PHYSICS

BOOKS - CENGAGE PHYSICS

REFRACTION OF LIGHT

Worked Examples

1. The refractive index of glass is 1.5. The speed of light in vacuum is $3 \times 10^8 ms^{-1}$. Calculate the speed of light in glass.

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2. A ray of light travels from water to glass. The angle of incidence is 40°. Calculate the angle of refraction and the deviation produced.

Given: $n_g = 1.5$ and $n_w = 1.3$

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3. The sparkling of diamond is due to its very small critical angle. If the refractive index of diamond is 2.4, calculate its critical angle.

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4. A ray of light is incident at an angle of 60° on one face of a rectangular glass slab of thickness $0.1m$, and refractive index 1.5 .Calculate the lateral shift produced.

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5. A glass cube of side 0.6 m contains a small air bubble. It appears to be at a distacne of 0.1 m when observed from the opposite face. Find the actual distance of the bubble from the first face and also the refractive index of glass.

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6. A prism of angle 59° produces a minimum deviation of 42°. Calculate the refractive index of the prism.

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7. What distance should an object be placed in front of a convex lens of focal length 0.4 m so that the image is thrice the size of the object ?

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8. A converging lens has a focal length of 40 cm . Calculate the size of the real image of an object, 4.0 cm in height, for the object

distance:

50 cm

Given $f = 40cm, h_0 = 4cm,$ and u in different cases. Find: h_1 in each case corresponding to the given value of u.

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9. A converging lens has a focal length of 40 cm . Calculate the size of the real image of an object, 4.0 cm in height, for the object distance:

50 cm

Given $f = 40cm, h_0 = 4cm,$ and u in different cases. Find: h_1 in each case corresponding to the given value of u.

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10. A convering lens has a focal length of 40 cm . Calculate the size of the real image of an object, 4.0 cm in height, for the object distahce:

80 cm

Given $f = 40cm, h_0 = 4cm,$ and u in different cases. Find: h_1 in each case correspoinding to the given value of u.

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11. A convering lens has a focal length of 40 cm . Calculate the size of the real image of an object, 4.0 cm in height, for the object distance:

100 cm

Given $f = 40cm, h_0 = 4cm,$ and u in

different cases. Find: h_1 in each case correspoinding to the given value of u.

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12. A convering lens has a focal length of 40 cm . Calculate the size of the real image of an object, 4.0 cm in height, for the object distance:

200 cm

Given $f = 40cm, h_0 = 4cm,$ and u in

different cases. Find: h_1 in each case correspoinding to the given value of u.

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13. A convering lens has a focal length of 40 cm . Calculate the size of the real image of an object, 4.0 cm in height, for the object distance:

Given $f = 40cm, h_0 = 4cm,$ and u in different cases. Find: h_1 in each case correspoinding to the given value of u.

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14. An object is located 20 cm to the left of a diverging lens, having a focal length $f = -32cm$. Determine the position of the image.

Given: $u = 20cm$ and $f = -32cm$

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15. An object is located 20 cm to the left of a diverging lens, having a focal length

$f = -32cm$. Determine

the magnification of the image.

Given: $u = 20cm$ and $f = -32cm$

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16. An object is located 20 cm to the left of a diverging lens, having a focal length $f = -32cm$. Determine

theconstruct a ray diagram for this arrangment.

Given: $u = 20cm$ and $f = -32cm$

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Mandatory Exercise Exercise Set I

1. A fish under water sees obliquely a fisherman standing on the bank of a lake. How does he appear?

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2. A parallel-sided glass plate is introduced in the path of a converging beam. What happens

to the point of convergence of the beam?

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3. In which case will the angle of incidence be equal to the angle of refraction?

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4. The moon and the planets do not twinkle. Why? Can you see the stars twinkling when observed from the moon? Why?

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5. Why does a convex lens converge the light rays?

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6. During hot days, at noon, trees and houses across open ground appear to be quivering. Why?

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7. Why does an air bubble in a jar of water shine brightly?

