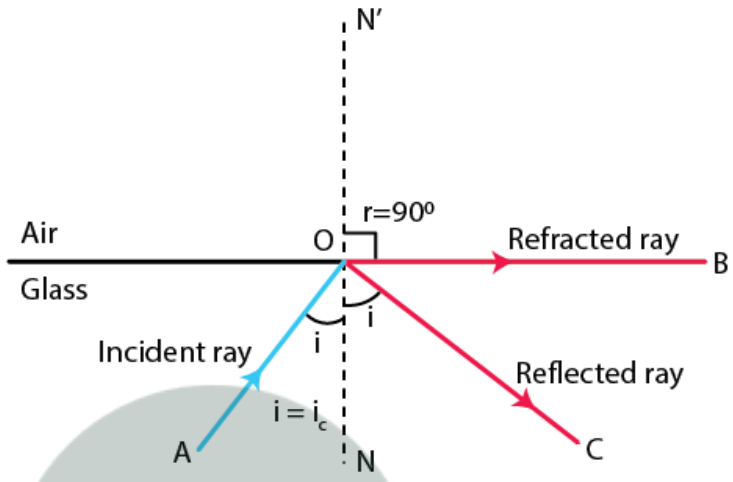
EXERCISE 4(D)

Solution:
Critical angle is defined as the angle of incidence in the denser medium corresponding to which the angle of refraction in the rarer medium is 90^0



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Solution:
The relation by which critical angle is related to the refractive index of a medium is
$\mu = 1 / \sin C = \text{cosec } C$

Solution:
(a) The critical angle for glass - air surface is
Refractive index ${}_a\mu_g = 3 / 2$
$\therefore \sin i_c = 1 / {}_a\mu_g = 2 / 3$
$i_c = 42^0$
(b) The critical angle for water – air surface is
Refractive index $\times {}_a\mu_w = 4 / 3$
$\therefore \sin i_c = 1 / {}_a\mu_g = 3 / 4$
$I_c = 49^0$

Solution:
The statement 'the critical angle for diamond is 24^0' implies that at an incident angle of 24^0, the angle of refraction in the air will be 90^0 within the diamond. If incident angle is more than the angle of refraction then the ray will suffer total internal reflection without any refraction.

Question: 5
A light ray is incident from 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?
Solution:
The angle of refraction becomes 90^0 when a ray is incident from a denser medium to a rarer medium at an angle of incidence equal to the critical angle.

Question: 6
Name two factors which affect the critical angle for a given pair of media. State how do the factors affect it.
Solution:
The two factors which affect the critical angle are
(a) The colour or wavelength of light, and
(b) The temperature
Effect on colour of light: The critical angle for a pair of media is least for the violet light and most for the red light. Thus the critical angle increases with the increase in wavelength of light.
Effect on temperature: On increasing the temperature of medium, its refractive index decreases. So, the critical angle increases with increase in temperature.

Question: 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, (ii) blue light?
Solution:
As the wavelength of light decreases (or increases) refractive index becomes more (or less) and critical angle becomes less (or more)
(i) For red light the critical angle will be more than 45^0
(ii) For blue light the critical angle will be less than 45^0

Question: 8

(a) What is total internal reflection?

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

(c) Draw diagrams to illustrate critical angle and total internal reflection.

Solution:

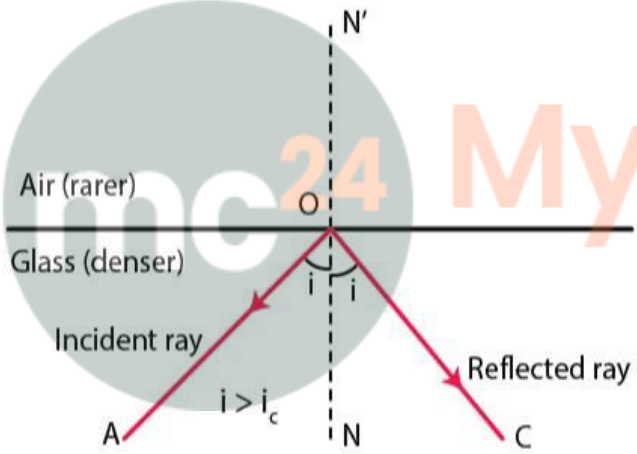
(a) Total internal reflection: When a ray of light travelling in a denser medium, is incident at the surface of a rarer medium at the angle of incidence greater than the critical angle for the pair of media, the ray is totally reflected back into the denser medium. This phenomenon is known as total internal reflection.

