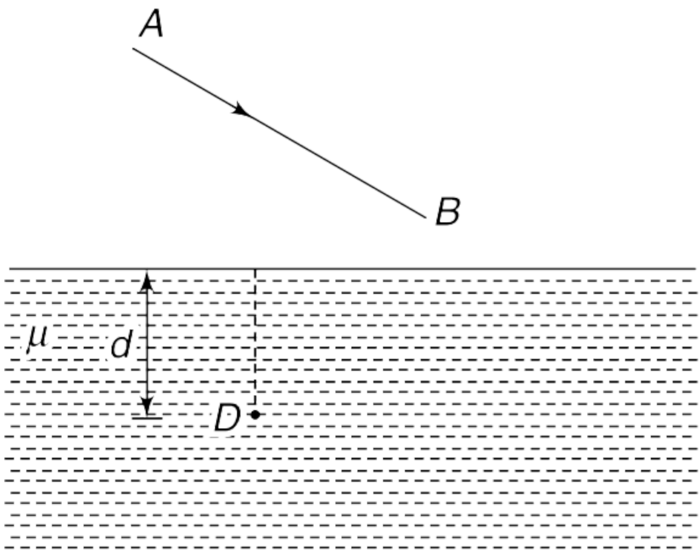
26. A diver D is still under water $\left(\mu = \frac{4}{3}\right)$ at a depth $d = 10m$. A bird is diving along line AB at a constant velocity in air. When the bird is exactly above the diver he sees it at a height of 50 m from himself and velocity of the bird appears to be inclined at 45° to the horizontal. At what distance from the diver the bird actually hits the water surface.



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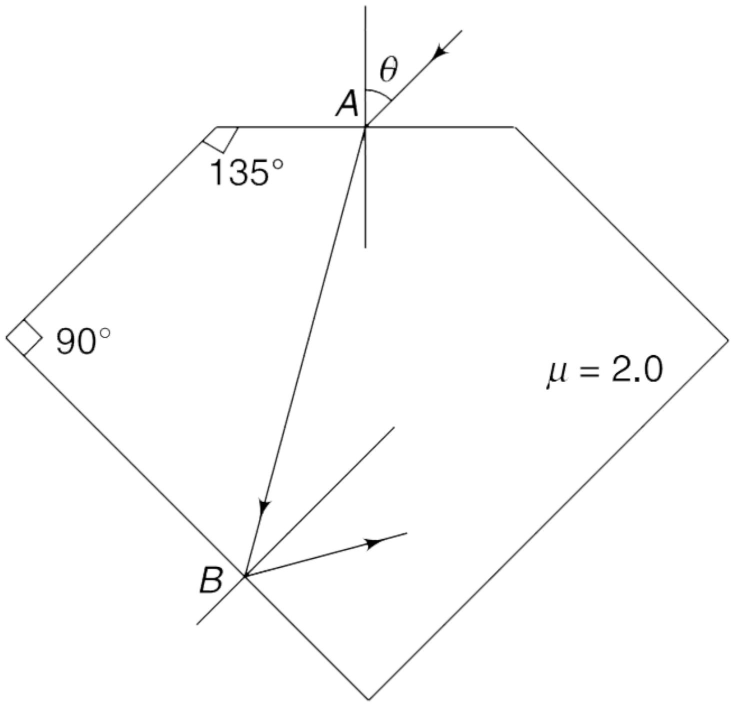
27. Light is incident at point A on one of the faces of a diamond crystal $(\mu = 2.0)$. Find the maximum allowed value of angle of incidence θ so that light suffers total internal reflection at point B.



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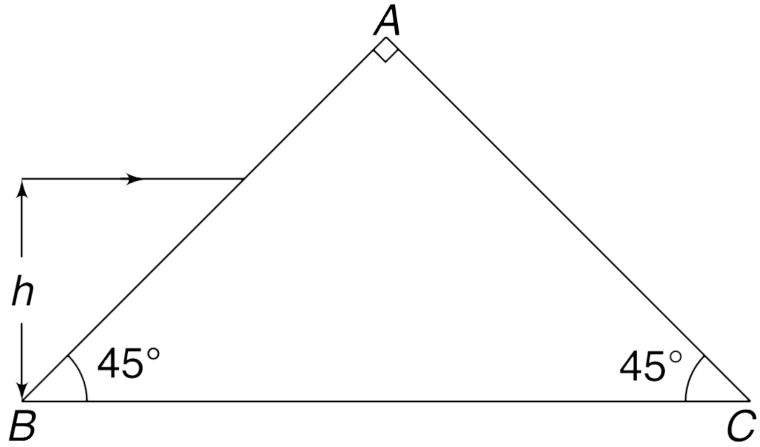
28. ABC is a glass prism with $\angle A = 90^\circ$ and other two angles 45° each



(a) Prove that any light ray that enters the prism through face AB will emerge out through the face AC if refractive index of the glass of the prism is $\mu \geq \sqrt{2}$.

(b) A ray of light is incident parallel to BC at a height h = 3.0 cm from BC. Find the height above BC at which the emergent ray leaves the surface AC. It is given that $\mu = \sqrt{2}$ and length $BC = 20cm$. [Take $\tan 15^{\circ} 0.25$]

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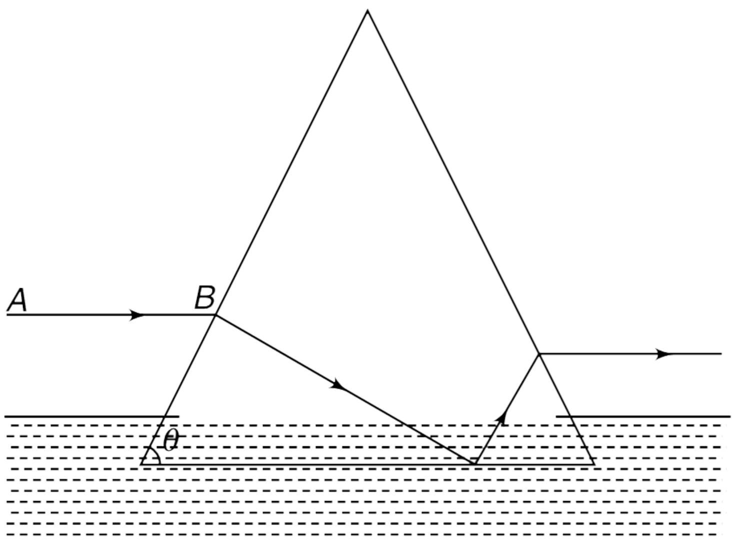
29. An isosceles glass prime (refractive index $= \frac{3}{2}$) has its base just submerged in water (refractive index $= \frac{4}{3}$) . The base of the prism is horizontal. A horizontal light ray AB is incident on the prism and takes a path shown in figure to emerge out of the prism. Find the maximum value of base angle θ of the prism for which total internal reflection can take place at the base.