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8. A virtual image, we always say, cannot be caught on a screen. Yet, when we see a virtual image, we are obviously bringing it on to the screen (i.e., the retina) of our eye. Is there a contradiction?

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9. Why does the sun or the moon appear elliptical near the horizon?

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10. H.G. Wells created the invisible man in his widely known story by the following trick: he made the refractive index of the invisible man exactly the same as that of air. So, light rays

simply passed through him without reflection or refraction. Is the invisible man blind?

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11. If you are in a boat and aiming a spear at a fish you see in the water, is the spear pointed above, below, or directly at the fish to make a direct hit? (Assume the fish is stationary in the water). If you instead used light from a laser as your spear, would you aim above, below, or directly at the observed fish?

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12. How can we determine of a lens which can be called 'thin lens?

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13. Will a ray go undeviating if the medium on both sides of a slab are different?

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14. If two materials have different critical angles with air, which material will have higher chances of total internal reflection?

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15. A stick appears bend when placed in water. Can the bend be 90° ?

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16. How will you define principal axis of plane convex lens?

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17. What is the difference between a slab and a prism?

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18. How can we determine refractive index of unknown materials?

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19. What can we say about the water of image if object and image are on opposite sides of lens.

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20. What can we say about the nature of image if object and image are on same side of lens.

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21. What can we say about the nature of image if image distance is more than object distance?

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Mandatory Exercise Exercise Set Ii

1. What can we say about the nature of image if image distance is less than object distance.

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2. In vacuum the speed of light depends upon

A. wavelength

B. frequency

C. speed of the source

D. it is independent of everything stated above.

Answer: D

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3. If the refractive index of glycerine = 1.48, water = 1.33, flint glass = 1.6, and diamond = 2.1, then, the speed of light is maximum in

A. glycerine

B. water

C. flint glass

D. diamond

Answer: B

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4. The velocity of light in a glass of refractive index 1.5 is $2x \times 10^8 ms^{-1}$. Its velocity in a certain liquid is found to be $2.5x \times 10^8 ms^{-1}$.

The refractive index of the liquid with respect to air is

A. 1.44

B. 1.64

C. 1.2

D. 0.8

Answer: C

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5. A glass slab is placed in the path of convergent light. The point of convergence

A. shifts towards the slab

B. shifts away from the slab

C. does not shift

D. shifts laterally

Answer: A

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6. The critical angle for total internal reflection is_____ when a ray of light travels from glass to water than when it travels from glass to air.

A. equal

B. lesser

C. greater

D. none of these

Answer: C

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7. For a ray of light to pass symmetrically through a prism of refracting angle 60° and $n = 1.6,$ the angle of incidence is

A. 36°

B. 38°

C. 35.5°

D. 54°

Answer: D

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8. A ray of light is incident normally on one of the equal faces of a right isosceles prism of refractive index 1.5. The angle between incident and emergent rays is

A. 45°

B. 90°

C. 180°

D. 0°

Answer: B

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9. Rays of light pass through an equilateral prism such that the angle of incidence is equal to the angle of emergence and the latter is equal three-fourths the angle of the prism. The angle of deviation is

A. 45°

B. 39°

C. 20°

D. 30°

Answer: D

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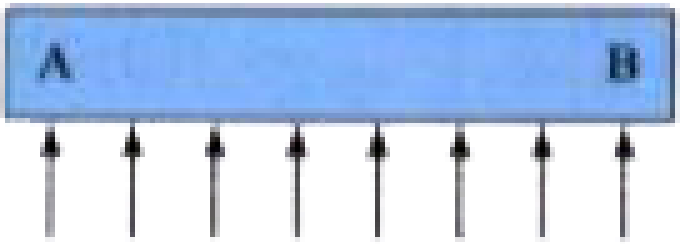
10. Rays of light fall perpendicularly on a glass slab $(n > 1)$ as shown in figure. If n at A is maximum and n at B is minimum, then the rays will



A. tilt towards A

B. tilt towards B

C. not deviate

D. undergo total internal reflection

Answer: C

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11. Light enters a medium (refractive index $>$ 1) from vacuum. Which property will remain unchanged?

