PHYSICS

BOOKS - RESNICK AND HALLIDAY PHYSICS (HINGLISH)

GEOMETRICAL OPTICS : REFRACTION

Sample Problem

1. Lateral displacement of ray passing through a glass slab

A ray of light is incident on a parallel sided glass slab of refractive index n and thickness t as shown in Fig. 34-2.

Find the lateral displacement of the ray as it passes through the slab.

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2. Refraction of ray passing through tank filled with water

An observer is viewing along the line shown in Fig. 34-4. When there is no water filled in the tank, he can see only wall AB and no other part of the base of the tank. Then water is filled in till height h and he is just able to see the point E as shown in Fig. 34-3. Find the angle of refraction into air (ϕ) and angle of incidence from water (ϕ). Also find the depth to which water has been filled.

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3. Refraction of ray incident on a boundary of another plane

A ray given by $-\hat{i}-2\hat{j}$ is incident on xz plane as shown in Fig. 34-4. Above the xz plane, refractive index is $n_1=2$ and below the xz plane refractive index is $n_2=\sqrt{5/2}$. Find a unit vector in the direction of the refracted ray.

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4. If a fish lies at the bottom of a 4 m deep water tank $(\mu=4/3)$ and a bird is flying at a height of 6m above

the water surface, then apparent distance at which the fish appears to the bird is

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5. Apparent distance of the image formed by a concave mirror dipped in water

Find the location of the final image of O formed by the system (Fig. 34-8). Assume that O is on the principal axis of the concave mirror.

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6. Apparent velocity of fish floating in tank

A tank is filled with water up to a height of $15cm$ and a fish is floating inside at a depth of 10cm. The tank is now being drained so that the surface moves down with a velocity of 1cm/s. An observer is viewing the fish from a height of 10cm.

(a) Find the apparent velocity of the fish as seen by the observer.

Find the apparent velocity of the observer as seen by the fish.

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7. Location of image after multiple events

Find the location of final image as shown in Fig.34-13. Take the refractive index of the slab as 4/3.

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8. Sparkle in the diamond

The purpose of a diamond is, of course, to sparkle . Part of the art of cutting a diamond is to ensure that all the light entering through the top face or side facets leaves through those surfaces, to participate in the sparkle. Figure 34-18 shows part of a cross-sectional slice through a brilliant-cut diamond, with a ray entering at point A on the top face. In this type of cut, the top and

bottom surfaces have normal lines that intersect at the indicated 48.84°. At point B, at least part of the light reflects and leaves the diamond properly , but part could refract and thus leak out of the diamond. Consider a light ray incident at angle $\theta_1 = 40^{\circ}$ at A. Does light leak at B if air $(n_4 = 1.00)$ lies next to the bottom surface ? Does light leak if greasy grime $(n_4 = 1.63)$ coats the surface? The index of refraction of diamond is $n_{d\in} = 2.419$.

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9. Total internal reflection of light ray from cylindrical optical fiber

An optical fiber consists of a cylindrical core of unknown

refractive index kept in air. A ray of light is incident on the flat face of the core so that it gets totally reflected at the curved surface (Fig.34-19). What is the possible refractive index if the ray is totally reflected at any angle of incidence ϕ from air ?

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10. A point source of light is placed $4m$ below the surface of a liquid of refractive index $5/3$. The minimum diameter of a disc, which should be placed over the source, on the surface of the liquid to cut off all light out of water, is

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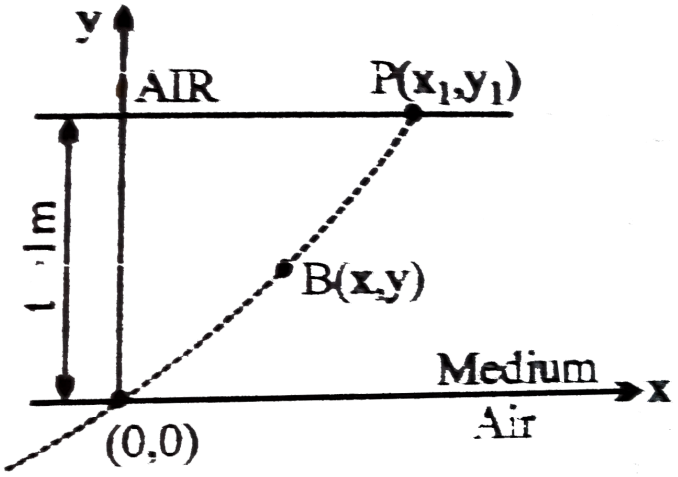
11. A ray of light travelling in air is incident at grazing angle (incident angle=90°) on a long rectangular slab of a transparent medium of thickness $t = 1.0$ (see figure). The point of incidence is the origin $A(O, O)$ .The medium has a variable index of refraction n(y) given by :$n(y) = \left[ky^{3/2} + 1\right]^{1/2}$,where k=$1.0m^{-3/2}$ .the refractive index of air is 1.0`



(i) Obtain a relation between the slope of the trajectory

of the ray at a point $B(x, y)$in the medium and the incident angle at that point

(ii) obtain an equation for the trajectory $y(x)$of the ray in the medium.

(ii) Determine the coordinates (x_1, y_1) of the point P .where the ray the ray intersects upper surface of the slab -air boundary.

Indicate the path of the ray subsequently.