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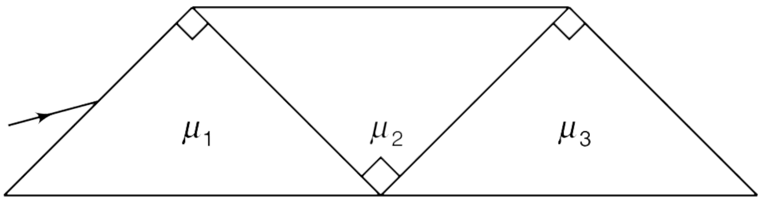
30. Three right angled prisms are glued as shown in the figure. An incident ray passes undeviated through the system. Express the refractive index (μ_2) of the middle prism in terms of μ_1 and μ_3.



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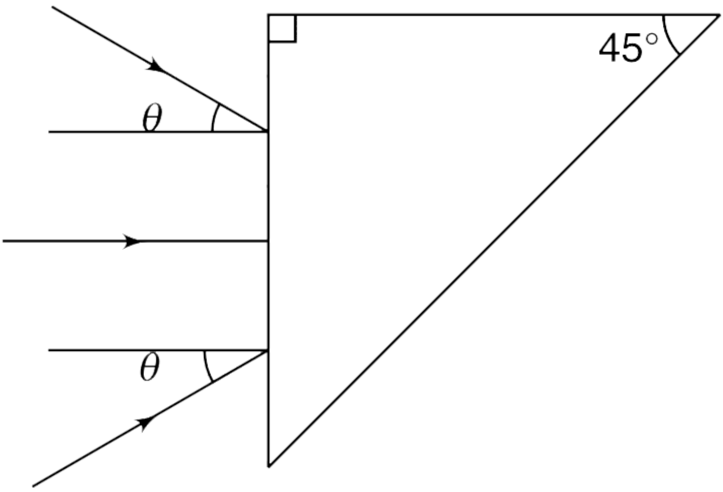
31. A prism has refracting angle of 60° and its material has refractive index 1.5 and 1.6 for red and violet light respectively. A parallel beam of white light is incident on one face of the prism such that the red light undergoes minimum deviation. Find the angle of incidence (i) and the angular width (θ) of the spectrum obtained.

Given:

$\sin(49^\circ) = 0.75^\circ, \sin(28^\circ) = 0.47, \sin(32^\circ) = 0.53, \sin(58^\circ) = 0.85$

32. A converging beam of light is incident on a right angled isosceles prism as shown in the Figure. The marginal rays in the beam are incident at angle $\pm\theta$. The refractive index for the glass of the prism is $\mu = 1.49\left(=\frac{1}{\sin 42^{\circ}}\right)$. Find the maximum value of θ for which no light comes out of the hypotenuse surface.



33. An equilateral prism is made of glass whose refractive index for red and violet light is 1.510 and 1.550 respectively. White light is incident at an angle of incidence i and the prism is set to give minimum deviation for red light. Find

(a) angle of incidence

(b) angular dispersion (i.e., angular width of the spectrum).

Given

$$\begin{array}{lllll} \theta = & 28^\circ & 32^\circ & 50^\circ & 55^\circ \\ \sin\theta = & 0.487 & 0.529 & 0.755 & 0.819 \end{array}$$

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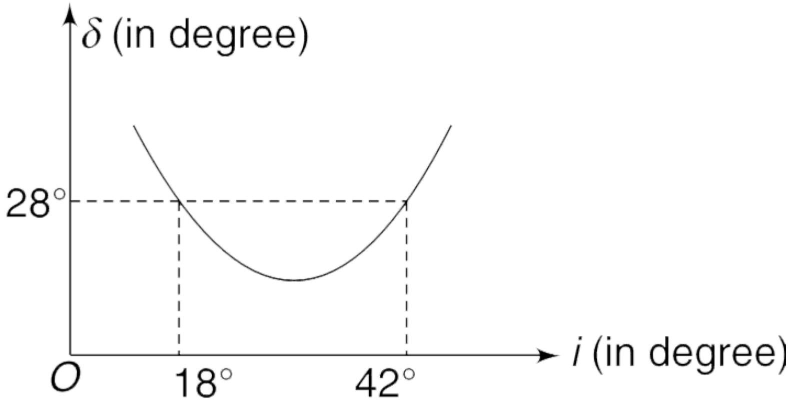
34. The plot of deviation (δ) vs angle of incidence (i) for a prism is as shown in the figure. Find the angle of the prism (A).



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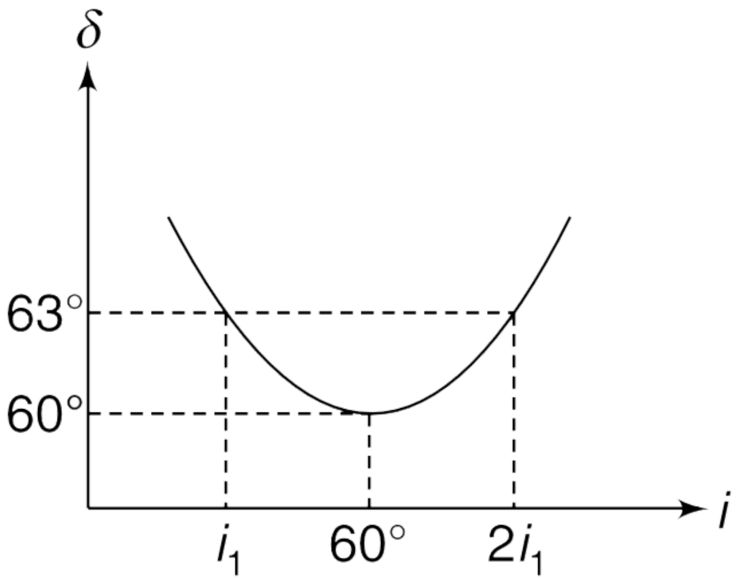
35. For a glass prism the plot of deviation (δ) vs angle of incidence (i) is as shown. Find the refractive index of the glass and value of angle i_1.



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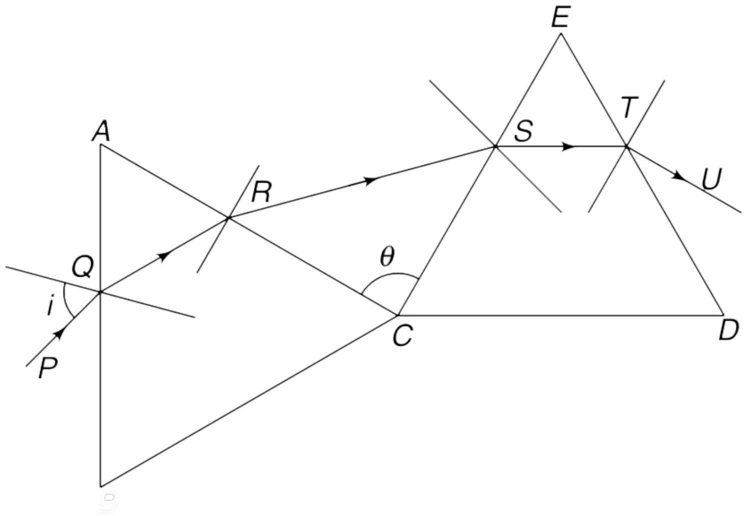
36. Two identical equilat- eral glass (refractive index $= \sqrt{2}$) prisms ABC and CDE are kept such that the angle between faces AC and CE is q. A ray of light is incident at an angle i at the face AB and traverses through the two prisms along the path PQRSTU. Find the value of angle i and θ such that angle between the incident ray PQ and emergent ray TU is minimum.