A. Wavelength

B. Frequency

C. Speed

D. All of them

Answer: B

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12. Which is true for total internal reflection?

A. Light travels from rarer to denser medium

B. Light travels from denser to rarer medium

C. Independent of the optical densities of two medium

D. Takes place in the same medium

Answer: B

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13. Light travels from medium 1 (refractive index = n_1) to medium 2 (refractive index = n_2). If it is found that deviation d=r-i. We can say that

A. $n_1 = n_2$

B. $n_1 < n_2$

C. $n_1 > n_2$

D. none of these

Answer: C

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14. In which process, reflection is not accompanied by refraction.

A. Refraction from a plane mirror

B. Reflection from sphere

C. Reflection on surface of water

D. Total internal reflection

Answer: D

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15. For a material with lower critical angle, the chances of total internal reflection will be

A. higher

B. lower

C. cannot be determined

D. independent of critical angle

Answer: A

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16. A bird flying in sky and a fish in water look at each other. For which of them, the distance between them seem to be less?

A. Bird

B. Fish

C. Same for both

D. Cannot be determined

Answer: A

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17. Which of the following heavenly bodies appear to twinkle when seen from earth?

A. Sirius

B. Polaris

C. Venus

D. All of them

Answer: C

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18. Which is true for optical fibers?

A. Core has higher refractive index than cladding

B. Core has less refractive index than cladding

C. Both have same refractive index

D. None of these

Answer: A

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19. The splitting of light into different components while passing through a prism is called

A. total refraction

B. scattering

C. deviation

D. dispersion

Answer: D

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20. For a ray to go undeviating where should it pass through?

A. Principal focus

B. Optical centre

C. Not possible

D. Both (A) and (B)

Answer: B

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21. Where should the object be kept in front of a concave lens to obtain enlarged image?

A. Between infinity and 2F

B. Between 2F and F

C. Between Fand optical centre

D. None of the these

Answer: D

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22. A stick partially submerged in water appears bend due to

A. reflection

B. refraction

C. total internal reflection

D. dispersion

Answer: B

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23. The ray passing through optical centre behave like a ray through

A. mirror

B. slab

C. prism

D. none of these

Answer: B

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24. Erect image by convex lens is always

A. same size

B. magnified

C. diminished

D. none of these

Answer: B

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25. For a real object, concave lens can never form a

A. real image

B. virtual image

C. erect image

D. diminished image

Answer: A

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26. A convex lens can be considered as a group of two _____

A. mirrors

B. slabs

C. prisms

D. none of these

Answer: C

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27. On increasing angle of incidence for a prism the angle of deviation

A. first increases then decreases

B. first decreases then increases

C. remains constant

D. none of these

Answer: B

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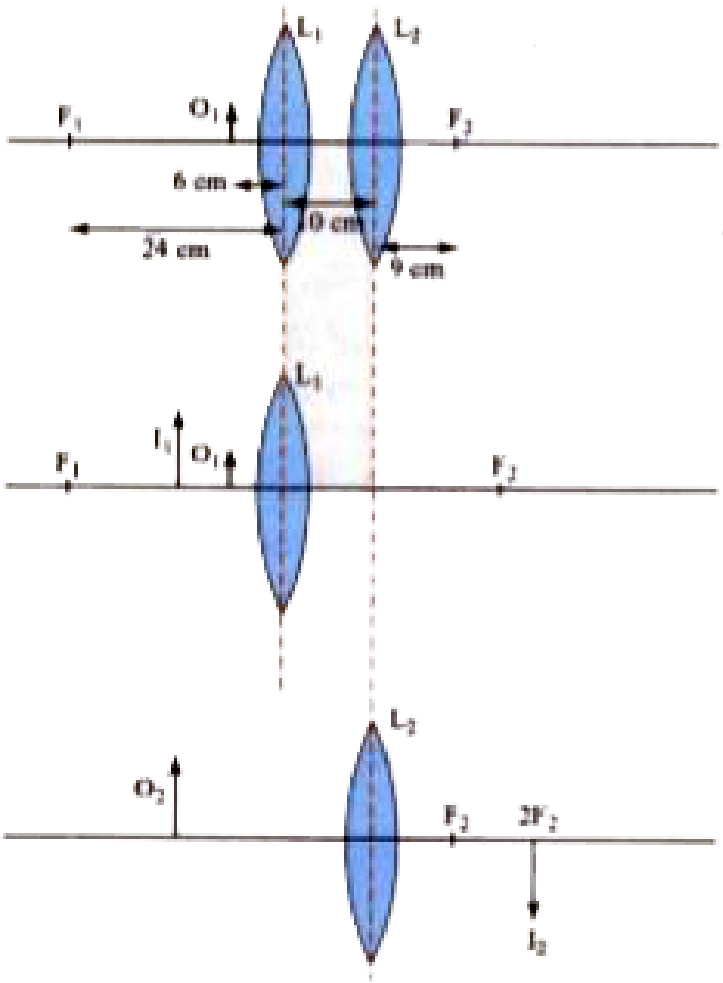
Mandatory Exercise Exercise Set Iii