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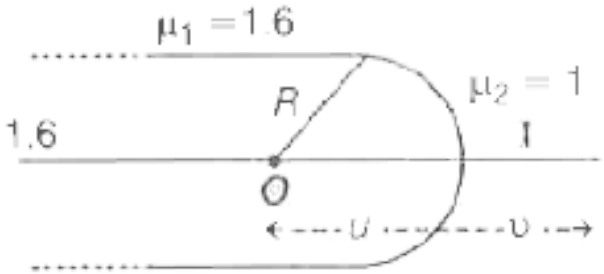
12. A point object O is placed on the axis of a cylindrical piece of glass of refractive index 1.6 as shown in the figure. One surface of the glass piece is convex with radius of curvature 3mm. The point appeared to be at 5

mm on the axis when viewed along the axis and from right side of convex surface. The distance of the point object from the convex surface is :



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13. Image of the fish in a spherical aquarium

Assume that a boy views a fish in a spherical aquarium of radius $10cm$ kept at a distance of $2cm$ from the center toward the left of center. The boy is viewing from

the left (Fig.34-27). Where will the image of fish be formed?

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14. Refraction through eye of Anableps anabelps fish

Figure 34-28 shows a vertical cross section through an eye of the Anableps anableps fish that swims with each eye half in and half out of the water, with a pigment band separating the two halves at the water surface. The front of the eye (the cornea) is a spherically convex refracting surface of radius $r = 1.95mm$ and index of refraction $n_2 = 1.335$. The refraction at the cornea is the first step in the eye's focusing of a real image into the back of the eye (the retina), where visual processing

begins. If the cornea faces an insect (lunch) at object distance $p = 0.20m$, what is the image distance i of that refraction for the cornea in air $(n_1 = 1.000)$ and in water $(n_1 = 1.333)$?

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15. Image of an object kept on the principal axis of transparent sphere with silvered rear surface

A sphere of radius 1m and n=1.5 is silvered at its back. A point objet is kept at a distance of 1m from the front face (Fig. 34-30). Where will the final image be formed ?

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16. Focal length of concavo-convex lens

A concavo-convex lens has radii of its faces 20cm and 60cm. If the refractive index of the material of the lens is 1.5, find its focal length.

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17. Deviation of a ray incident on a converging lens

Find the point at which the first ray crosses the principal axis after refraction (Fig. 34-39). Also find its deviation.

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18. Formation of image by a combination of converging and a diverging lens

Find the location of the final image after all the refrections in Fig. 34-41. The radius of both the plano-convex lens and plano-concave lens is 10cm and refrective index is 1.5.

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19. Condition for autocollimation

Find the distance between the convex lens and convex mirror, both of focal length 20cm (Figs. 34-42a and b), so that for an object kept at 30cm from the lens, the final image is at the object itself. (This is commonly

known as condition for autocollimation that we discussed in Section 33.5)

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20. Find the radius of the light spot on the screen as shown in Fig. 34-44. Consider only the light rays refracted from the lens. Find the average intensity on the screen. The source is point source of power $100W$. The lens has an aperture of $6cm$.

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21. Beam expander

Assume that a parallel beam is incident on two convex lens of focal length 20cm and 40cm. The beam has a diameter of 2cm. What should be the distance between them so that the final beam emerges parallel to the principal axis(Fig. 34-46) ?

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22. Finding focal length by displacement method

In an experiment for finding focal length of a convex lens the object and screen are kept fixed. There are two position of lens between the object and screen for which an image is obtained on the screen. These

positions are separated by 20cm. Also, the magnification in first situation is -2. Find the distance between the object and the screen, that is the focal length of the lens.

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23. Finding equivalent focal length

Two equiconcave lens of focal length -20cm each having a refractive index of 1.50 are kept together and the space between them is filled with water as shown in Fig. 34-49. Find the equivalent focal length of the arrangement thus formed.

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24. A convex lens of radii of curvature 20cm and 30 cm respectively. It is silvered at the surface which has smaller radius of curvature. Then it will behave as $(\mu_g = 1.5)$

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25. Refractive index of a prism

A ray is incident on an equilateral prism such that the angle of deviation is 30° . It is seen that if the angle of incidence is increased by 30°, then the deviation is again 30°. Find the refractive index of the prism.

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26. Minimum and maximum deviation in a prism

A 60° prism has a refractive index of 1.5.

(a) Calculate the angle of incidence for minimum deviation.

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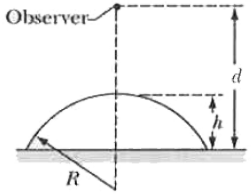
27. Total internal reflection in a prism

What is the relationship between A and n so, that no rays come out of second face ?



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28. Image formation by a system of thin prism and lens

A beam parallel to the principal axis is incident on a thin prism (Fig. 34-60). Find the location of final image.

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29. Deviation without dispersion and disperison without deviation

What should be the condition on a combination of prism for the following ?

(a) Angle of dispersion is zero but angle of deviation is not zero.

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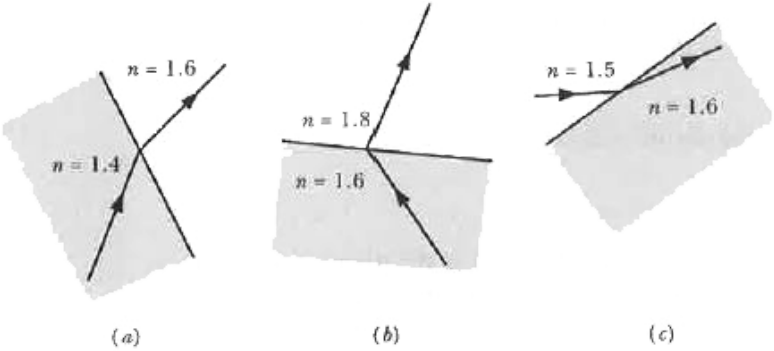
Check Point

1. Which of the three drawings here (if any) show physically possible refraction?



(a) (b) (c)

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2. Suppose now that the fish sees the boy. Find (a) apparent distance of eye as seen by fish. (b) apparent distance of image of eye as seen by fish.

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3. We know that the light ray bends toward the normal when it goes from a denser medium. This adjacent photograph seems to be wrong ! The straw dipped in water seems to be bent away from the normal . Explain.