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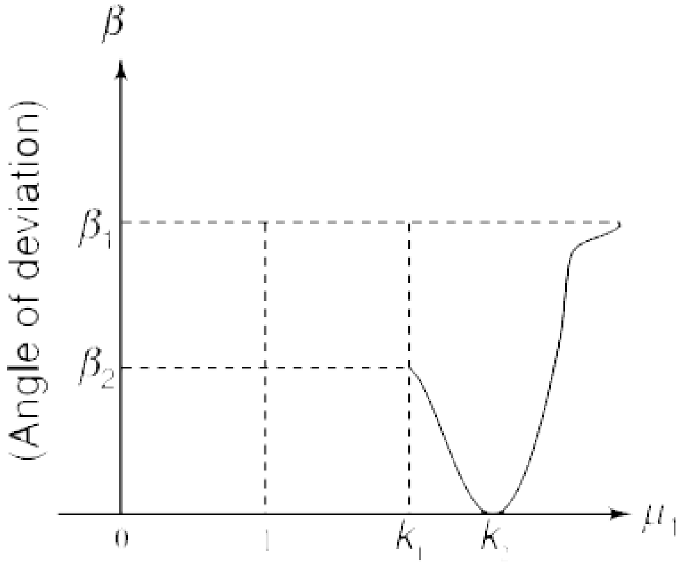
37. An equilateral prism of refractive index $\mu = \frac{4}{\sqrt{3}}$ is kept in a medium of refractive index μ_1. Consider a light ray to be normally incident on one of the refracting faces. The diagram shows variation of magnitude of angle of deviation (β) with respect to μ_1.



(a) Find value of k_2.

(b) Find value of k_1.

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38. A rectangular glass block $(\mu = 1.5)$ is on top of a sheet of paper on which there on which there is a small dot. There is a layer of liquid between the paper and the glass block. The dot is visible through a vertical face up to a point where the angle of emergence of light (starting from the dot) is 30°. Find the refractive index (m_0)

of the liquid. Can we see the dot through a vertical face if the liquid layer is replaced with air? $\sin^{-1}.\frac{2}{3} = 42^\circ$

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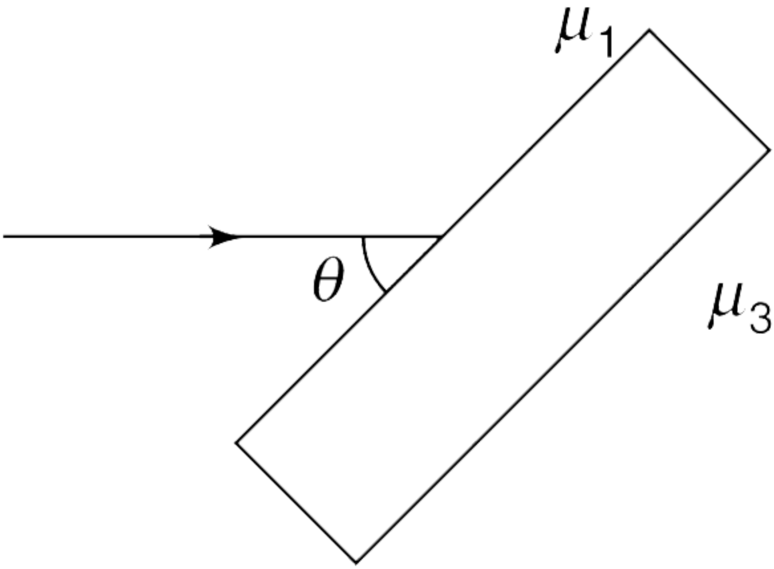
39. A light ray travelling in a medium of refractive index μ_1 is incident on a parallel faced glass slab making an angle of θ with the glass surface. The refractive index of the medium on the other side of the glass slab is $\mu_3(>\mu_1)$. Find the angular deviation suffered by the light ray.



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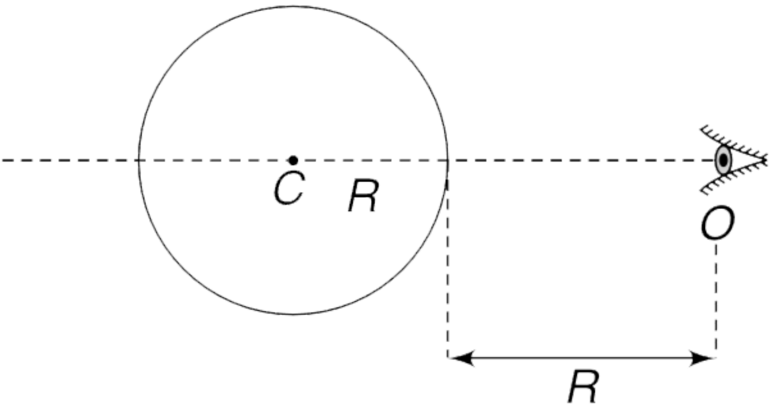
40. The Figure shows the equatorial circle of a glass sphere of radius R having centre at C. The eye of an observer is located in the plane of the circle at a distance R from the surface. A small insect is crawling along the equatorial circle.

(a) Calculate the length (L) of the are on the circle where the insect lies where its image is visible to the observer.

(b) Calculate the value of L when the eye is brought very close to the sphere. Refractive index of the glass is $\mu = \frac{1}{\sqrt{2}}$



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41. On a hot summer day in a desert the refractive index of the atmosphere changes with height (y) above the surface of the earth as $\mu = m_0(1 + by)^{1/2}$ where m_0 is the refractive index at the surface and $b = 6 \times x10^{-4}m^{-1}$. A man of height 1.5 m is standing on a straight level road. Calculate the distance beyond which he cannot see a point on the road.

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42. The angle of minimum deviation caused by a prism is equal to the angle of the prism. What are the possible values of refractive index of the material of the prism?