(b) For total internal reflection, the two necessary conditions are

(i) The light must travel from a denser medium to a rarer medium.

(ii) The angle of incidence must be greater than the critical angle for the pair of media.

(c) Below diagram shows the total internal reflection when incidence angle is more than the critical angle



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Question: 9

Fill in the blanks to complete the following sentences:

(a) Total internal reflection occurs when a ray of light passes from a ……..medium to a.....medium.

(b) Critical angle is the angle of.....in denser medium for which the angle of ……in rarer medium is ……

Solution:

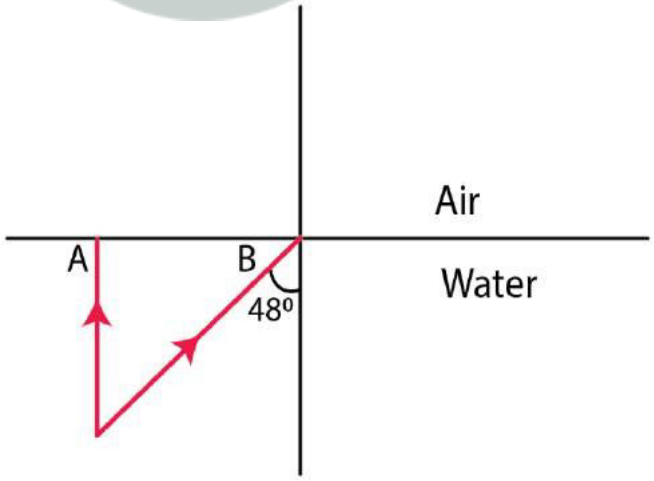
(a) Total internal reflection occurs when a ray of light passes from a denser medium to a rarer medium.

(b) Critical angle is the angle of incidence in denser medium for which the angle of refraction in rarer medium is 90^0

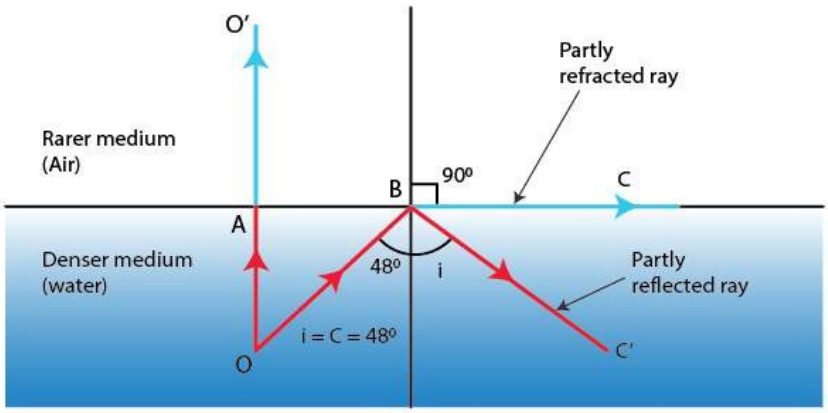
Question: 10
State whether the following statement is true or false:
If the angle of incidence is greater than the critical angle, light is not refracted at all, when it falls on the surface from a denser medium to a rarer medium.
Solution:
True

Question: 11
The refractive index of air with respect to glass is expressed as ${}_{g}\mu_{a} = \sin i / \sin r$
(a) Write down a similar expression for ${}_{a}\mu_{g}$ **in terms of angle i and r.**
(b) If angle r = 90^0, what is the corresponding angle i called?
(c) What is the physical significance of the angle i and part (b)?
Solution:
(a) ${}_{a}\mu_{g} = \sin r / \sin i$
(b) The corresponding angle of incidence i will be equal to critical angle, if refractive angel, r = 90^0
(c) Total internal reflection occurs, if the angle of incidence exceeds the value of i obtained in part (b)

Question: 12
Figure below show 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 rays for each. State conditions when the ray will suffer total internal reflection.