1. The given figure shows the object O_1 that is placed in front of two thin symmetrical coaxial lenses 1 and2, with focal lengths $f_1 = +24cm$ and $f_2 = +9c$, respectively and with lens separation L = 10 cm. The seed is 6 cm from lens 1. Where does the system of

two lenses produce an image of the speed ?



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Mandatory Exercise Exercise Set Iv

1. Important expressions

A	B
(1) Critical angle	(a) $\mu = \frac{\sin i}{\sin r}$
(2) Lens formula	(b) ${}_1n_2 = \frac{v_1}{v_2} = \frac{n_2}{n_1}$
(3) Snell's law	(c) $S_1 = \frac{t}{\cos r}\sin(i-r)$
(4) Lateral shift	(d) $S_n = t\left(1 - \frac{1}{{}_1n_2}\right)$
(5) Refractive index of material of prism	(e) $C = \sin^{-1}\left(\frac{1}{n}\right)$
(6) Relative refractive index	(f) $n = \frac{\sin\left(\frac{A+D}{2}\right)}{\sin\left(\frac{A}{2}\right)}$
(7) Magnification of a lens	(g) $f = \frac{1}{u} + \frac{1}{v}$
(8) Normal shift	(h) $m = \frac{h_1}{h_2} = \frac{-v}{u}$

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2. Image formation by a convex lens

A (Position of object)	B (Position, size, and nature of image)
(1) Infinity	(a) At 2F, same, real
(2) Beyond 2F	(b) At infinity, highly magnified
(3) At 2F	(c) Beyond 2F, magnified, real
(4) Between 2F and F	(d) Between 2F and F, diminished, real
(5) At F	(e) At F, highly diminished, real
(6) Between F and P	(f) On the same side of the object, magnified, virtual

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Mandatory Exercise Exercise Set V

1. Find the velocity of light in water, if its velocity in glass of refractive index 1.5 is $2 \times 10^8 m/s$. The refractive index of water is 1.33.

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2. The refractive index of water and diamond are 1.33 and 2.42, respectively. Calculate the refractive index of diamond with respect to water.

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3. What is the real depth of a swimming pool that appears to be 10 m for a swimmer? The refractive index of water is 1.33.

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4. The refractive index of a glass prism is 1.65. If the angle of the prism is 60°, find the angle of minimum deviation.

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5. A small object is placed on the axis of a convex lens of focal length 0.2 m at a distance of 0.5 m from it. Find the position and linear magnification of the image.

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6. A vessel is filled with two different liquids which do not mix. One liquid is 40 cm deep and has $n_1 = 1.6$ and the other is 30 cm deep

and has $n_2 = 1.5$. What is the apparent depth of the vessel when viewed along the normal?

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7. Light travelling in air falls at a boundary between air and water at an angle 30 degrees with the normal. Find the deviation (R.I. of water is = 4/3)

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8. Refractive index of glass with respect to water is 1.125. What is the refractive index of water of refractive index of glass is 1.5.

