PHYSICS

BOOKS - SELINA PHYSICS (ENGLISH)

REFRACTION OF LIGHT AT PLANE SURFACES

Examples

1. A ray of light bends while passing from one transparent medium to another medium

having a different refractive index.

(a) Name the phenomenon. Give reason for it.

(b) How do the following quantities change:

speed. Wavelength, frequency and amplitude

is second medium is denser than the first

medium.

(c) State whether the ray of light will bend or

not, if both media have the same refractive

index.

2. A ray of light falls normally on a glass slab. Draw a diagram showing the path of the ray till it emerges out of the slab. What is the angle of incidence and angle of refraction at each surface of slab ?

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3. The refractive index of water is 4/3'. Explain the meaning of this statement.

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4. Refractive index of water is 4/3. calculate the speed of light in water. Speed of light in vacuum is $3 \times 10^8 ms^{-1}$.

5. The refractive index of water is $\frac{4}{3}$ and glass is $\frac{3}{2}$. What is the refractive index of glass with respect to water ?

6. Orange light of wavelength 6600 Å travelling in air gets refracted in water. If the speed of light in air is $3 \times 10^8 ms^{-1}$ and refractive index of water is 4/3, find : (i) the frequency of light in air, (ii) the speed of light in water, and (iii) the wavelength of light in water.

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7. A ray of light strikes a glass slab 5 cm thick, making an angle of incidence equal to $30°$.
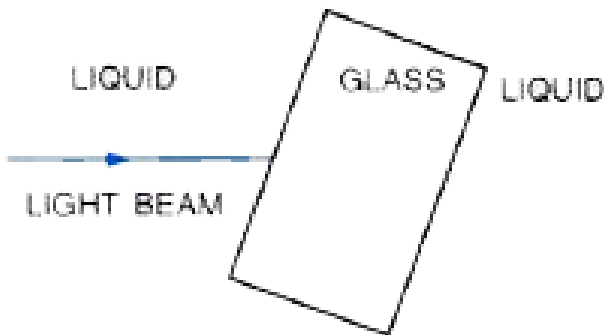
(a) Draw a ray diagram showing the emergent ray and the refracted ray through the glass block. The refractive index of glass is $1 \cdot 5$.

(b) Measure the lateral displacement of the ray. The $\sin 19 \cdot 5° = 1/3$.

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8. The diagram below shows a glass block suspended in a liquid. A beam of light of single colour is incident from liquid on one side of the block.


LIQUID   GLASS   LIQUID

LIGHT BEAM

(a) Draw diagrams to show how does the light bend when it travels from liquid to glass and then to liquid if (i) the light slows down in glass, and (ii) the light speeds up in glass.

(b) State two conditions under which the light ray passing from liquid to glass travels straight without bending. will the glass be visible then ?

9. The diagram below shows two parallel rays A and B of red and violet light respectively incident from air on air-glass boundary. Complete the diagram showing the refracted rays for them in the glass.
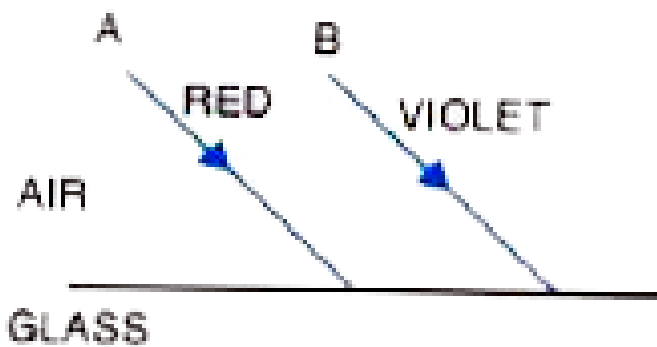
(i) How do the speeds of the rays differ in glass ?

(ii) are the two refracted rays in glass parallel ? Give a reason for your answer.

(iii) How does the refractive index of glass differ for the two rays ?
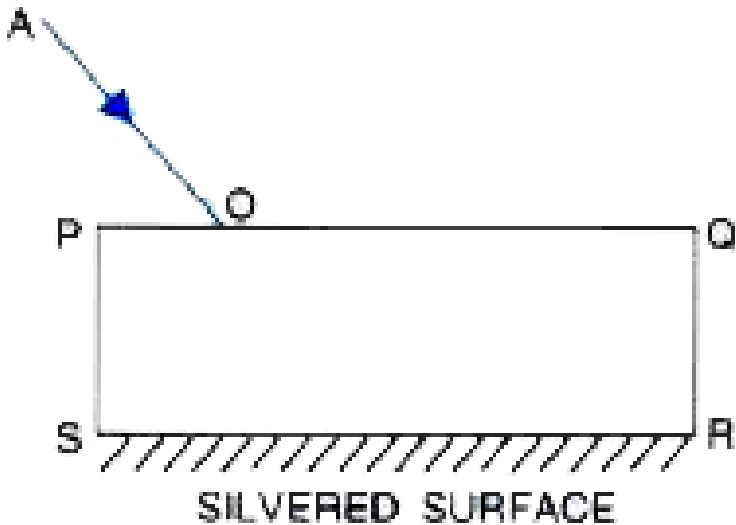
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10. Figure shows a ray of light AO incident on a rectangular glass block PQRS, which is silvered at the surface RS. The ray is partily reflected and partly refracted.

(a) Draw the path of the reflected and refracted rays.

(b) Show at least two rays emerging from the surface PQ after reflection from the surface RS.

(c) How many images are formed in the above

case ? Which image is the brightest ?

SILVERED SURFACE

11. Figure alongside shows an equilateral prism ABC and the ray QR emerging out from the prism after suffering minimum deviation.