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4. All along we have been considering the apparent depth of an object viewed normally. Suppose that the object is being viewed at an angle θ to the surface. If the actual depth is d and angle of ray inside water is ϕ, what is the apparent depth ?

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5. A bee is hovering in front of the concave spherical refracting surface of a glass sculpture. (a) Which part of Fig. 34-24 is like this situation ? (b) Is the image produced by the surface real or virtual and (c) is it on the same side as the bee or the opposite side ?

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6. A thin symmetric lens provides an image of a fingerprint with a magnification of $+0.2$ when the fingerprint is $1.0cm$ farther from the lens than the focal point of the lens. What are the type and orientation of the image, and what is the type of lens ?

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Problems

1. In an oscillating LC circuit with L=79mH and C=4.0 μF, the current is initially a maximum . How long will it take

before the capacitor is fully charged for (a) the first time and (b) the second time ?

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2. Light in vacuum is incident on the surface of a glass slab. In the vacuum the beam makes an angle of a glass slab. In the vacuum the beams makes an angle of 37° with the normal to the surface, while in the glass it makes an angle of 23.5° with the normal. What is the index of refraction of the glass ?

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3. A small piece of wood is floating in the water of depth $1m$. The refractive index of water is $4/3$ and the sum rays are incident at an angle of 53° to the vertical. Find the location of the shadow of the wood piece on the bottom of the ocean.

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4. Light rays travel from liquid (refractive index $= 2$) to air. (a) What is the maximum angle of deviation ? (b) What is the angle of incidence corresponding to this maximum angle of deviation? (c) At what angle (s) of incidence can the angle of deviation be 30° ?

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5. A double-convex lens is to be made of glass with an index of refraction of 1.5. One surface is to have 2 times the radius of curvature of the other and the focal length is to be $60mm$. What is the (a) smaller and (b) larger radius?

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6. A 20 mm thick layer of water ($n = 1.33$) floats on a 40 mm thick layer of carbon tetrachloride $(n = 1.46)$ in a tank. A coin lies at the bottom of the tank. At what

depth below the top water surface do you perceive the coin ?

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7. v22

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8. A concave mirror of radius of curvature one meter is placed at the bottom of a tank of water. The mirror forms an image of the sun when it is directly overhead. Calculate the distance of the images from the mirror for

(a) $80cm$ and (b) $40cm$ of water in the tank ($\mu = 4/3$ for water)

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9. A slab of glass of refractive index 1.5 and thickness $3cm$ is placed with the faces perpendicular to the principle axis of a concave mirror. If the radius of curvature of the mirror is $10cm$, the distance at which an object must be placed from the mirror so that the image coincides with the object is

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10. A light ray, going through a prism with the angle of prism 60°, is found to deviate by 30°. What limit on the refractive index can be put from these data ?

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11. A movie camera with a (single) lens of focal length $75mm$ takes a picture of a person standing $27m$ away. If the person is $180cm$, tall what is the height of the image on the film ?

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12. The index of refraction of benzene is 1.8 . What is the critical angle for a light ray traveling in benzene toward a flat layer of air above the benzene ?

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13. A point source of light is $80.0cm$ below the surface of a body of water. Find the diameter of the circle at the surface through which light emerges from the water.

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14. Two spherical-shaped equal-sized glass fishbowls filled with water are standing on the table. In the middle of each fishbowl a small fish is swimming. What will be the distance of the image as seen by another ? The refraction index of water is $\frac{4}{3}$. Take radius =R and distance between the centres of fishbowls as 3R.

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15. When viewed normally through the flat surface the apparent thickness of a plano-covex lens appears to be $2mm$. If the radius of curvature of the spherical surface is $10cm$ then find thickness of the lens when viewed

from the curved surface. Refractive index of the glass is 1.5.

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16. One end of a glass rod 8cm in diameter has a hemishperical surface of 4cm radius. Determine the position of the image of an object placed on the axis at following distance from the hemishperical end (a) at infinity, (b) 16cm, (c) 4cm, refractive index of the glass is 1.5.

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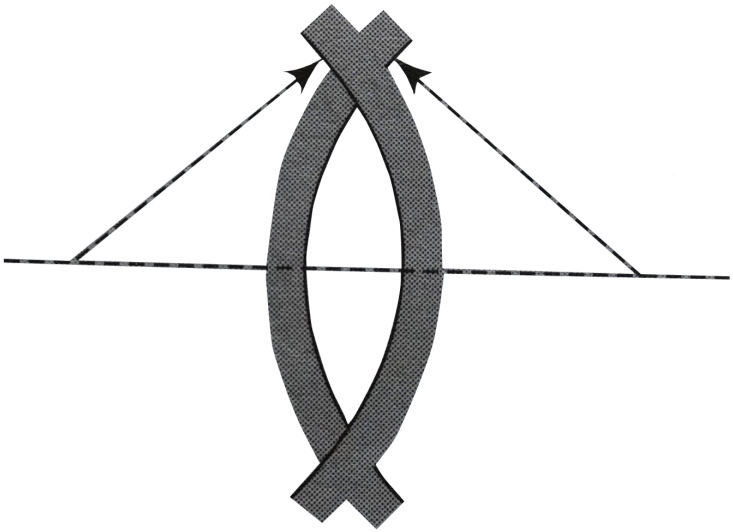
17. There are two spherical surfaces of radii $R_1 = 30cm$ and $R_2 = 60cm$. In how many ways these surfaces may be arranged to get different lenses. If all the lenses are made of glass $(\mu = 1.5)$, find the focal length of each lens.



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18. What area of the ground below can be photographed at one time by a camera of focal length 45cm and plate size $3cm \times 3cm$ kept in a satellite at height of $1500km$?

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19. Two watch glasses of radii of curvature $10cm$ and $30cm$ are cemented at the edges to form an air convex lens. (a) What is its focal length in air and water? (b) Is it convergent or divergent in water ?