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9. For a fish under water, what will be the height of a person whose actual height is 6 feet? Refractive index of water is 1.33?

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10. Speed of light in a liquid is 1.8×10^8 m/s. What is the critical angle for the liquid air pair?

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11. Which pair of medium has higher critical angle. Air-water or air-glass? Refractive indexes for water and glass are 1.33 and 1.5 respectively?

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12. In an experiment to find refractive index of a prism it was found that the minimum deviation was 30°. What is the refractive index if angle of prism is also 30°.

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13. A convex lens has focal length 20 cm. What is the power of the lens?

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14. Power of a lens is -2.5 D. What is the focal length and nature of the lens.

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15. The lateral shift for a ray of light incident at 60° on one face of a rectangular slab of thickness 1 m is 0.577 m. What is the refractive index of the slab.

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16. Where should an object be kept if a real image is obtained at a distance 60 cm from a concave lens of focal length 20 cm. Is the object real or virtual?

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17. Where should an object be kept before a convex lens such that the image is real and twice the size. Given focal length of lens is 10 cm.

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General Exercise

1. What is refraction ?

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2. Define relative refractive index in terms of velocity of light.

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3. Define critical angle.

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4. What is a prism ?

Watch Video Solution

5. What is a lens ?

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6. Obtain the relation between critical angle and refractive index for a pair of media.

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7. Write the lens formula. Explain the terms.

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8. Why does light bond on changing medium?

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9. Can the value of refractive index of a material be less than 1?

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10. What are the factors that the angle of refraction depends on?

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11. Explain how Snell's law fails to give the value of refractive index for normal incidence.

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12. What is lateral shift?

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13. Why do stars twinkle?

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14. Draw ray diagrams for incident rays at angle of incidence less than critical angle and more than critical angle?

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15. Explain the process of looming.

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16. Explain different parts of optical fibers with a neat labeled diagram.

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17. Explain the working of optical fibers.

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18. Mention three advantages of optical fibers over metal fibers.

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19. Explain the relation between angle of incidence and deviation for a prism

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20. Mention three ways in which total reflecting prisms are better than mirrors.

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21. What are the different types of lenses based on the nature of their surfaces?

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22. Why are convex and concave lens known as converging and diverging lens respectively?

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23. Why does a lens have two principal focus?

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24. A convex lens has a real focus and a concave lens has a virtual focus. Explain.

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25. Draw the ray diagram for an object located at 2F for a convex lens and write the nature of image.

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26. Draw ray diagram for object located at infinity for a concave lens and write the nature of image.

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27. Define centre of curvature of a lens.

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28. Define radius of curvature of a lens.

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29. Define principal axis of a lens.

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30. Define principal focus of a lens.

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31. Define focal length of a lens.

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32. Write down the sign convention used for their lenses.

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Challenging Exercise

1. A ray of light is incident at an angle of 60° on a parallel side of a glass slab of thickness

0.1 m and refractive index 1.5. Calculate the lateral shift produced.

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2. A small air bubble is situated in a glass cube of edge 0.24 m. When viewed from one face it appears to be 0.1 m from the face and when viewed from the opposite face it appears to be 0.06 m from the face. Calculate the refractive index of glass.

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3. A ray of light is incident on a 60° glass prism at an angle of 60°. Find the

the angle of emergence

the angle of deviation, given the refractive index of glass = 1.5.

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4. A ray of light incident normally on the first face of a glass prism of refractive index 1.6 just

emerges from the other face. Find the angle of the prism.

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5. The real image formed by a convex lens is three times the object in size, when the object is 0.12 m from the lens. What is the focal length of the lens? Where must the object be placed to obtain a real image magnified four times?