Complete the diagram to show the refracted ray PQ inside the prism and the incident ray OP on the prism. State in words how have you completed the diagram to show the refracted ray PQ inside the prism and the incident ray OP on the prism. state in words how have you completed the diagram.
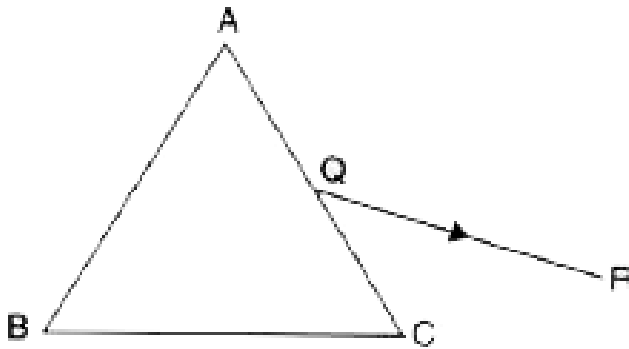
12. In Figure, a monochromatic point source of light S is viewed by an observer O through a prism P. complete the diagram to show the image formed by the prism and as seen by the observer O. label the image by the letter I.


S.

P

OBSERVER
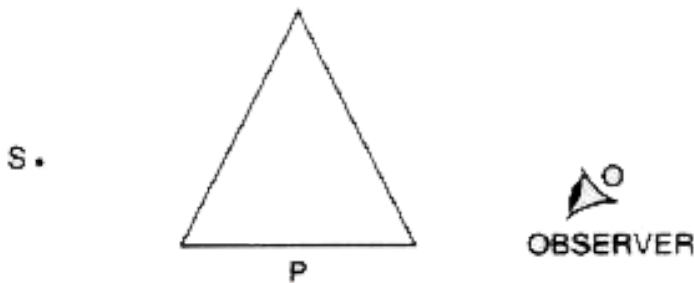
13. Figure shows two identical prisms P and Q placed with their faces parallel to each other. A light ray AB of yellow colour is incident at the face of the prism P. Complete the diagram to show the path of the ray till it emerges out of the prism Q.
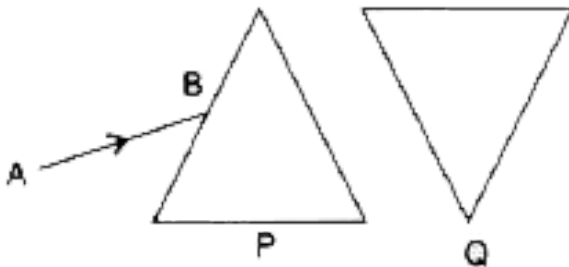
14. Figure below shows a light ray of green colour incident on the prisms A,B and C. in each case, draw the path of the ray of light as it enters and emergest out of the prism. Mark the angle wherever necessary.
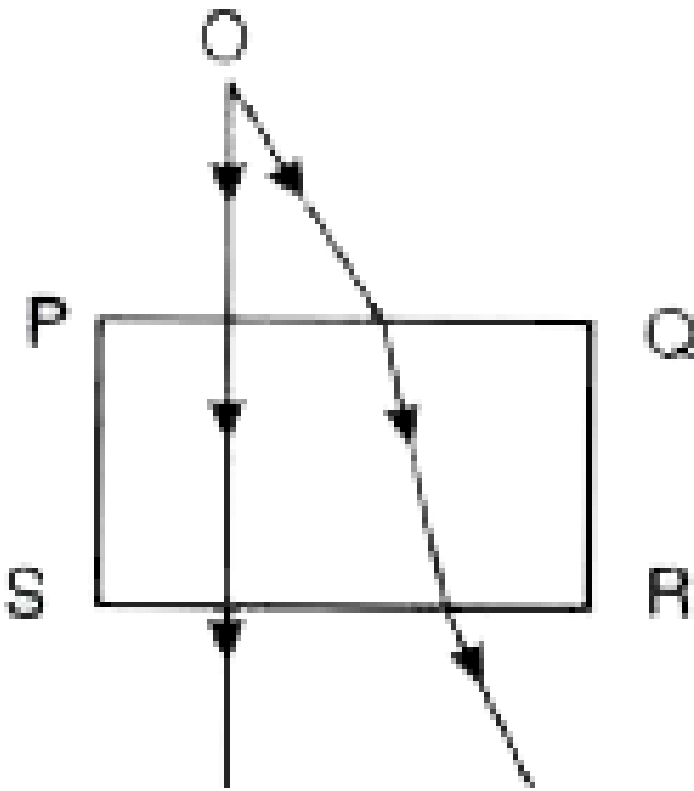

(a)   (b)   (c)
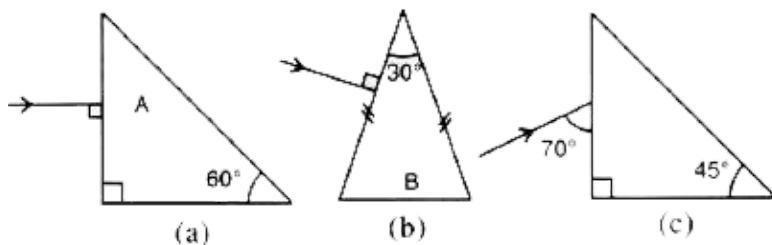
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15. The apparent depth of a liquid in a vessel is 15 cm, when its real depth is 20 cm. find the

refractive index of the liquid.

16. A point source of light O of single colour is seen through a rectangular glass slab PQRS. The paths of two rays, in and outside the slab, are shown in figure.

In the diagram, label the position I of the source O where it will appear when seen through the surface RS.

(ii) Does the source O appear to be nearer or farther with respect to the surface PQ ?

(iii) How does the shift depend on the thickness PS or QR of the slab?

(iv) Justify your answer in (iii) with the help of an appropriate ray diagram.

(v) For the same rectangular glass slab, which colour from the visible spectra (violet to red) will produce the maximum shift ?

17. A glass slab is placed over a piece of paper on which VIBGYOR is printed with each letter

into its corresponding colour.

(i) Will the image of all the letters be in the same place?