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20. An illuminated slide is held $68cm$ from a screen. How far from the slide must a lens of focal length $11cm$ be placed (between the slide and the screen) to form an image of the slide's picture on the screen ?

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21. A converging beam of light forms a sharp image on a screen. A lens is placed in the path of the beam at $10cm$ from the screen. It is found that the screen has to be moved $8cm$ further away from the lens to obtain a sharp image. Find the focal length and nature of the lens.

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22. A convex lens focuses an object 40cm from it on a screen placed 10cm away from it. A glass plate ($\mu = 1.5$) and of thickness 3cm is inserted between the lens and the screen. Where should the object be placed so that its image is again focused on the screen ?

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23. A plano-convex lens of focal length 40cm and refractive index =1.5 is silvered at plane surface. (a) What will be its focal length in air ? (b) What will be the equivalent mirror behave like ? (c) What will be its focal

length when it is silvered at curved surface instead of being silvered at the plane surface ?

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24. A beam of light diverges from P on the axis of a convex lens and the after passing through the lens is reflected from the surface of a convex mirror. The reflected beam is brought to a focus by the lens at P itself. (a) Find the focal length of the lens. Given that the distance of the lens and the mirror is 10cm. The distance of P from the mirror is 30cm and the focal length of the mirror is 10cm.

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25. Find the nature and focal length of a lens which must be placed in contact with a concave lens of focal length $25cm$ in order that the lens combination may produce a real image of an object placed at infinity.

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26. A thin equiconvex lens of refractive index $3/2$ and radius of curvature $50cm$ is placed on a reflecting convex surface of radius of curvature $100cm$. A point object is placed on the principle axis of the system such that its final image coincides with itself. Now few drops of a transparent liquid are placed between the mirror

and lens such that final image of the object is at infinity. Find (a) the refractive index of the liquid used and (b the position of the object.

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27. The cross section of a glass prism $\mu = 2$ has the form of an isosceles right-angled triangle. It is submerged in a liquid of refractive index 1.2. A ray is incident on to one of the equal faces perpendicularly. What is the angle between the direction of incident ray and the ray that emerges from the prism ?

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28. A prism having refractive index $\sqrt{2}$ and refracting angle 30°, has one of the refracting surfaces polished. A beam of monochromatic light incident on the other refracting surface will retrace its path if the angle of incidence is

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29. A quartz glass prism of refracting angle 4° is to be combined with a crown glass prism to create a direct-vision prism combination . (a) Find the refracting angle of the crown prism. (b) Find the angular width of the spectrum found by the combination. (For crown glass

$\mu_R = 1.52, \quad \mu_v = 1.56,$ and for quartz glass $\mu_R = 1.70, \mu_v = 1.74$).

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30. Focal lengths of two lenses are $10cm$ and $-20cm$ and dispersive powers of their materials are 0.03 and w. To form achromatic combination from these, (a) what is the value of ω ? (b) What is the resulting focal length of the combination ?

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31. A small fish $0.4m$ below the surface of a lake, is viewed through a simple converging lens of focal length $3m$. The lens is kept at $0.2m$ above the water surface such that the fish lies on the optical axis of the lens. Find the distance of the image of the fish from the lens as seen by the observer. The refractive index of water is $4/3$.

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32. The dispersive powers of crown and flint glasses are 0.03 and 0.05 respectively. The refractive indices for yellow light for these glasses are 1.517 and 1.621 respectively. It is desired to form an achromatic

combination of prism of crown and flint glasses which can produce a deviation of 1° in the yellow ray. Find the refracting angles of the two prisms needed.

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33. While light falls on one face of crown glass prism of refracting angle 50°. The angle of incidence is 30°. Find the (a) mean deviation produced by the prism and (b) the angle of dispersion $(\mu_v = 1.538, \mu_R = 1.52)$.

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34. A flint glass prism and a crown glass prism are to be comblined in such a way that the deviation of the mean ray is zero. The refractive index of the flint glass for the mean ray is 1.62 and for the crown glass it is 1.518. If the angle of the flint glass prism is 6°, what would be refracting angle of the

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35. A fish is rising up vertically inside a pond with velocity of $4cm/s$, and notices a bird , which is diving vertically downward and its velocity appears to be $16cm/s$ (to th fish). What is the real velocity of the diving bird, if refractive index of water is $4/3$?

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36. A ray is ihncident at an angle of incidence ii on one surface of a prism of small angle A and emerge normally from opposite surface. If the refractive index of the material of prism is μ. the angel of incidance I is nearly equal to

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37. A prism of refractive index $\sqrt{2}$ has a prism angle of 60°. At what angle must a ray incident on it so that it suffers minimum deviation ?

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38. Find the (a) angle of minimum and (b) the maximum deviation for an equilateral prism having refractive index $n = \sqrt{3}$.

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39. Suppose the prism of Fig. 34-83 has apex angle $ph = 60.^{\circ}$ and index of refraction $n = 1.60$. (a) What is the smallest angle of incidence θ for which a ray can enter the left face of the prism and exit the right face ? (b) What angle of incidence θ is required for the ray to exit the prism with an identical angle θ for its refraction

as it does in Fig. 34-83.

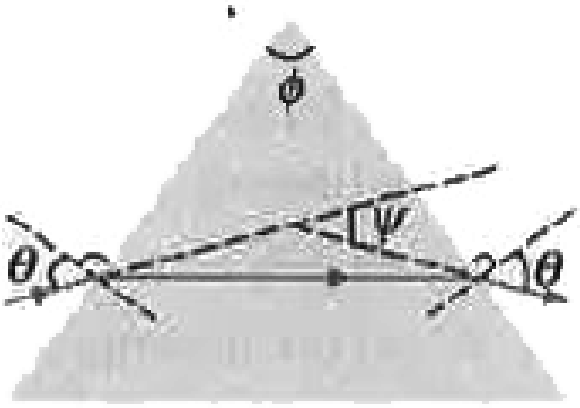

Figure 34-83 Problem 53.