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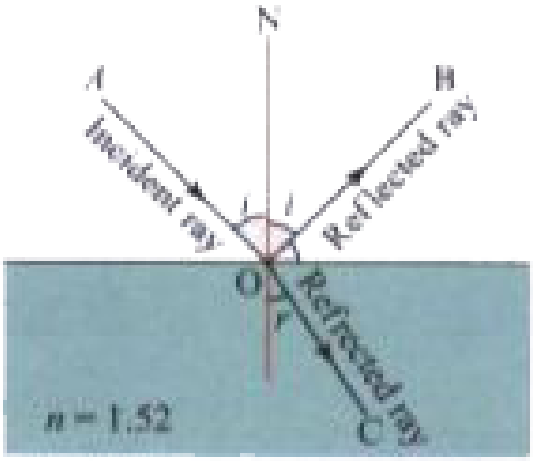
6. A ray of light falls on a transparent glass slab of refractive index 1.52. If the reflected ray and refracted ray are mutually perpendicular, what is the angle of incidence?



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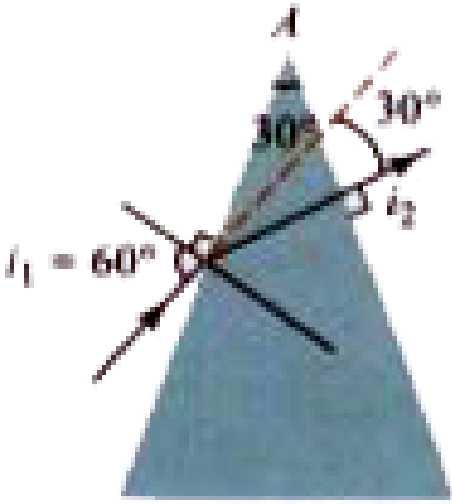
7. A ray of light is incident at an angle of 60° on one face of a 30°) prism. The emergent ray from the prism makes an angle of 30° with the incident ray. Show that the emergent ray is normal to the surface from which it emerges. Calculate the refractive index of the material of the prism.



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8. A bird is at a height 60m from the surface of water and a fish is at a depth 40 m from surface. Both are at the same vertical line. What is the distance between them as seen by Bird

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9. A bird is at a height 60m from the surface of water and a fish is at a depth 40 m from

surface. Both are at the same vertical line. What is the distance between them as seen by Fish

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10. The minimum deviation on a prism of refractive index $\sqrt{3}$ is equal to the angle of prism. Find the angle of the prism.

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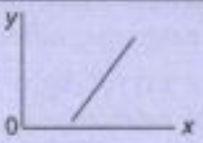
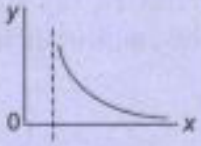
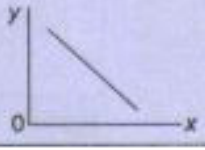
Olympiad And Nse Level Excercises

1. The graphs given apply to a convex lens of focal length f, producing a real image at a distance V from the optical center when self-luminous object is at distance u from the optical center. The magnitude of magnification is m. Match the graphs in Column II with the quantity names in Column I being plotted. Assume object distance greater than focal

length.

Column I		Column II	
(p)	v against u	(a)	
(q)	m against v	(b)	
(r)	$\frac{1}{v}$ against $\frac{1}{u}$	(c)	

A. $\begin{matrix} p & q & r \\ a & b & c \end{matrix}$

B. $\begin{matrix} p & q & r \\ c & a & b \end{matrix}$

C. $\begin{matrix} p & q & r \\ b & a & c \end{matrix}$

D. $\begin{matrix} p & q & r \\ a & c & b \end{matrix}$

Answer: C

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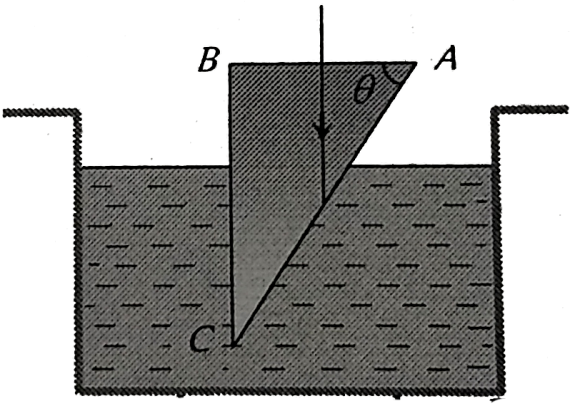
2. A glass prism $(\mu = 1.5)$ is dipped in water $(\mu = 4/3)$ as shown in figure. A light ray is incident normally on the surface AB . It reaches the surface BC after totally reflected, if