(ii) The letter of which colour will appear to be raised (a) maximum, and (b) minimum ? Explain your answer.
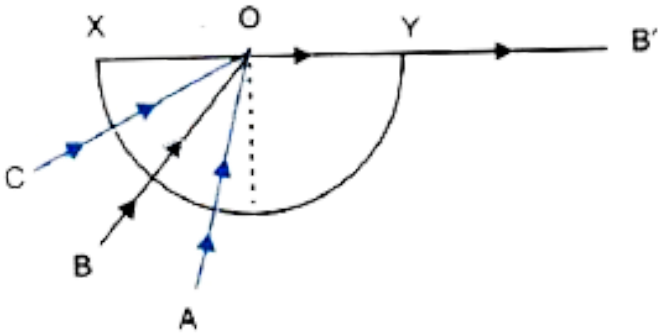
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18. A coin kept inside water $(\mu = 4/3)$ when viewed from air in a vertical direction, appears

to be raised by $2 \cdot 0 mm$. Find the depth of the coin in water.

19. Figure shows the section of a semi-circular glass slab having its centre at O. three rays of light A,B and C of the same colour are incident on the slab and strike on the edge XY at the point O. the light ray B suffers refraction along OB'.

(a) On the diagram, mark the critical angle by C.

(b) The rays enter the slab undeviated. give reason.

(c) Draw the path of rays A and C after they strike the edge XY.

(d) Name the phenomenon which the rays A and C exhibit.

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20. Show with the aid of a ray diagram, how a right angled isosceles prism can be used to invert the rays. (a) How sould the rays fall on the prism ?
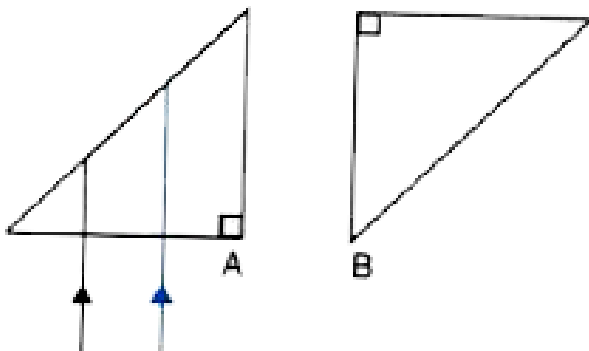
(b) Which phenomenon is responsible for this action of prism? (c) What is the nature of the image in relation to the object ?

21. (a) Figure shows two isosceles right angled prisms A and B and the light rays incident on the prism A. complete the diagram to show the rays emerging out of the prism B.

(b) State the principle used for completing the ray diagram in part (a) above.

22. The critical angle for material of which the equiangular prism ABC shown in figure is made, is $60°$. A ray of light incident on the side AB of the prism is refracted along DE such that the angle it makes with the side AC is $150°$ and $\angle EDB = 90°$. draw the path of the incident ray on the side AB (which travels along DE) and also the path along which the

ray DE travels from the point E onwards.

A
D
90°
150° E
B
C
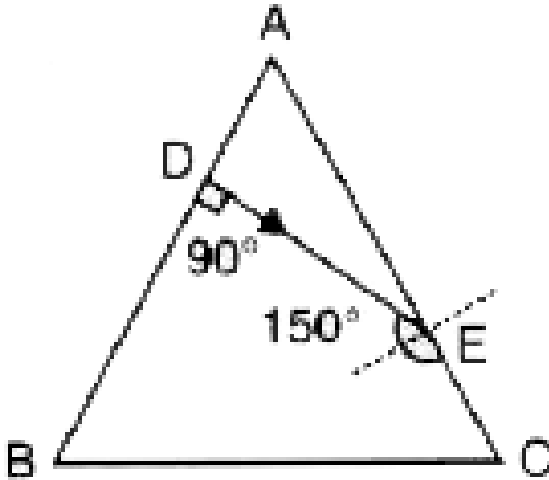
Exercise 4 A

1. What do you understand by the term 'refraction of light'?

2. Draw diagrams to show the refraction of light from (i) air to glass, and (ii) glass to air. In each diagram, label the incident ray, refracted ray, the angle of incidence (i) and the angle of refraction (r).

3. A ray of light is incident normally on a plane glass slab. What will be (i) the angle of refraction, and (ii) the angle of deviation for the ray ?

4. An obliquely incident light ray bends at the surface due to change in speed, when passing from one medium to another. The ray does not

bend when it is incident normally. Will the ray

have different speed in the other medium ?

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5. What is the cause of refraction of light when

it passes from one medium to another ?

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6. A light ray suffers reflection and refraction

at the boundary in passing from air to water.

Draw a neat labelled ray diagram to show it.

7. A ray of light passes from medium 1 to medium 2. which of the following quantities of the refracted ray will differ from that of the incident ray speed, intensity, frequency, and wavelength ?

8. State the Snell's laws of refraction of light.

9. Define the term refractive index of a medium. Can it be less than 1 ?

10. (a) Compare the speed of light of wavelength 4000 Å (i.e., violet light) and 8000

Å (i.e. red light) in vacuum.

(b) How is the refractive index of a medium related to the speed of light in it and in vacuum or air ?

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11. A light ray passes from water to (i) air, and (ii) glass. In each case, state how does the speed of light change.

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12. A light ray in passing from water to a medium (a) speeds up, (b) slows down. In each case, (i) give one example of the medium, (ii) state whether the refractive index of medium is equal to, less than or greater than the refractive index of water.

13. What do you understand by the statement the refractive index of glass is $1 \cdot 5$ for white light' ?

14. A monochromatic ray of light passes from air to glass. The wavelength of light in air is λ, the speed of light in air is c and in glass is V. if the refractive index of glass is $1 \cdot 5$, write down (a) the relationship between c and V, (b) the wavelength of light in glass.

15. A boy uses blue colour of light to find the refractive index of glass. He then repeats the experiment using red colour of light. Will the refractive index be the same or different in the two cases? Give a reason to support your answer.

16. (a) For which colour of white light, is the refractive index of a transparent medium (i)

the least, (ii) the most ?