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40. In Fig. 34-84, a light ray enters a glass slab at point A at incident angle $\theta_1 = 45.0^\circ$ and then undergoes total internal reflection at point B. What minimu value for the index of refraction of the glass can be inferred

from this information ?

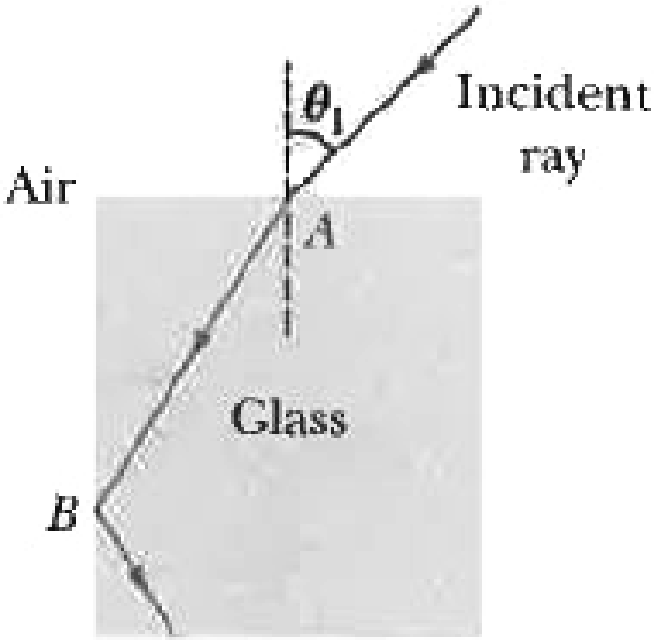

Figure 24-84 Problem 54.

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41. An object is placed at a certain distance from a screen. A convex lens of focal length 20cm is placed

between the screen and the object. A real image is formed on the screen for two positions of the lens, which differ by a distance of 10cm. What is the distance of the object from the screen ?

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42. A convex lens A of focal length $20cm$ and a concave lens B of focal length $5cm$ are kept along the same axis with a distance d between them. If a parallel beam of light falling on A and B as a parallel beam, then d is equal to .....cm

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43. Two thin sysmmetrical lenses of different nature and of different material have equal raii of curvature $R = 15cm$. The lenses are put close together and immersed in water $(\mu_w = 4/3)$. The focal length of the system ini water is 30cm. The difference between refractive indices of tthe two lenses is

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44. An object is placed $1cm$ above the principal axis of a convex lens of focal length of 40cm. Object distance is 60cm. If the object now starts moving perpendicularly away from optical axis with a speed of 10cm/s, then what is the speed of the image ?

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Practice Questions Single Correct Choice Type

1. A concave mirror has a local length of 2m in vacuum. What would be its focal length when used in a medium of refractive index 2.759 ?

A. $2m$

B. $2 \times 2.759m$

C. $2/2.759m$

D. Data inadequatc

Answer: A

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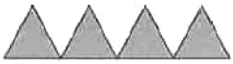
2. Four similar prisms of same material having same angle of prism are arranged. Which among the four of the arrangements shown in the following figures gives no not angular deviation ?

A. 

B. 

C. 

D. 

Answer: B

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3. A layered lens is made of materials indicated by shades in the figure. The number of images formed is

A. 1

B. 2

C. 3

D. 4

Answer: D

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4. In a swimming pool, a person is viewing outside objects by keeping an eye at a depth h inside water. If the critical angle for water is ' θ_c', then the value of the diameter of the circle of view for outside objects will be

A. $2h\sin\theta_c$

B. $2h\cos\theta_c$

C. $2h\tan\theta_c$

D. $2h\cot\theta_c$

Answer: C

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5. If $f(V)$ and f_R are the focal lengths of a concex lens for violet and red light respectively and $F_V$and F_R are the focal lengths of concave lens for violet and red light respectively, then we have

A. $f_V = f_R$ and $f'_V < f'_R$

B. $f_V > f_R$ and $f'_V > f'_R$

C. $f_V < f_R$ and $f'_V < f'_R$

D. $f_V < f_R$ and $f'_V > f'_R$

Answer: D

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6. The angle of prism is 60° and its refractive index is 1.5. There will be no emergent light if the angle of incidence on the first face is

A. equal to 30°

B. less than 27°

C. more than 30°

D. equal to 60°

Answer: B

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7. A thin prism of glass is placed in air and water respectively. If $n(g) = \frac{3}{2}$ and $n_w = \frac{4}{3}$, then the ratio of deviation produced by the prism for a small angle of incidence when placed in air and water separately is

A. $9:8$

B. $4:3$

C. $3:4$

D. $4:1$

Answer: D

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8. The dispersion for a medium of wavelength λ is D, then the dispersion for the wavelength 2λ will be

A. (D/8)

B. (D/4)

C. (D/2)

D. D

Answer: B

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9. A concave lens of focal length f produces an image (1/x) of the size of the object, the distance of the object from the lens is

A. $(x-1)f$

B. $(x+1)f$

C. $\{(x-1)/x]f$

D. $\{(x+1)/x\}f$

Answer: A

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10. A lens is placed between the source of light and a wall. It forms images of area A_1 and A_2 on the wall for its two displaced positions. The area of source of light is

A. $\frac{A_1 + A_2}{2}$

B. $\sqrt{(A_1 A_2)}$

C. $\left[\frac{1}{A_1} + \frac{1}{A_2}\right]$

D. $\left(\frac{\sqrt{A_1} + \sqrt{A_2}}{2}\right)^2$

Answer: B

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11. A thin biconvex lens of focal length f=25cm forms a real image of a real object an a screen. The object is separated by 5cm from the lens. The screen is drawn closer to the lens by a distance 18cm. Through what distance (approximately) must the object be shifted so that its image is again formed on the screen ?