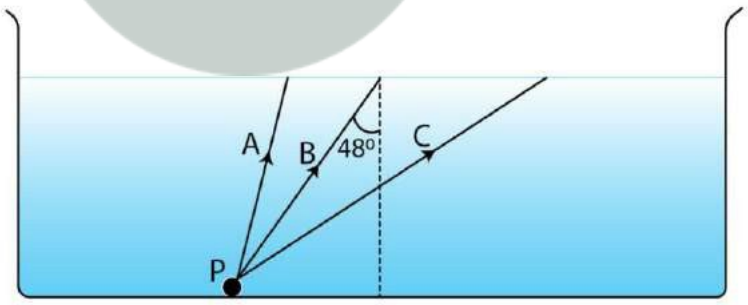


Solution:

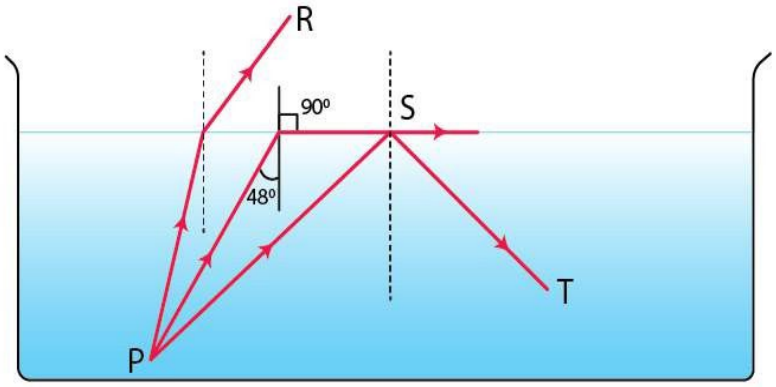


Two necessary conditions for the total internal reflection are
(i) Light must travel from a denser medium to a rarer medium.
(ii) The angle of incidence must be greater than the critical angle.
In this case, the angle of incidence $\angle i > 48^0$

Question: 13
Fig. 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.

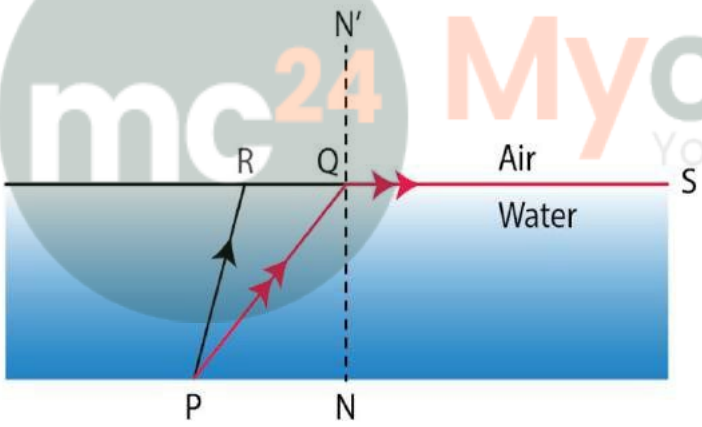


Solution:
(a)



(b) Rays A and B shows the phenomenon of 'refraction of light'
(c) Ray C shows the phenomenon of 'total internal reflection'

Question: 14
In the figure, PQ and PR are the two light rays emerging from an object P. The ray PQ is refracted as QS.

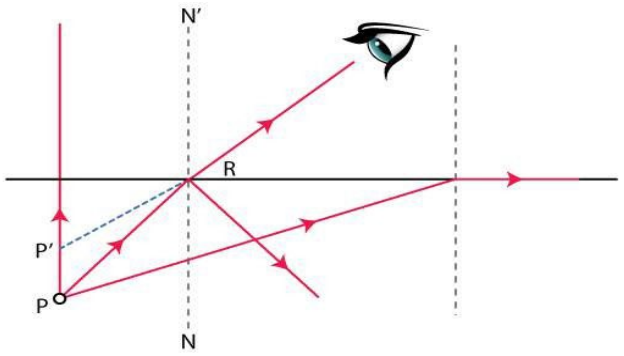


(a) State the special name given to the angle of incidence ∠PQN of the ray PQ.
(b) What is the angle of refraction for the refracted ray QS?
(c) Name the phenomenon that occurs if the angle of incidence ∠PQN is increased.
(d) The ray PR suffers partial reflection and refraction on the water-air surface. Give reason.
(e) Draw in the diagram the refracted ray for the incident ray PR and hence show the position of image of the object P by the letter P' when seen vertically from above.
Solution:
(a) Critical angle
(b) The angle of refraction is 90^0 for the refracted ray QS

(c) The phenomenon that occurs if the angle of incidence ∠PQN is increased is total internal reflection

(d) For the ray PR, the angle of incidence is less than ∠PQN i.e the critical angle. Hence, as per the laws of reflection at the interface of two media, ray PR suffers partial reflection and refraction.