(b) Which colour of light travels fastest in any medium except air ?

17. Name two factors on which the refractive index of a medium depends ? State how does it depend on the factors stated by you.

18. How does the refractive index of a medium depend on the wavelength of light used ?

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19. How does the refractive index of a medium depend on its temperature ?
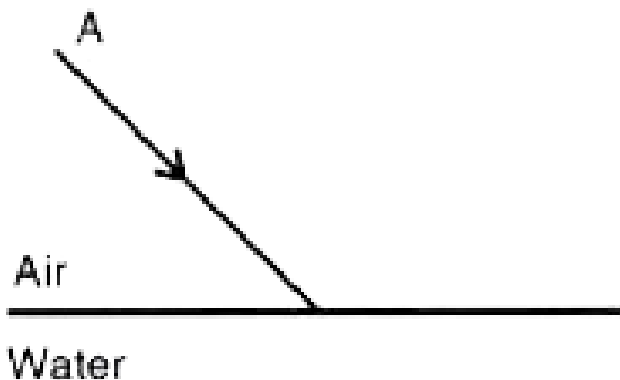
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20. Light of a single colour is passed through a liquid having a piece of glass suspended in it. On changing the temperature of liquid, at a particular temperature the glass piece is not seen.

(i) When is the glass piece not seen ?

(ii) why is the light of a single colour used ?

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21.

In Figure, a ray of light A incident from air

suffers partial reflection and refraction at the

boundary of water.

(a) Complete the diagram showing (i) the

reflected ray B and (ii) the refracted ray C.

(b) How are the angles of incidence i and
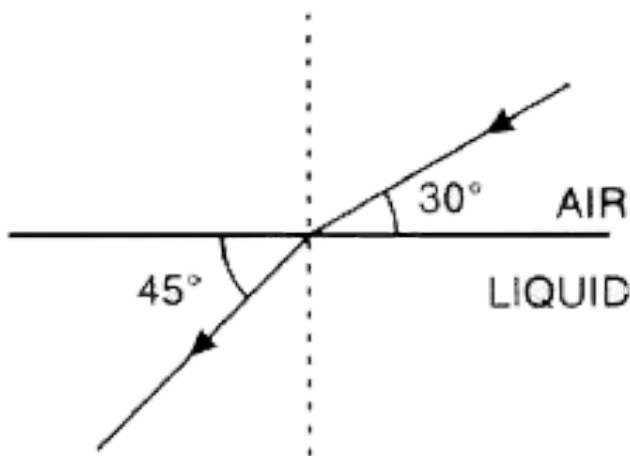
refraction r related ?

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22. The diagram alongside shows the refraction of a ray of light from air to a liquid.

(a) Write the values of (i) angle of incidence, and (ii) angle of refraction.

(b) Use snell's law to find the refractive index of liquid with respect to air.

23. The refractive index of water with respect to air is $_a\mu_w$ and of glass with respect to air is $_a\mu_g$. Express the refractive index of glass with respect to water.

24. What is lateral displacement ? Draw a ray diagram showing the lateral displacement of a

ray of light when it passes through a parallel sides glass slab.

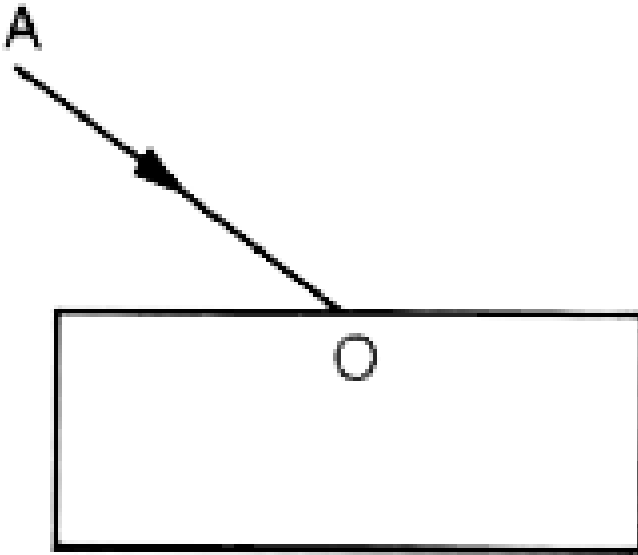**25.** A ray of light strikes the surface of a rectangular glass slab such that the angle of incidence in air is (i) $0°$, $(ii)45°$. In each case, draw a diagram to show the path taken by the ray as it passes through the glass slab and emerges from it.

A

O

26.

In the adjacent diagram, AO is a ray of light incident on a rectangular glass slab.

(a) Complete the path of the ray till it emerges out of the slab.

(b) In the diagram, mark the angle of incidence (i) and the angle of refraction (r) at the first

interface. how is the refractive index of glass related to the angles i and r ?

(c) Mark angle of emergence by the letter e. how are the angles i and e related ?
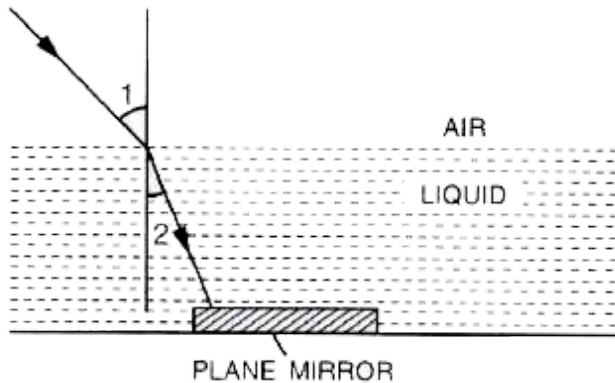
(d) Which two rays are parallel to each other ? Name them

(e) Indicate in the diagram the lateral displacement between the emergent ray and the incident ray. state one factor that affects the lateral displacement.