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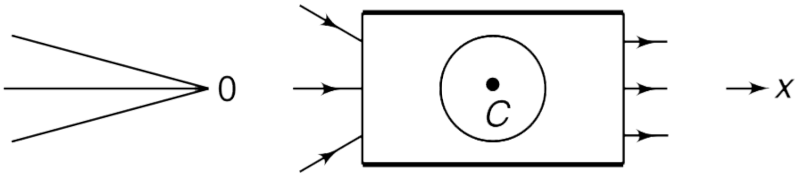
43. A beam of light rays converges to a point O on x-axis as shown. The angle of convergence is small. A cube of glass of refractive index $\mu = 1.5$ and side length $40cm$containing a concentric spherical air cavity of radius 10 cm is to be placed in the path of the converging beam so that the beam emerging from the cube is parallel to x-axis. At what point C on x-axis should the centre of the cube be placed to achieve this? Give the x coordinate of C taking O as origin.



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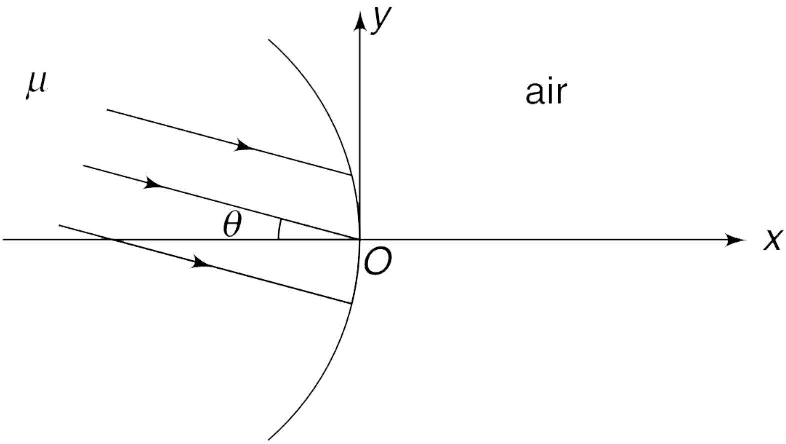
44. A spherical surface of radius R separates air from a medium of refractive index μ. Parallel beam of light is incident, from medium side, making a small angle θ with the principal axis of the spherical surface. Find the co-ordinates of the point where the rays will focus in air.



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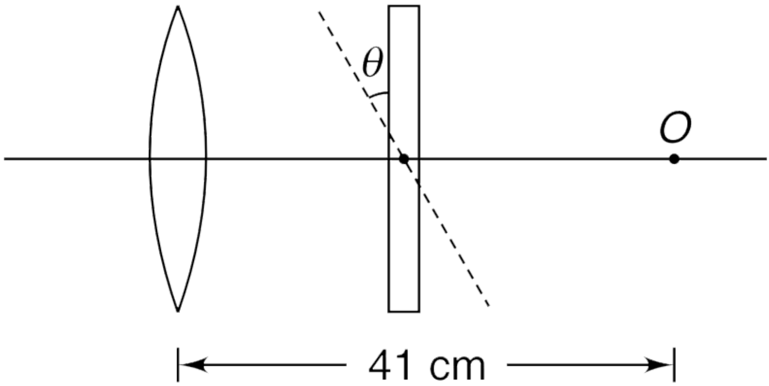
45. A point object O is placed at a distance of 41 cm from a convex lens of focal length $f = 20$ cm on its principal axis. A glass slab of thickness 3 cm and refractive index $\mu = 1.5$ is placed between the lens and the object with its faces perpendicular to the principal axis of the lens. Image of the object is formed at point I_1. Now the glass slab is tilted by an angle of $\theta = 1^\circ$ (as shown in the Figure) and the final image is formed at I_2. Calculate the distance between points I_1 and I_2. Consider only paraxial rays for the lens and near normal incidence for the glass slab.



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46. A man is Standing on the peak of a mountain and finds that evening sun rays are nearly horizontal. At a horizontal distance of 6 km from him, its raining and he sees a beautiful rainbow. The sun rays entering water drop get refracted, reflected and refracted to form a rainbow. The red light is emitted from a drop upto a maximum angle of 42° with respect to the incident sunlight. In front of the man there is a flat valley at a depth of 0.5 km from the

mountain peak. What fraction of the complete circular arc of the rainbow is visible to the man?

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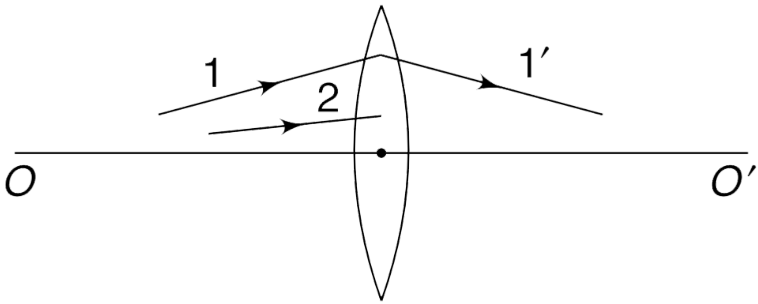
47. A light ray 1 after passing through a lens kept in air, goes along path 1'. OO' is the principal axis. Draw the refracted path of light ray 2. Write all steps used in construction.



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48. An observer holds in front of himself a thin equi convex lens. R is the radius of curvature of each face. He sees two images of his nose, one erect and the other inverted. Explain the formation of these images and assuming the refractive index of glass to be 1.50 prove that he will see two erect images if the distance of the lens is less than 0.25 R from his nose.

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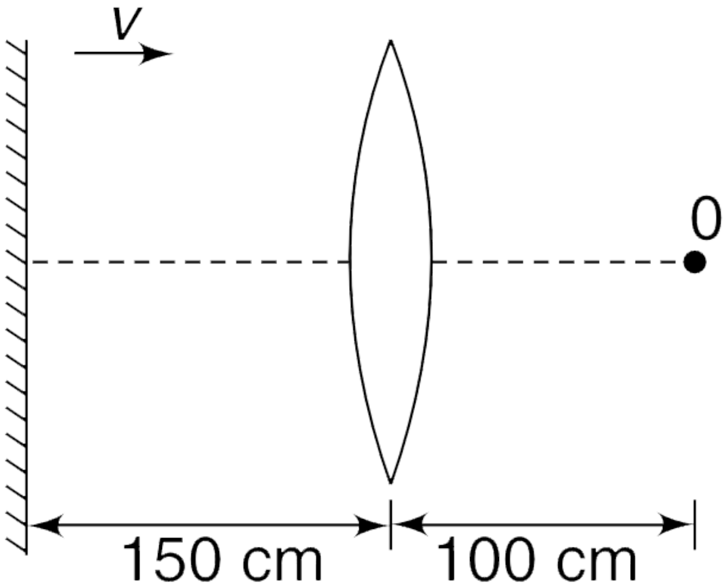
49. An observer is standing at a point O, at a distance of 100 cm from a convex lens of focal length 50 cm. A plane mirror is placed behind the lens at a distance of 150 cm from the lens. The mirror now starts moving towards the right with a velocity of $10 cm / s$. What will be the magnitude of velocity (in m / s) of her own image as seen by the observer, at the moment when the mirror just starts moving?