A. $\sin\theta \geq 8/9$

B. $2/3 < \sin\theta < 8/9$

C. $\sin\theta \leq 2/3$

D. It is not possible

Answer: A

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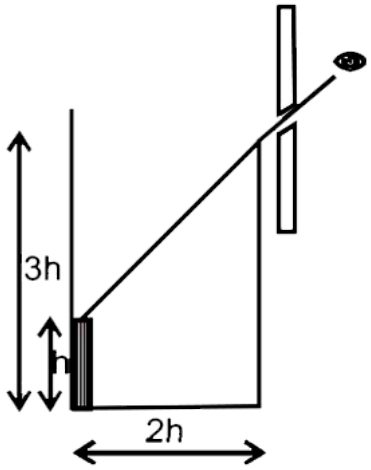
3. An observer can see through a pin-hole the top end of a thin rod of height h, placed as shown in the figure. The beaker height is 3h and its radius h. When the beaker is filled with

a liquid up to a height 2h, he can see the lower end of the rod. Then the refractive index of the liquid is



A. $5/2$

B. $\sqrt{(5/2)}$

C. $\sqrt{(3/2)}$

D. $3/2$

Answer: B

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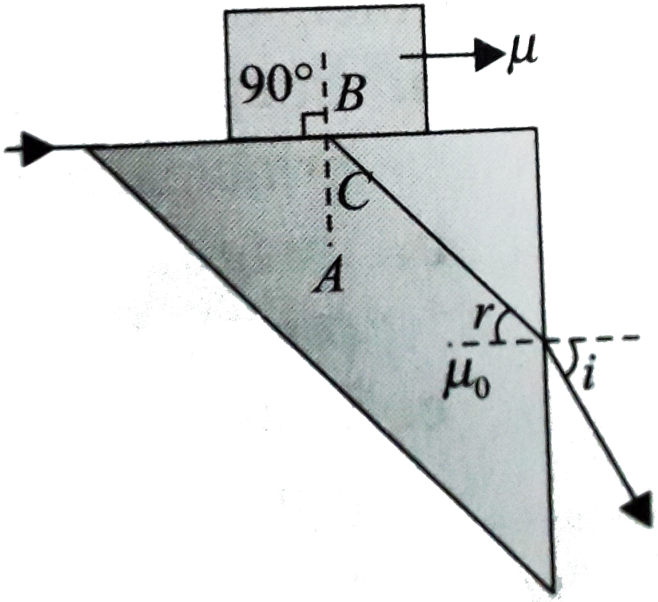
4. Pulfrich refractometer is used to measure the refractive index of solids and liquid. It consist of right angled prism. A having its two faces perfectly plane. One of the face is horizontal and the other is vertical as shown is figure. The solid B whose refractive index is to be determined is taken having two faces cut perpendicular to one another. Light is incident

in a direction parallel to the horizontal surface so that the light entering the prism A is at critical angle C. Finally, it emerges from the prism at an angle i. Let the refractive index of the solid be μ and that of the prism A be μ_0 (which is known). Here $\mu_0 > \mu$ and by measuring i, μ can be determinged.