27. A ray of green light enters a liquid from air, as shown in figure. Angle 1 is $45°$ and angle 2 is $30°$.

(a) Find the refractive index of the liquid

(b) Show in the diagram the path of the ray after it strikes the mirror and re-enters in air. mark in the diagram the angles wherever necessary.

(c) Redraw the diagram if plane mirror

becomes normal to the refracted ray inside the liquid.

state the principle used.

28. When an illuminated object is held in front of a thick plane glass mirror, several images are seen, out of which the second image is brightest. Give reason.

29. Fill in the blanks to complete the following sentence:

Q: When light travels from a rarer to a denser medium, its speed _____

30. Fill the blanks to complete the following sentence:

Q: When light travels from a denser to a rarer medium, its speed _____

31. Fill in the blanks to complete the following sentence:

Q: The refractive index of glass with respect to air is 3/2. thee refractive index of air with respect to glass will be _____

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Exercise 4 A Multiple Choice Type

1. When a ray of light from air enters a denser medium, it :

    A. bends away from the normal

    B. bends towards the normal

    C. goes undeviated

    D. is reflected back

Answer: B

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2. A light ray does not bend at the boundary in passing from one medium to the other medium if the angle of incidence is :

A. $0°$

B. $45°$

C. $60°$

D. $90°$

Answer: A

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3. The highest refractive index is of :

A. glass

B. water

C. diamond

D. ruby

Answer: C

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Exercise 4 A Numericals

1. The speed of light in air is $3 \times 10^8 ms^{-1}$. Calculate the speed of light in glass. The refractive index of glass is $1 \cdot 5$.

2. The speed of light in diamond is $125,000$ km s^{-1} what is its refractive index ? (Speed of light in air $= 3 \times 10^8 ms^{-1}$).

3. The refractive index of water with respect to air is $4/3$. What is the refractive index of aiir with respect to water ?

4. A ray of light of wavelength 5400 Å suffers refractive from air to glass. Taking $_a\mu_g = 3/2$, find the wavelength of light in glass.
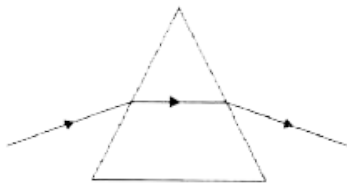
1. What is prism? With the help of a diagram of the principal section of a prism, indicate its refracting surface, refracting edge and base.
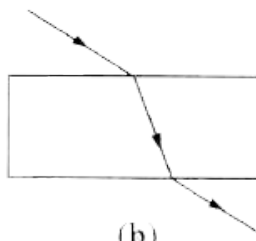
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2. Diagram (a) and (b) in figure below show the refraction of a ray of light of single colour through a prism and a parallel sided glass slab respectively.

(a)   (b)

(i) In each diagram, label the incident, refracted, emergent rays and the angle of deviation.

(ii) In what way the direction of the emergent ray in the two cases differ with respect to the incident ray ? explain your answer.

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3. Define the term angle of deviation.

4. Complete the following sentence :

Angle of deviation is the angle which the

____ray makes with the direction of ____ray.

5. What do you understand by the deviation

produced by a prism? Why is it caused ? State

three factors on which the angle of deviation depends.

6. (a) How does the angle of deviation produced by a prism change with increase in the angle of incidence. Draw a curve showing the variation in the angle of deviation with the angle of incidence at a prism surface.

(b) Using the curve in part (a) above, how do you infer that for a given prism, the angle of

minimum deviation δ_{min} is unique for a given light.

7. State whether the following statement is 'true' or 'false'.

The deviation produced by a prism is independent of the angle of incidence and is same for all colours of light.

8. How does the deviation produced by a prism depend on (i) the refractive index of its material, and (ii) the wavelength of incident light.

9. How does the angle of minimum deviation produced by a prism change with increase in (i) the wavelength of incident light, and (ii) the refracting angle of prism ?

10. Write a relation for the angle of deviation (δ) for a ray of light passing through an equilateral prism in terms of the angle of incidence (i_1), angle of emergence (i_2) ang angle of prism (A).

11. A ray of light incident at an angle of incidence i_1 passes through an equilateral

glass prism such that the refracted ray inside the prism is parallel to its base and emerges at an angle of emergence i_2.

(i) How is the angle of emergence $'i_1'$ related to the angle of incidence $'i_1'$?

(Ii) What can you say about the angle of deviation in such a situation ?

12. Draw a ray diagram to show the refraction of a monochromatic ray through a prism when

it suffers minimum deviation. How is the angle of emergence related to the angle of incidence in the position.

13. A light ray of yellow colour is incident on an equilateral glass prism at an angle of incidence equal to $48°$ and suffers minimum deviation by an angle of $36°$. (i) What will be the angle of emergence ?

(ii) If the angle of incidence is changed to (a)

$30°$

(b) $60°$, state in each case whether the angle of deviatioin will be equal to, less than or more than $36°$. ?

14. Name the colour of white light which is deviated (i) the most, and (ii) the least, on passing through a prism.

15. Which of the two prisms, A made of crown glass and B made of flint glass, deviates a ray of light more ?

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16. How does the angle of deviation depend on the refracting angle of the prism?

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17. An object is viewed through a glass prism with its vertex pointing upwards. Draw a ray diagram to show the formation of its image as seen by the observer.

18. A ray of light is normally incident on one face of an equilateral glass prism. Answer the following :

(a) What is the angle of incidence on the first

face of the prism?

(b) What is the angle of refraction from the first face of the prism ?

(c) What will be the angle of incidence at the second face of the prism ?

(d) Will the light ray suffer minimum deviation by the prism ?