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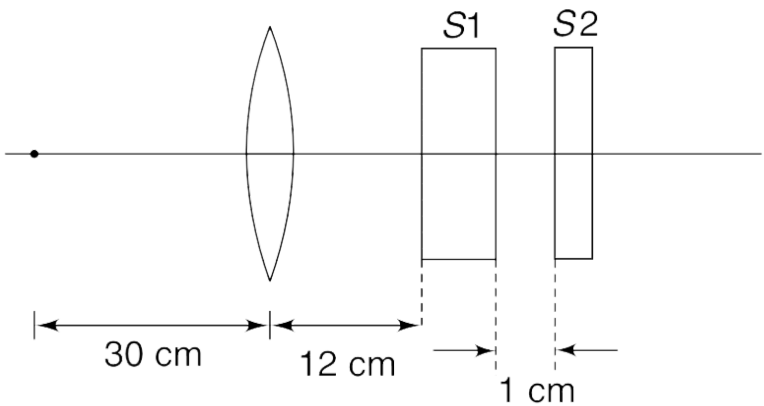
50. A small object (A) is placed on the principal axis of an equiconvex lens at a distance of 30 cm. The refractive index of the glass of the lens is 1.5 and its surfaces have radius of curvature $R = 20cm$. Two glass slabs S1 and S2 have been placed behind the lens as shown in Figure. Thickness of the two slabs is 6 cm and 4 cm respectively and their refractive indices are $\frac{3}{2}$ and 2 respectively.

(a) Find the distance of the final image measured from the lens. Also find the magnification.

(b) How does the position of the image change if the slab S2 is moved to left so as to put it in contact with S1.

(c) How does the position of the image change if the two slabs in contact are together moved to right by a distance of 100 cm.



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51. A virtual image is formed by a lens for a real object.

Take $\left|\frac{v}{f}\right| = y$ and $\left|\frac{u}{f}\right| = x$ and draw y vs x graph if

(a) lens is diverging.

(b) lens is converging.

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52. An equiconvex lens of refractive index 1.5 has its two surfaces having radius of curvature of 30 cm. A point object has been placed on the principal axis at a distance of 60 cm from the lens. Find the distance of image from the lens formed by the rays which suffer refraction at first surface, reflection at second surface, again a reflection on the first surface and finally a refraction from the second surface.

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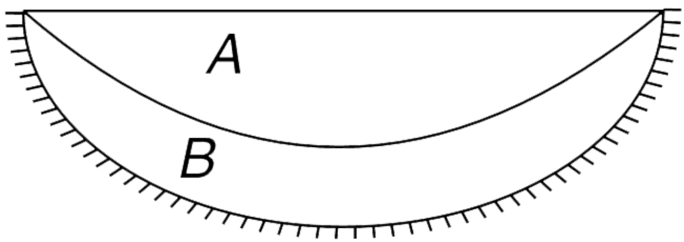
53. A thin plano convex lens A has material of refractive index $\mu_A = 1.8$ and its curved surface has radius of curvature R. A thin layer of transparent material B is laid over the curved surface of A. The refractive index of B is $\mu_B = 1.2$ and the curved surface of B that is not touching a has radius of curvature $\frac{R}{2}$. This surface of B is silvered. A point object is kept at a distance of 10 cm on the principal axis of the system (above the plane surface) and its image is formed at a distance of 40 cm above the plane surface. Find R.



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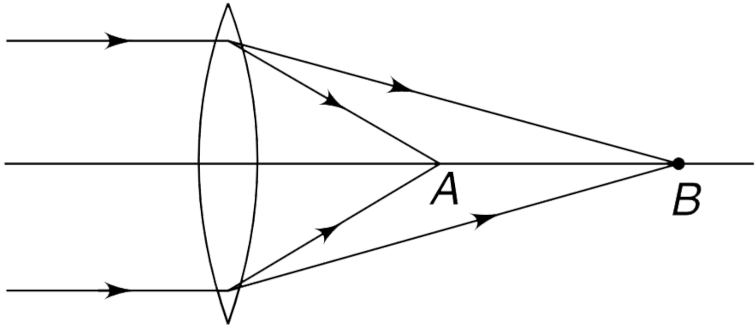
54. The refractive index of light in glass varies with its wavelength according to equation

$\mu(\lambda) = a + \frac{b}{\lambda^2}$ where a and b are positive constants.



A nearly monochromatic parallel beam of light is incident on a thin convex lens as shown. The wavelength of incident light is $\lambda_0 \pm \Delta\lambda$ where $\Delta\lambda < < \lambda_0$. The light gets focused on the principal axis of the lens over a region AB. If the focal length of the lens for a light of wavelength λ_0 is f_0, find the spread AB.

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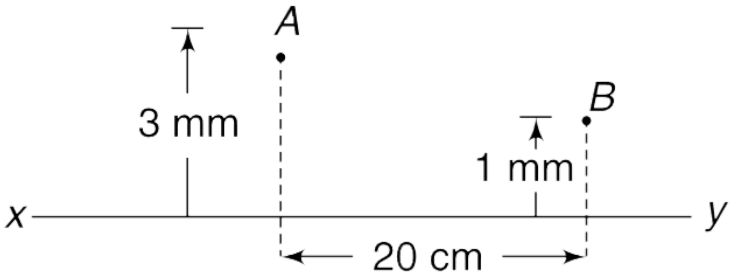
55. An image B is formed of a real point object A by a lens whose optic axis is XY.

(a) Draw a ray diagram to locate the lens and its focus point.

(b) If A and B are separated by 20 cm along the axis, find the focal length of the lens.



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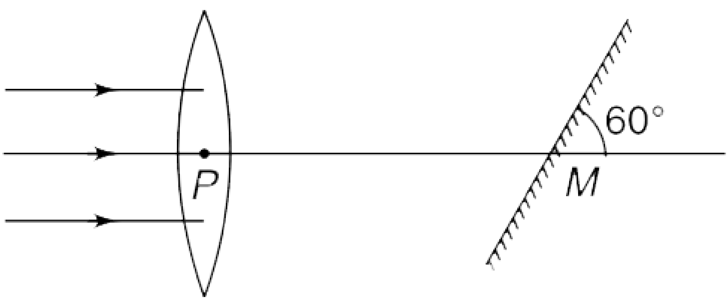
56. A horizontal parallel beam of light passes through a vertical convex lens of focal length f. The optical centre of the lens is P. A small plane mirror is placed at point M inclined at 60° to the axis of the lens. Distance $PM = f/2$. The mirror reflects the light passing through the lens and forms an image at point I. Find distance PI.