Q. Refractive index of the solid (μ) in terms of μ_0 and i is

A. $\sqrt{\mu_0^2 + \sin^2 i}$

B. $\mu_0 + \sin^2 i$

C. $\sqrt{\mu_0^2 - 2\sin^2 i}$

D. $\sqrt{\mu_0^2 - \sin^2 i}$

Answer: D

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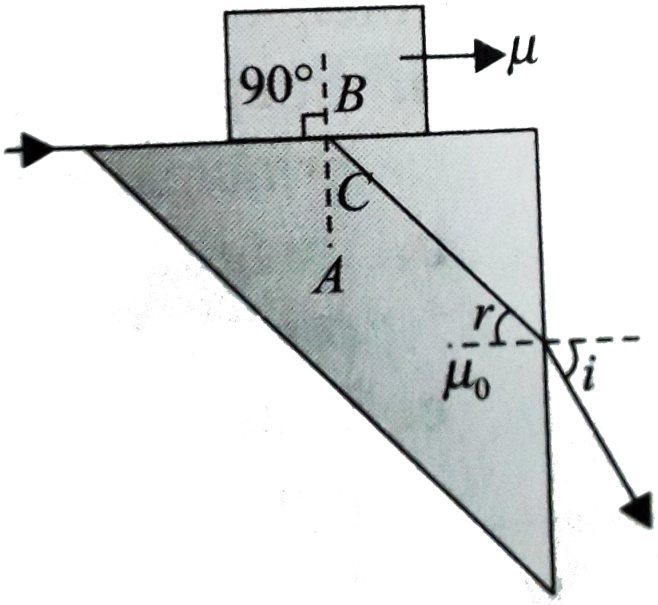
5. Pulfrich refractometer is used to measure the refractive index of solids and liquid. It consist of right angled prism. A having its two faces perfectly plane. One of the face is horizontal and the other is vertical as shown is figure. The solid B whose refractive index is to be determined is taken having two faces cut perpendicular to one another. Light is incident in a direction parallel to the horizontal surface so that the light entering the prism A is at critical angle C. Finally, it emerges from the prism at an angle i. Let the refractive index of

the solid be μ and that of the prism A be μ_0 (which is known). Here $\mu_0 > \mu$ and by measuring i, μ can be determinged.



Q. Refractive index of the solid (μ) in terms of μ_0 and i is

A. 1.21

B. $\sqrt{2}$

C. 1

D. $\sqrt{3}/2$

Answer: C

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6. Assertion : If the angles of the base of the prism are equal, then in the position of minimum deviation, the refracted ray will pass parallel to the base of prism.

Reason : In the case of minimum deviation, the angle of incidence is equal to the angle of emergence.

A. If both assertion and reason are true and reason is the correct explanation of assertion.

B. If both assertion and reason are true but reason is not the correct explanation of assertion.

C. If assertion is true but reason is false.

D. If assertion and reason both are false.

Answer: A

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7. A rectangular glass slab ABCD, of refractive index n_1, is immersed in water of refractive index $n_2(n_1 > n_2)$. A ray of light in incident at the surface AB of the slab as shown. The maximum value of the angle of incidence

$\alpha_{\max}$, such that the ray comes out only from the other surface CD is given by

A. $\sin^{-1}\left[\frac{n_1}{n_2}\cos\left(\sin^{-(1)}\frac{n_2}{n_1}\right)\right]$

B. $\sin^{-1}\left[n_1\cos\left(\sin^{-1}\frac{1}{n_2}\right)\right]$

C. $\sin^{-1}\left(\frac{n_1}{n_2}\right)$

D. $\sin^{-1}\left(\frac{n_2}{n_1}\right)$

Answer: A

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8. A convex lens of focal length f is placed somewhere, in between an object and a screen. The distance between the object and the screen is x. If the numerical value of the magnification produced by the lens is m, then the focal length of the lens is

A. $\frac{mx}{(m+1)^2}$

B. $\frac{mx}{(m-1)^2}$

C. $\frac{(m+1)^2}{m}x$

D. $\frac{(m-1)^2}{m}x$

Answer: A

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9. A glass slab of thickness $3cm$ and refractive index $3/2$ is placed on ink mark on a piece of paper. For a person looking at the mark at a distance $5.0cm$ above it, the distance of the mark will appear to be

A. $3.0cm$

B. $4.0cm$

C. $4.5cm$

D. $5.0cm$

Answer: B

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10. A lens (focal length $50cm$) forms the image of a distant object which subtends an angle of 2 milliradian at the lens. What is the size of the image ?

A. 5 mm

B. 1 mm

C. $0.5mm$

D. $0.1mm$

Answer: C

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