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19. Figure below shows two identical prisms A and B placed with their faces parallel to each

other. A ray of light of single colour PQ is incident at the face of the prism A. complete the diagram to show the path of the ray till it emerges out of the prism B.
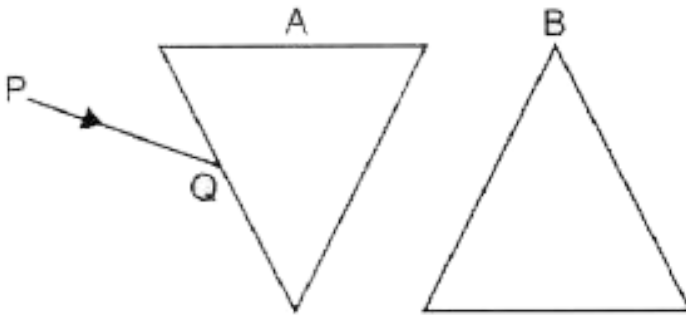
Exercise 4 B Multiple Choice Type

1. In refraction of light through a prism the light ray:

    A. suffers refraction only at one face of the prism

    B. emergest out from the prism in a direction parallel to the incident ray

    C. bends at both the surface of the prism towards its base

D. bends at both the surfaces of the prism

opposite to its base.

Answer: C

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2. A ray of light suffers refraction through an equilateral prism. The deviation produced by the prism does not depend on the:

A. angle of incidence

B. colour of light

C. material of prism

D. size of prism

Answer: D

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Exercise 4 B Numericals

1. A ray of light incident at an angle of incidence $48°$ on a prism of refracting angle

$60°$ suffers minimum deviation. Calculate the angle of minimum deviation.

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2. What should be the angle of incidence for a ray of light which suffers minimum deviation of $36°$ through an equilateral prism ?

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Exercise 4 C

1. How is the refractive index of a medium related to the real and apparent depths of an object in that medium ?

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2. Prove that

Refractive index=$\dfrac{\text{real depth}}{\text{apparent depth}}$

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3. A tank of water is viewed normally from above.

(a) State how does the depth of the tank appear to change.

(b) Draw a labelled ray diagram to explain your answer.

4. Water in a pond appears to be only three-quarter of its actual depth. (a) what property

of light is responsible for this observation ? Illustrate your answer with the help of a ray diagram. (b) how is the refractive index of water calculated from its real and apparent depths ?

5. Draw a ray diagram to show the appearance of a stick partially immersed in water. Explain your answer.

6. A fish is looking at a $1 \cdot 0$m high plant at the edge of a pond. Will the plant appear to the fish shorter or taller than its actual height ? Draw a ray diagram to support your answer.

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7. A student puts his pencil into an empty trough and observes the pencil from the position as indicated in Figure.

(i) What change will be observed in the appearance of the pencil when water is poured into the trough?

(ii) Name the phenomenon which accounts for the above stated observation.

(iii) Complete the diagram showing how the student's eye sees the pencil through water.

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8. An object placed in one medium when seen from the other medium, appears to be vertically shifted. Name two factors on which the magnitude of the shift depends and state how does it depend on them.

1. A small air bubble in a glass block when seen from above appears to be raised because of :

   A. refraction of light

   B. reflection of light

   C. reflection and refraction of light

   D. none of the above

Answer: A

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2. An object in a denser medium when viewed from a rarer medium appears to be raised. The shift is maximum for :

A. red light

B. violet light

C. yellow light

D. green light

Answer: B

1. A water pond appears to be $2 \cdot 7m$ dep. If the refractive index of water is $4/3$, find the actual depth of the pond.

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2. A coin is placed at the bottom of a beaker containing water (refractive index=4/3) at a depth of 12cm. By what height the coin

appears to be raised when seen from vertical above ?

3. A postage stamp kept below arectangular glass slab of refractive index $1 \cdot 5$ when viewed from vertically above it, appears to be raised by $7 \cdot 0 mm$. Calculate the thickness of the glass slab.

1. Explain the term critical angle with the aid of a labelled diagram.

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2. How is the critical angle related to the refractive index of a medium ?

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3. State the approximate value of the critical angle for (a) glass-air surface (b) water-air surface.

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4. What is meant by the statement 'the critical angle of diamond is $24°$'?

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5. A light ray is incident fromt a denser medium on the boundary separating it from a rarer medium at an angle of incidence equal to the critical angle. What is the angle of refraction for the ray ?

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6. Name two factors which affect the critical angle for a given pair of media. State how do the factors affect it.

7. The critical angle for glass-air is $45°$ for the light of yellow colour. State whether it will be less than, equal to, or more than $45°$ for (i) red light, and (ii) blue light ?

8. Which colour of light has a higher critical angle? Red light or Green light.

9. (a) What is total internal reflection ?

(b) State two conditions necessary for total internal reflection to occur.

(c) draw diagrams to illustrate total internal reflection.

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10. Fill in the blanks:

Q: Total internal reflection occurs only when a

ray of light passes from a ____medium to a ____medium.

11. Fill in the blanks:

Q: Critical angle is the angle of ___in denser medium for which the angle of ___in rarer medium is ___-

12. State whether the following statement is true or false ? If the angle of incidence is greater than the critical angle, light is not refracted at all, when it falls on the surface from a denser medium to a rarer medium.

13. The refractive index of air with respect to glass is expressed as $_g\mu_a = \dfrac{\sin i}{\sin r}$.

(a) Write down a similar expression for $_a\mu_g$ in

terms of the angles i and r.

(b) if angle $r = 90°$, what is the corresponding angle i called ?

(c) What is the physical significance of the angle i in part (b) ?

14. Figure alongside shows two rays A and B travelling from water to air. If the critical angle for water-air surface is $48°$, complete the ray
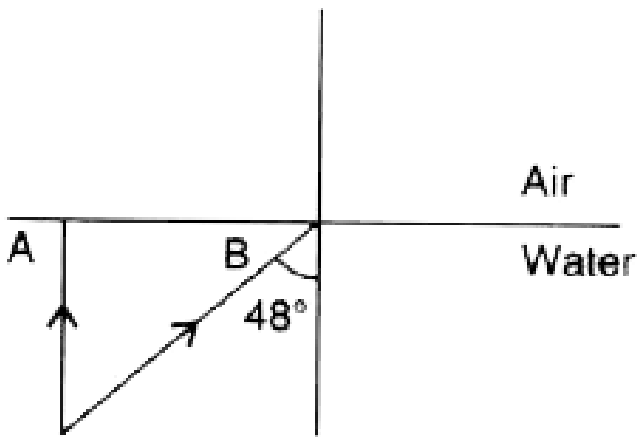
diagram showing the refracted for each. State conditions when the ray will suffer total internal reflection.