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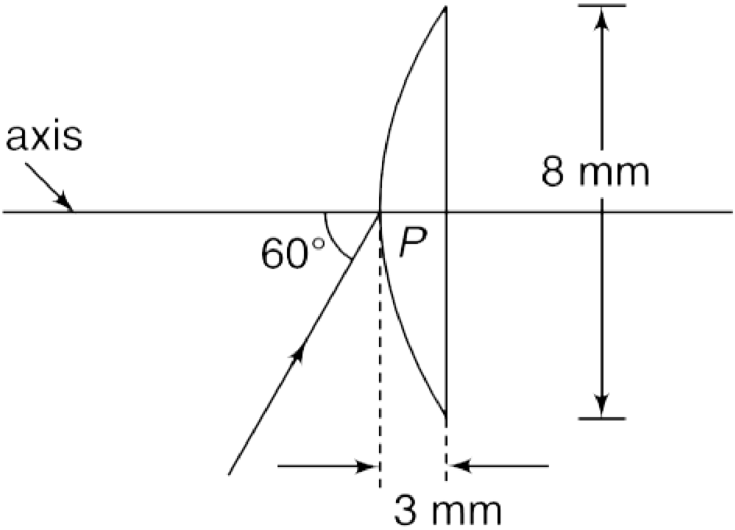
57. A plane convex lens has aperture diameter of 8 mm and thickness of the lens at the centre is 3 mm. The refractive index of the material of the lens is $\sqrt{3}$. A light ray is incident at mid point P of the curved surface at an angle of incidence of 60°.

(a) Calculate the angular deviation suffered by the ray as it passes through the lens. (b) Find the lateral shift in the path of the ray as it passes through the lens.

(c) Find the radius of curvature of the curved surface.

(d) If a narrow beam of light is incident at P parallel to the axis shown, where will it get focused. Take $2\sqrt{3}(\sqrt{3}-1) \approx 2.5$



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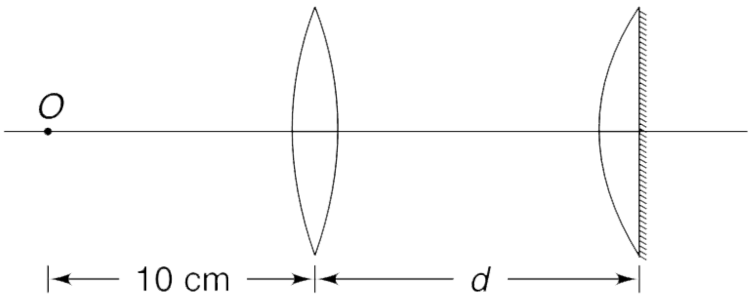
58. A convex lens of focal length 20 cm and another planocovex lens of foal length 40 cm are placed co-axially. The plane surface of the plano convex lens is silvered. An object O is kept on the principal axis at a distance of 10 cm from the convex lens (see Figure). Find the distance d between the two lenses so that final image is formed on the object itself.



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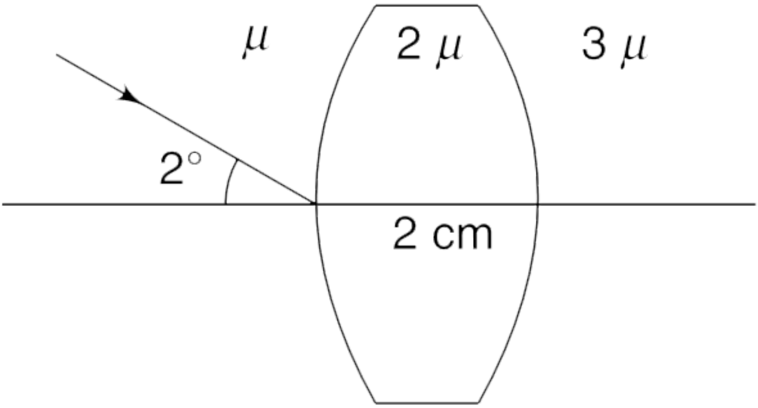
59. An equiconvex lens has its two surfaces of radius of curvature $R = 10cm$. Thickness of the lens at its centre is 2 cm. A light ray is incident making an angle of 2° with the optic axis of the lens. Find the angle that the emergent ray will make with the optic axis. The refractive index of all media is as marked in the Figure.



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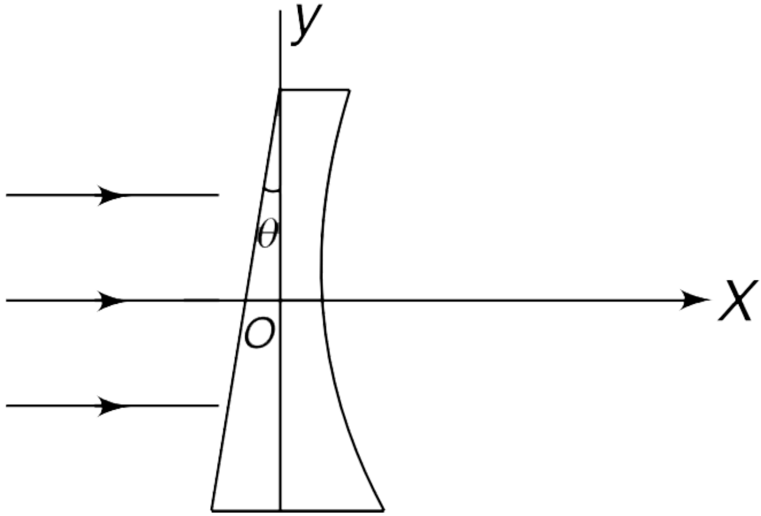
60. Due to manufacturing defect, the plane surface of a thin plano-concave lens has been made tilted at a small angle q outwards from its usual place. The spherical surface has radius of curvature R and refractive index of the material of the lens is μ. A parallel beam of light is incident as shown. In the co-ordinate system shown find the co-ordinates of the point where the rays will focus or appear to be diverging from.



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61. Two lenses L_1 and L_2 are used to make a telescope. The larger lens L_1 is a convex lens with both surfaces having radius of curvature equal to 0.5 m. The smaller lens L_2 has two surfaces with radius of curvature 4 cm. Both the lenses are made of glass having refractive index 1.5. The two lenses are mounted in a tube with separation between them equal to 1 cm less than the sum of their focal length.

(a) Find the position of the image formed by such a telescope for an object at a distance of 100 m from the objective lens L_1.

(b) What is the size of the image if object is 1 m high? Do you think that lateral magnification is a useful way to characterize a telescope?

(c) Angular magnification is defined as ratio of angle subtended by the image at the eyepiece to the angle subtended by the distant object at an unaided eye. Find the angular magnification of the above mentioned telescope.