A. 0.5mm toward left

B. 0.25mm toward left

C. 2.5mm toward left

D. 1.4mm toward left

Answer: A

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12. A laser beam and a sound wave from directional sources both enter a liquid at an angle of 60° from the horizontal surface of the liquid. The speed of sound in the liquid is 5 times than that of the speed of the sound in air. For light, the refractive index of the liquid is 1.8. What happens ?

A. Both the light and the sound refract at an angle of 74° from the horizontal

B. The light refracts to an angle of 26° from the horizontal and the sound refracts to an angle of 74° from the horizontal

C. The light refracts to an angle of 26° from the horizontal and the sound reflection completely off the surface.

D. The light refracts to an angle of 74° from the horizontal and the sound refracts to an angle of 26° form the horizontal

Answer: A

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13. An air bubble inside a glass slab (μ=1.5) appears 6 cm when viewed from one side and 4 cm when viewed from

the opposite side. The thickness of the slab is

A. 10cm

B. 6.67m

C. 15cm

D. None of these

Answer: B

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14. A bird is flying 3m above the surface of water. To a fish underwater, the height of the bird from the water surface appears to be

A. 2.25m

B. 3.33m

C. 4m

D. 4/3m

Answer: C

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15. In the previous question, if the bird is diving vertically down with speed =6m/s , his appearent speed as seen by a stationary fish underwater is

A. 8m/s

B. 6m/s

C. 12m/s

D. 4m/s

Answer: A

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16. A bucket of total height is half filled with a liquid of index and half with another liquid of index. The apparent depth of the bucket for an observer directly above the bucket

A. 45cm

B. 30cm

C. 35cm

D. 45cm

Answer: C

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17. A flat glass slab of thickness 6cm and index 1.5 is placed in front of a plane mirror . An observer is standing behind the glass slab and looking at the mirror. The actual distance of the observer from the mirror is 50cm. The distance of his image from himself, as seen by the observer is

A. 94cm

B. 96cm

C. 98cm

D. 100cm

Answer: B

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18. Critical angle of glass is θ_1 and that of water is θ_2. The critical angle for water and glass surface would be $\left(\mu_g = 3/2, \mu_w = 4/3\right)$

A. Less than θ_2

B. Between θ_1 and θ_2

C. Greater than θ_2

D. Greater than θ_1

Answer: C

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19. A ray of light travels from a medium of refractive index n into air. If the angle of incidence at the plane surface of separation is θ. And the correspoonding angle of deviation is δ, the variation δ with θ is shown correctly in the figure.

A. 

B. 

C. 

D. 

Answer: C

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20. A real object is kept in air and refraction occurs at the convex boundry of a spherical glass surface. For the image to be real, the real object distance $\left(n_g = 3/2\right)$

A. Should be greater than three times the radius of curvature of the refracting surface.

B. Should be lesser than two times the radius of curvature of the refracting surface

C. Should be greater than the radius of curvature of the refracting surface

D. Is independent of the radius of curvature of the refracting surface

Answer: B

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21. Half the surface of a transparent sphere of refractive index 2 is silvered. A narrow, parallel beam of light is incident on the unsilvered surface, symmetrically with respect to the silvered part. The light finally emerging from the sphere will be a

A. Parallel beam

B. Converging beam

C. Slightly divergent beam

D. Widely divergent beam

Answer: A

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22. A solid transparent sphere has a small, opaque dot at its center. When observed from outside the apparent postion of the dot will be

A. Closer to the eye than its actual position

B. The same as its actual position

C. Farther away from the eye than its actual position

D. Independent of the refractive index of the sphere

Answer: B:D

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23. An object was placed upright 25cm in front of a converging lens with a focal length of 20cm. A concave mirror with a focal length of 15cm was placed 120cm behind the lens. Which of these describes the final image?

A. Real, erect

B. Virtual, erect

C. Real, inverted

D. Virtual, inverted

Answer: C

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24. A lens behaves as a converging lens in air and as a diverging lens in water. If refractive index of water is 1.33, the refractive index of the material of the lens will be

A. Equal to unity

B. Equal to 1.33

C. Between unity and 1.33

D. Greater than 1.33

Answer: C

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25. A convergent lens of focal length 20cm and made of a material with refractive index 1.1 is immersed in water. The lens will behave as a

A. Converging lens of focal length 20cm

B. Converging lens of focal length less than 20cm

C. Converging lens of focal length more than 20cm

D. Divergent lens

Answer: D

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26. A parallel beam of light is incident on a converging lens parallel to its principal axis. As one moves away from the les on the other side on its principal axis, the intensity of light

A. Remains constant

B. Continuously increases

C. Continuously decreases

D. First increases then decreases

Answer: D

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27. Which one of these ray diagrams is most accurate ?

A. 

B. 

C. 

D. 

Answer: C

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28. A point source of light is placed at a distance of 2f from a converging lens of focal length f. The intensity onteh other side of the lens is maximum at a distance

A. f

B. Between f and 2f

C. 2f

D. More than 2f

Answer: C

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29. A converging lens can from a virtual image if the object is placed

A. Between the lens and its focus

B. At the focus of the lens

C. Between f and 2f

D. At infinity

Answer: A

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30. A concave mirror and a convex lens are of the same focal length in air. When they are immersed in water

A. The concave mirror will have its focal length increased

B. The convex lens will have its focal length increased

C. They will have equal focal lengths, defferent from those in air

D. They will have equal focal lengths, same as those in the air

Answer: B

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31. A section of a spherical shell of outer radius R_0 and inner radius R_1 is cut, and used as a lens. The light first strikes what was originally the outer surface of the glass shell. Which of the following statements about the resulting lens is true ?