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15. Figure shows a point source P inside a water container. Three rays A,B and C starting
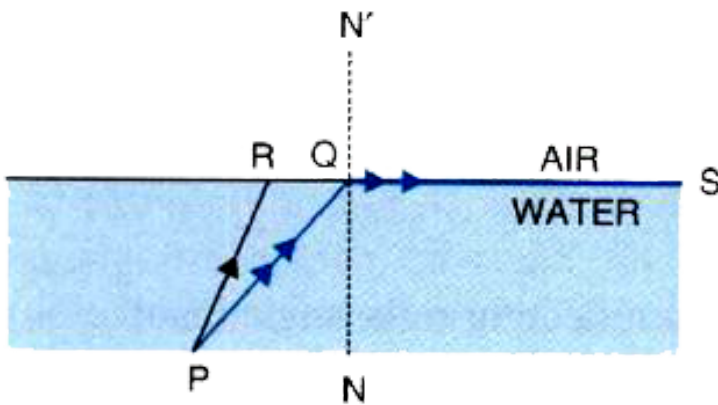
from the source P are shown up to the water surface.

(a) show in the diagram the path of these rays after striking the water surface. The critical angle for water-air surface is $48°$. (b) Name the phenomenon which the rays A, B and C exhibit.
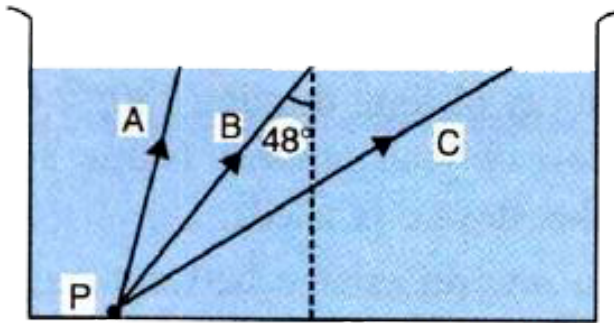
16. In figure, PQ and PR are the two light rays emerging from an object P. the ray PQ is refracted as QS.

(a) state the special name given to the angle of incidence $\angle PQN$ for the ray PQ.

(b) What is the angle of refraction for the refracted ray QS?

(c) Name the phenomenono that occurs if the

angle of incidence $\angle PQN$ is increased.

(d) The ray PR suffers partial reflection and refraction on the water-air surface. give reason.

(e) Draw in the diagram the refracted ray for the incident ray PR and hence show the position of the image of the object P by the letter P' when seen vertically from above.

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17. The refractive index of glass is $1 \cdot 5$ from a point P inside a glass slab, draw rays PQ, PB and PC incident on the glass-air surface at an angle of incidence $30°$, $42°$ and $60°$ respectively.

(a) In the diagram show the approximate direction
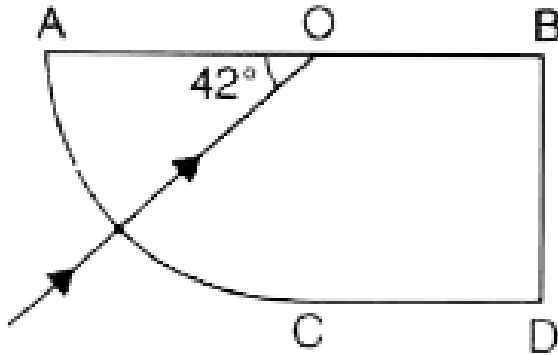
of these rays as they emerge out of the slab.

(b) What is the angle of refraction for the ray PB

(Take $\sin 42° = \dfrac{2}{3}$)

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18.

A ray of light enters a glass slab ABCD as shown in figure and strikes at the centre O of the circular parth AC of the slab. The critical angle of glass is $42°$. Complete the path of the ray till it emerges out from the slab. mark the angles in the diagram wherever necessary.

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19. What is a total reflecting prism ? State three actions that it can produce. Draw a diagram to show one such action of the total reflecting prism.
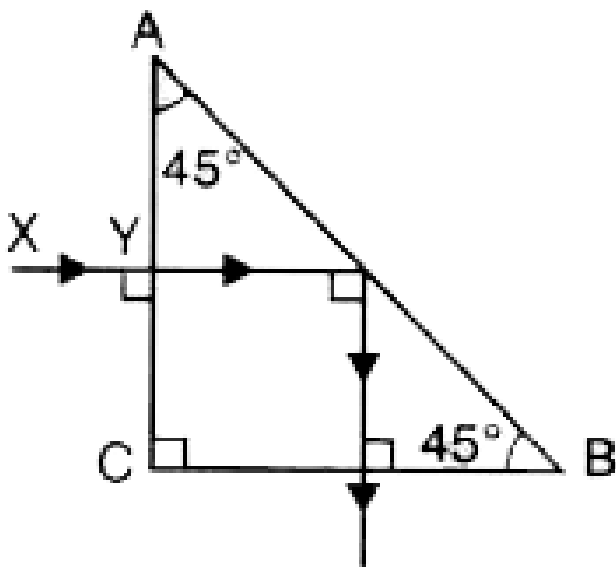
20. Show with the help of a diagram how a total reflecting prism can be used to turn a ray

of light through $90°$. Name one instrument in which such a prism is used.

21.

A ray of light XY passes through a right angled isosceles prism as shown alongside Figure.

(a) What is the angle through which the incident ray deviates and emerges out of the prism?

9b) Name the instrument where this action of prism is put into use.

(c) Which prism surface will behave as a mirror ?

22. Draw a diagram of a right angled isoscels prism which is used to make an inverted image

erect.