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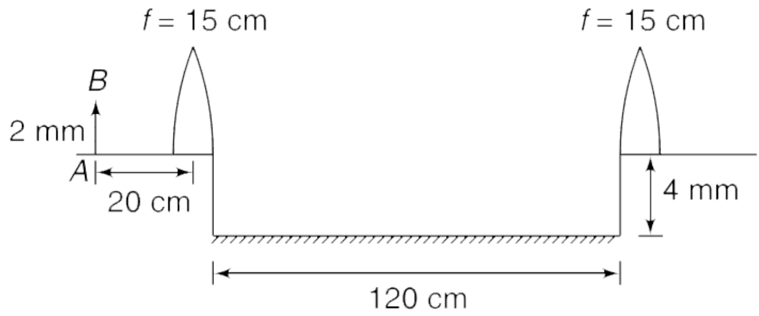
62. A convex lens of focal length 15 cm is split into two halves and the two halves are placed at a separation of 120 cm. Between the two halves of convex lens a plane mir- ror is placed horizontally and at a distance of 4 mm below the principal axis of the lens halves. An object AB of length 2 mm is placed at a distance of 20 cm from one half lens as shown in figure. Find the distance of final image of the point A from the principal axis.



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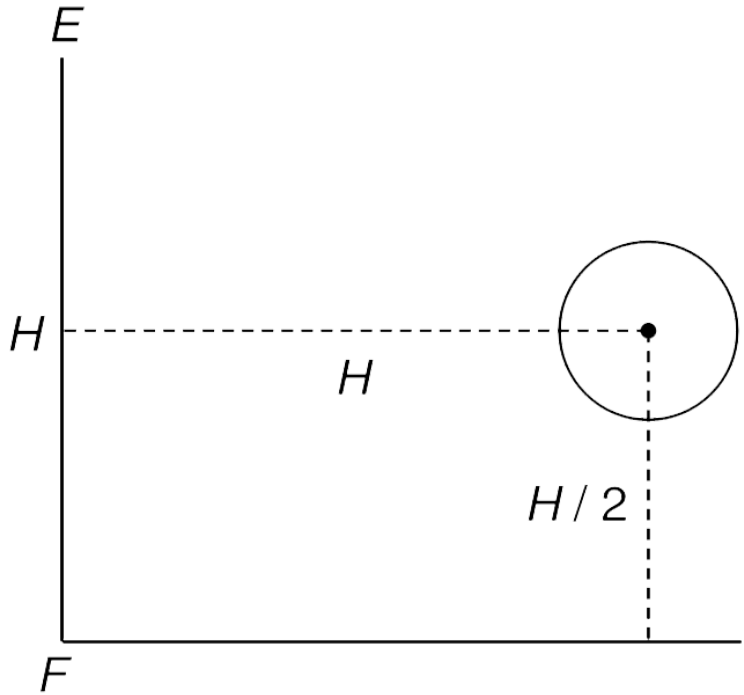
Level 3

1. In the Figure FE is a man of height H standing on a floor. E is eye of the man and F is his foot. The distance between eye and the head is negligible. A steel ball of radius r is suspended in front of him. The distance of the ball from the man is H and height of the centre of the ball from the floor is $\frac{H}{2}$. It is given that $r < < H$. The surface of the ball acts like a mirror and the man sees his image in it.

Calculate the angle subtended by the image at the eye of the man.



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2. An observer views his own image in a convex mirror of radius of curvature R. If the least distance of distinct vision for the observer is d, calculate the maximum possible magnification.

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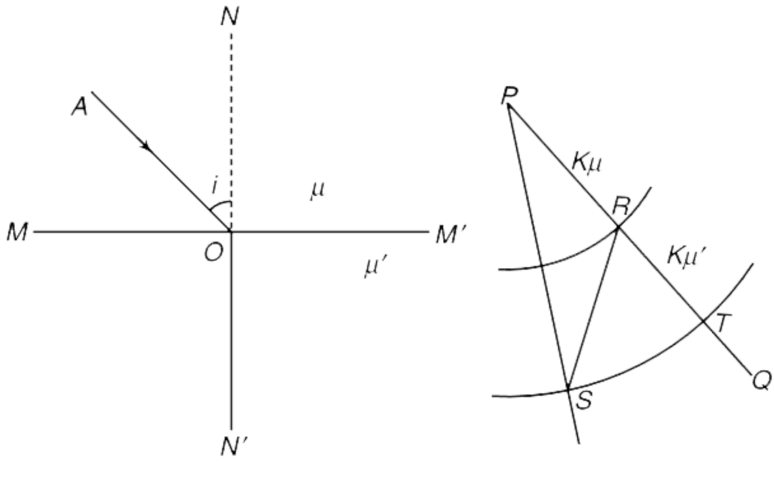
3. The Figure (a) shows two media having refractive index μ and μ'

with MM' as boundary. A ray of light AO is incident at the boundary and gets refracted.



(a) (b)

In order to construct the refracted ray graphically a teacher suggests to draw a line PQ parallel to the incident ray AO. With P as centre, two circular arcs are drawn having radii $k\mu$ and $k\mu$' where k is a positive number. The arcs intersect the line PQ at R and T respectively. From R, a line is drawn parallel to normal NN' and it intersects the other arc at S. Prove that the refracted ray is parallel to line PS.

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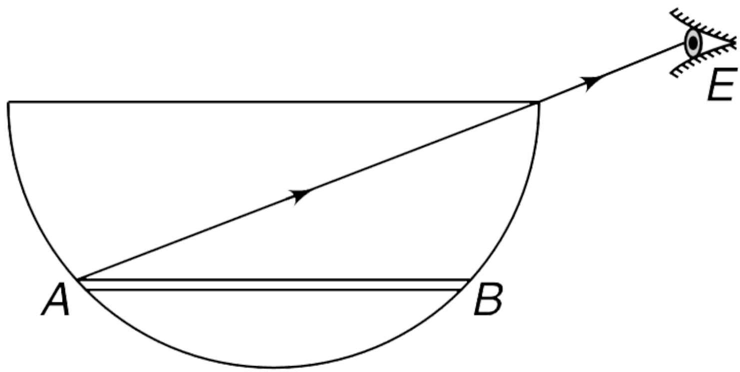
4. A stick is placed inside a hemispherical bowl as shown in Figure. The stick is horizontal and has a length of 2a. Eye of an observer is located at E such that it can just see the end A of the stick. A liquid is filled upto edge of the bowl and the end B of the stick becomes visible to the observer. Radius of the bowl is R. Find the refractive index (μ) of the liquid.