A. The lens is converging

B. The lens is diverging

C. The lens has zero focal length

D. The lens has infinite focal length

Answer: B

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32. A concave lens of glass, refractive index 1.5 has both surfaces of same radius of curvature R. On immersion in a medium of refractive index 1.75, it will behave as a

A. Convergent lens of focal length $3.5R$

B. Convergent lens of focal length $3.0R$

C. Divergent lens of focal length $3.5R$

D. Divergent lens of focal length $3.0R$

Answer: A

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33. When an object is at a distance u_1 and u_2 from the optical centre of a lens, a real and virtual image are formed respectively, with the same magnification.The focal length of lens is:

A. $u_1 + u_2$

B. $(u_1 + u_2)/2$

C. $u_1 + u_2/2$

D. $\sqrt{u_1 \cdot u_2}$

Answer: B

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34. A concavo-convex glass (index=1.5) lens has radii of curvatures 60cm and 40cm, respectively. Its convex surface is silvered , and its placed on a horizontal table with concave surface up. The concave surface is then filled with a liquid of index 2.0. The combination behaves like

A. Concave mirror

B. Convex mirror

C. Flat mirror

D. Convex lens

Answer: A

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35. Angle of minimum deviation is equal to the angle of prism A of an equilateral glass prism. The angle of incidence at which minimum deviation will be obtained is

A. 60°

B. 45°

C. 30°

D. $\sin^{-1}(2/3)$

Answer: A

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36. A ray of light passes through an equilateral prism such that the angle of incidence is equal of emergence and later is equal to 3/4th the angle of prism. The angle of deviation is

A. 45°

B. 20°

C. 39°

D. 30°

Answer: D

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37. The critical angle for glass to air refraction is least for which color ?

A. Orange

B. Blue

C. Violet

D. Red

Answer: C

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38. A prism is made of glass which has a higher index of refraction for violet light than for red light. Which diagram best indicates the paths of red and violet light rays through the prism ?

A. 

B. 

C. 

D. 

Answer: A

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39. The focal lengths of a convex lens for blue and red colors of light are f_B and f_R respectively, and those of a concave lens are f'_B and f'_R then

A. $f_B > f_R$ and $f'_B < f'_R$

B. $f_B < f_R$ and $f'_B > f'_R$

C. $f_B > f_R$ and $f'_B > f'_R$

D. $f_B < f_R$ and $f'_B < f'_R$

Answer: B

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40. A secondary rainbow is formed when light rays coming from the Sun undergo the following through spherical water droplets

A. A refraction internal reflection and then refraction

B. Two refractions only

C. A refraction internal reflection again internal reflection and then refraction

D. A refraction internal reflection and again internal reflection

Answer: C

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41. The dispersive powers of two lenses are 0.01 and 0.02 . If focal length of first lens is $+10cm$, then what should be the focal length of the second lens, so that they form an achromatic combination ?

A. Diverging lens having focal length 20cm

B. Converging lens having focal length 20cm

C. Diverging lens having focal length10cm

D. Converging lens having focal length 10cm

Answer: A

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42. Focal lengths of two lenses are f and f' and dispersive powers of their materials are ω and ω'. To form achromatic combination from these, which relation is correct ?

A. $\omega = \omega_0, \omega' = 2\omega_0, f' = 2f$

B. $\omega = \omega_0, \omega' = 2\omega_0, f' = f/2$

C. $\omega = \omega_0, \omega' = 2\omega_0, f' = -2f$

D. $\omega = \omega_0, \omega' = 2\omega_0, f' = -f/2$

Answer: D

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43. The table lists the index of refraction for various substances at $20^\circ C$ for light with a wavelength of $589nm$ in a vacuum. Through which substance will light with a vacuum wavelength of 589nm travel with the

greatest speed ?

Substance	n
Fused quartz	1.458
Ethyl alcohol	1.362
Crown glass	1.520
Carbon tetrachloride	1.461
Crystalline quartz	1.544

A. Fused quartz

B. Ethyl alcohol

C. Crown glass

D. Carbon tetrachloride

Answer: B

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44. What is the frequency of light that has a wavelength in water of $6.00 \times 10^2 nm$ if the refractive index for this light is 1.33 ?

A. $3.76 \times 10^{14} Hz$

B. $6.65 \times 10^{14} Hz$

C. $5.00 \times 10^{14} Hz$

D. $7.25 \times 10^{14} Hz$

Answer: A

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45. Blue light with a wavelength of 425 nm passes from a vacuum into a glass lens, and the index of refraction is found to be 1.65. The glass lens is replaced with a plastic lens. The index of refraction for the plastic lens is 1.54. In which one of the two lenses does the light have the greatest speed and what is that speed ?

A. glass, $2.28 \times 10^8 m/s$

B. plastic, $2.13 \times 10^8 m/s$

C. glass, $1.82 \times 10^8 m/s$

D. plastic, $1.95 \times 10^8 m/s$

Answer: D

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46. A child is looking at a reflection of the Sun in a pool of water. When the puts on a pair of Polaroid sunglasses with a vertical transmission axis, she can no longer see the reflection. At what angle is she looking at the pool of water ?

A. 45.0°

B. 53.1°

C. 48.8°

D. 61.6°

Answer: B

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47. A ray of light originating in oil $(n = 1.21)$ is incident at the Brewster angle upon a flat surface of a quartz crystal $(n = 1.458)$. Determine the angle of incidence for this ray.

A. 0.82°

B. 40°

C. 1.2°

D. 50°

Answer: D

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48. A converging lens with a focal length of 12cm produces a 3cm light virtual image of a 1cm hgh object. When entry in the table below is correct?

A.

Image distance	Location of image
$8cm$	Same side lens as object

B.

Image distance	Location of image
$8cm$	Opposite side of lens from object

C.

Image distance	Location of image
$12cm$	Opposite side of lens from object

D.