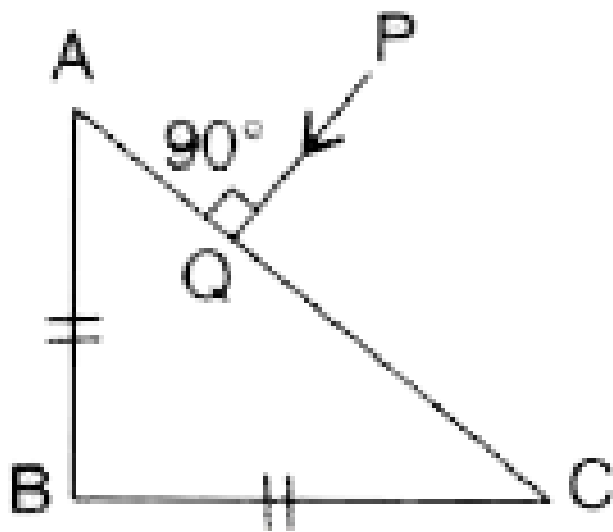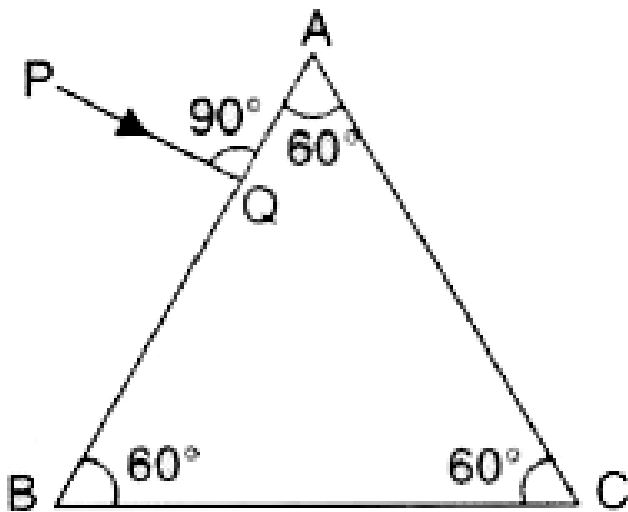**23.** In figure, a ray of light PQ is incident normally on the hypotenuse of an isosceles right angled prism ABC. (a) complete the path of the ray PQ till it emerges from the prism. Mark in the diagram the angle wherever necessary. (b) what is the angle of deviation of the ray PQ ?

(c) Name a device in which this action is used.

24.

In figure, a ray of light PQ is incident normally

on the face AB of an equilateral glass prism.

Complete the ray diagram showing its

emergence into air after passing through the

prism. Take critical angle for glass=$42°$.

(a) Write the angles of incidence at the faces

AB and AC of the prism.

(b) Name the phenomenon which the ray of light suffers at the face AB, AC and BC of the prism.
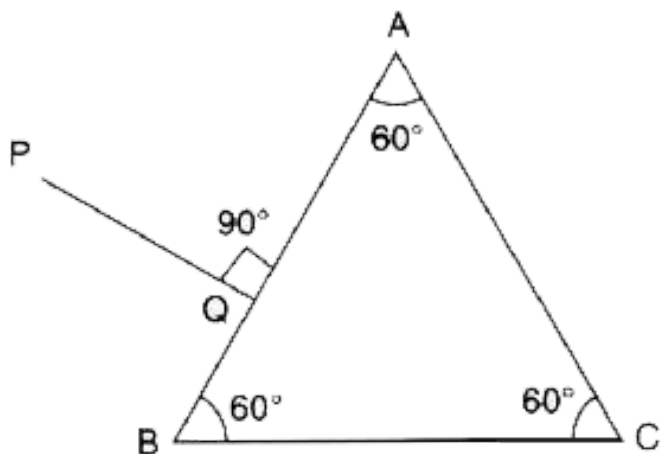
25.

Copy the diagram given below and complete the path of the light ray till it emerges out of

the prism. The critical angle of glass is $42°$. In your diagram mark the angles wherever necessary.

**26.** Draw a neat labelled ray diagram to show total internal reflection of a ray of light incident normally on one face of a $30°$, $90°$, $60°$ prism.

27. (a) Figure shows two isosceles right angled prisms A and B and the light rays incident on the prism A. complete the diagram to show the rays emerging out of the prism B.

(b) State the principle used for completing the ray diagram in part (a) above.
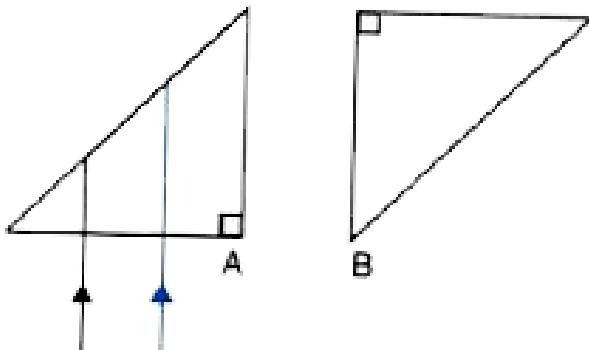
28. What device other than a plane mirror can be used to turn a ray of light through $180°$? Draw a diagram in support of your answer. Name an instrument in which this device is used.

29. Mention one difference between reflection of light from a plane mirror and total internal reflection of light from a prism.

30. State one advantage of using a total reflecting prism as a reflector in place of a plane mirror.

Exercise 4 D Multiple Choice Type

1. The critical angle for glass-air interface is :

A. $24°$

B. $48°$

C. $42°$

D. $45°$

Answer: C

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2. A total reflecting right angled isosceles prism can be used to deviate a ray of light through :

A. $30°$

B. $60°$

C. $75°$

D. $90°$

Answer: D

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3. A total reflecting equilateral prism can be used to deviate a ray of light through :

A. $30°$

B. $60°$

C. $75°$

D. $90°$

Answer: B

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