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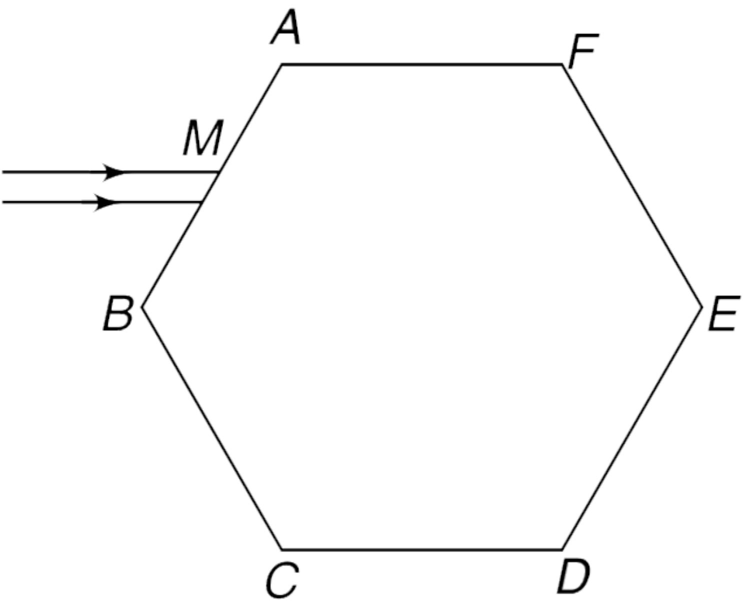
5. The cross section of a prism is a regular hexagon. A narrow beam of light strikes a face of the prism just below the midpoint (M) of the edge AB. The beam is parallel to the top and bottom faces of the prism. Final the minimum value of refractive index of the material of the prism for which the emergent beam will be parallel to the incident beam.



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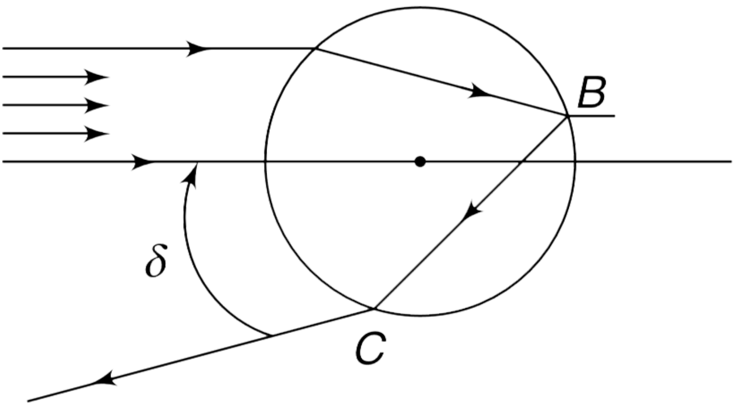
6. A parallel beam of light is incident on a spherical drop of water $(\mu = 4/3)$. Consider refraction of light at air-water interface, then reflection at water-air boundary (of course there will be refracted light energy in air as well), followed by refraction at water-air interface. Path of a typical ray refracted at A, then reflected at B and finally refracted at C has been shown in the Figure. Find the maximum value of angle δ. use $\sin^{-1}\sqrt{\frac{20}{27}} = 60^\circ$ and $\sin^{-1}\sqrt{\frac{5}{12}} = 40^\circ$.



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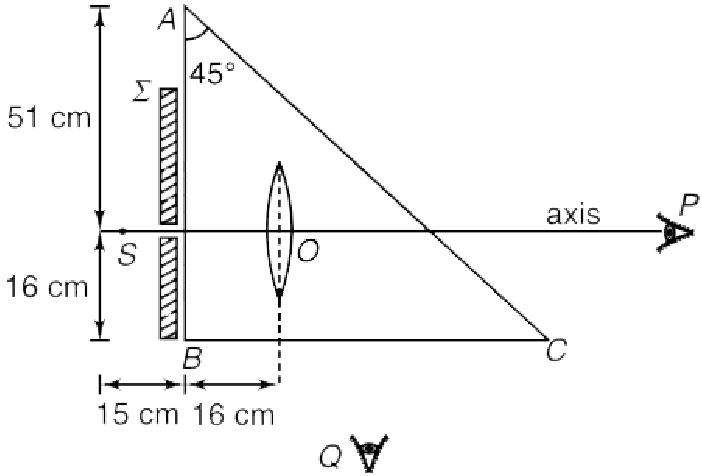
7. An isosceles right angled triangular glass $(\mu = 1.6)$ prism has a cavity inside it in the shape of a thin convex lens whose both surfaces have radius of curvature equal to 20 cm. The cavity has been filled with a transparent liquid of refractive index 2.4. S is a point source and σ is an opaque sheet having a small hole such that the source and the hole both lie on the principal axis of the lens. The small hole in the opaque sheet is just to ensure that only paraxial rays are incident on the optical system. However, the size of hole is large enough to neglect diffraction effects. Will the observers at P and Q be able to see the image of source S? Where is the image located?



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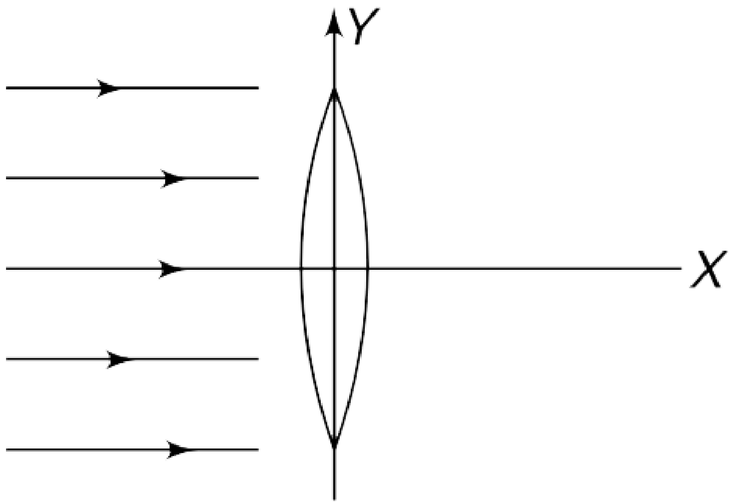
8. Monochromatic light rays parallel to the principal axis (the x axis) are incident on a convex lens of focal length f. If the lens oscillates such that it tilts up to a small angle θ on either side of the y axis, then find the distance between the exterme positions of the image.

Take $\sec\theta \approx 1 + \frac{\theta^2}{2}$ for small θ.



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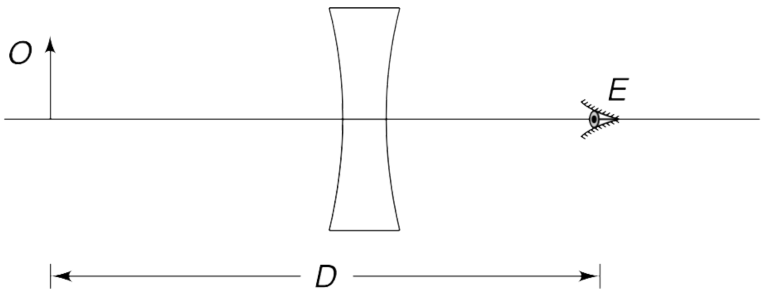
9. O is a small object placed at a distance D from the eye E of an observer. A concave lens of focal length $f(\angle D)$ is placed near to the eye and image of the object is viewed. Now the lens is moved towards the object O, away from the eye.

(a) Show that the angle subtended by the image at the eye first decreases and then increases as the lens is moved away from the eye.

(b) Find the distance of the lens from the object when the apparent size of image is smallest.



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