Image distance	Location of image
$24cm$	Same side of lens as object

Answer: D

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49. A camera with a focal length of 0.0500m (a 50mm lens) is focused for an object at infinity. To focus the camera on a subject which is 4.00m away, how should the lens be moved ?

A. 1.0cm closer to the film

B. 0.06cm farther from the film

C. 0.06 cm closer to the film

D. 4.94 cm farther from the film

Answer: B

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Practice Questions More Than One Correct Choice Type

1. A vitual image larger than the object can be produced by

A. Convex mirror

B. Concave mirror

C. Diverging lens

D. Converging lens

Answer: B::D

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2. If a convergent beam of light passes through a diverging lens, the result

A. May be a convergent beam

B. May be a divergent beam

C. May be a parallel beam

D. Must be a parallel beam

Answer: A::B::C

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3. Which of the following form virtual and erect image for all positions of a self- luminous subject

A. Convex lens

B. Concave lens

C. Convex mirror

D. Concave mirror

Answer: B::C

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4. When the object is moved slightly closer to a converging lens, the image may

A. Increase in size and move closer to the lens

B. Increase in size and move farther away from the lens

C. Decrease in size and move closer to the lens

D. Decrease in size and move farther away from the lens

Answer: B::C

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5. A convex lens forms an image of an object on a screen. The height of the image is 9 cm . The lens is now displaced until an image is again obtained on the

screen. Then height of this image is 4 cm . The distance between the object and the screen is 90 cm.

A. The distance between the two positions of the lens is 30cm

B. The distance of the object from the lens in its first position is 36cm

C. The height of the object is 6cm

D. The focal length of the lens is 21.6cm

Answer: B::C::D

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6. A ray of light traveling in a trasparent medium falls on a surface separating the medium from air, at an angle of incidence of 45°. The ray undergoes total internal reflection. If n is the refractive index of the medium with respect to air, select the possible values of n from the following.

A. 1.3

B. 1.4

C. 1.5

D. 1.6

Answer: C::D

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7. A solid, transparent sphere has a small, opaque dot at its center. When observed from outside, the apparent position of the dot will be

A. Closer to the eye than its actual position

B. Farther away from the eye than its actual position

C. The same as its acutal position

D. Independent of the refractive index of the sphere

Answer: C::D

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8. A thin concavo-convex lens has two surfaces of radii of curvature R and 2R. The material of the lens has a refractive index n. When kept in air, the focal length of the lens.

A. Will depend on the direction from which light is incident on it

B. Will be the same irrespective of the direction from which light is incident on it

C. Will be equal to R/n-1

D. Will be equal to 2R/n-1

Answer: B::D

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9. If a convergent beam of light passes through a diverging lens, the result

A. May be a convergent beam

B. May be a divergent beam

C. May be a parallel beam

D. Must be a parallel beam

Answer: A::B::C

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10. A converging lens of focal length f_1 is placed in front of and coaxially with a convex mirror of focal length f_2. Their separation is d. A parallel beam of light incident on the lens returns as a parallel beam from the arrangement, Then,

A. The beam diameters of the incident and reflected beams must be the same

B. $d = 2f_2 - |f_1|$

C. $d = |f_2| - |f_1|$

D. If the entire arrangement is immersed in water, the conditions will remain unaltered.

Answer: A::B

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11. A converging lens of focal length f_1 is placed in front of and coaxially with a convex mirror of focal length f_2. Their separation is d. A parallel beam of light incident on the lens returns as a parallel beam from the arrangement, Then,

A. The beam diameters of the incident and reflected beams must be the same

B. $d = f_1 - 2 \mid f_2|$

C. $d = f_1 - \mid f_2|$

D. If the entire arrangement is immersed in water, the conditions will remain unaltered.

Answer: A::B

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12. A ray of white light passes through a rectangular glass slab, entering and emerging at parallel faces. The angle of incidence measured from the normal to the glass surface, is large. Then

A. White light will emerge from the slab

B. The light emerging from the slab will have a number of parallel, colored rays

C. The emergent rays will not form a spectrum on a screen

D. Colors will be seen if the emergent rays enter the eye directly

Answer: A::B::C

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13. A light of wavelength 6000 in air enters a medium of refractive index 1.5. Inside the medium , its frequency is

v and it wavelength is λ.

A. $v = 5 \times 10^{14} Hz$

B. $v = 7.5 \times 10^{14} Hz$

C. $\lambda = 4000$

D. $A = 9000$

Answer: A::C

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14. When lights of different colors move through water, they must have different

A. Wavelengths

B. Frequencies

C. Velocities

D. Amplitudes

Answer: A::C

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Practice Questions Linked Comprehension

1. Light in air is incident on a plastic plate at the Brewster angle. The angle of refraction is 35.0°

Determine the Brewster angle.

A. 35.0°

B. 46.5°

C. 55.0°

D. 43.5°

Answer: C

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2. Light in air is incident on a plastic plate at the Brewster angle. The angle of refraction is 35.0°

What is the index of refraction of the plastic plate ?

A. 1.58

B. 1.36

C. 1.43

D. 1.61

Answer: C

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Practice Questions Integers

1. Let us consider simple microscope of a concave lens of power -10D and a convex lens of power +30D in contact. If the image is formed at infinity, what is the

magnifying power of the microscope ? Consider distance of the distinct vision as 25cm.

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2. Radius of curvature of two surfaces of a glass convex lens is $20cm$ each. If refractive index of glass is $3/2$, what is the power of lens in D ?

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3. A thin glass prism of angle 6° of refractive index 1.5 is combined with another glass prism of refractive index

1.6 to produce dispersion without deviation. What is the angle of the second prism ?

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4. In a tank filled with a liquid of refractive index $5/3$, a point source of light is placed $2m$ below the surface of water. To cut off all light coming out of water from the source, what should be the minimum diameter of a disc, which should be placed over the source on the surface of water ?

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