(e)



Question: 15

The refractive index of glass is 1.5. From a point P inside a glass block, draw rays PA, PB and PC incident on that glass-air surface at an angle of 30º, 42º and 60º respectively.

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

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

Solution:

(a) Given,

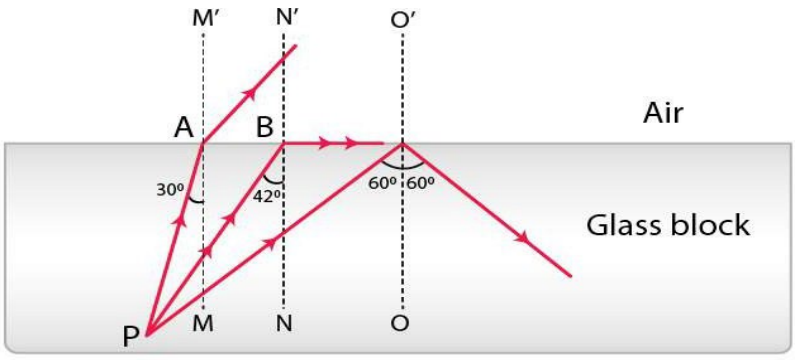
Refractive index of glass, $\mu = 1.5$

$\text{Sin } i_c = 1 / \mu$

$= 1 / 1.5$

$= 0.667$

$i_c = 41.8 \approx 42^0$



(b) Since, the angle of incidence inside the glass block is 42^0

$\sin i / \sin r = {}_a\mu_g$

$\sin r = {}_a\mu_g \times \sin i$

$\sin r = {}_a\mu_g \times \sin 42^0$

Take $\sin 42^0 = 2 / 3$ and ${}_a\mu_g = 3 / 2$

$\sin r = (3 / 2) \times (2 / 3)$

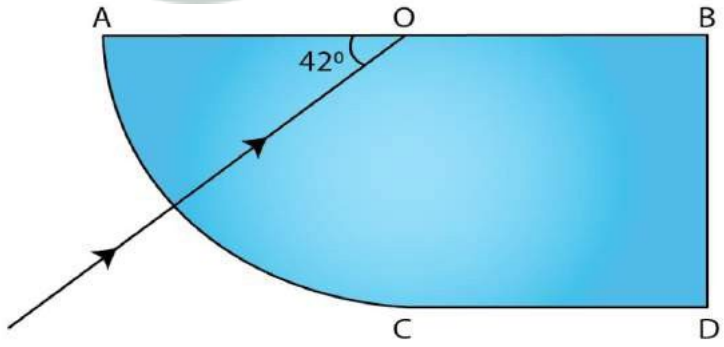
$\sin r = 1$

$r = 90^0$

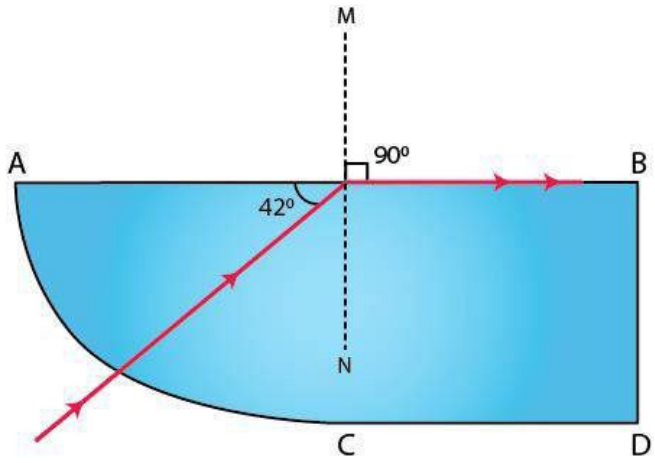
This shows that the ray PB is incident at the critical angle

Question: 16

A ray of light enters a glass ABCD as shown in Fig. and strikes at the Centre O of the circular part 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.



Solution:



The ray is incident on the glass at its critical angle. So, the angle of refraction will be 90^0

Question: 17

What is a total reflecting prism? State three actions that it can produce. Draw a diagram to show one action of the total reflecting prism.

Solution:

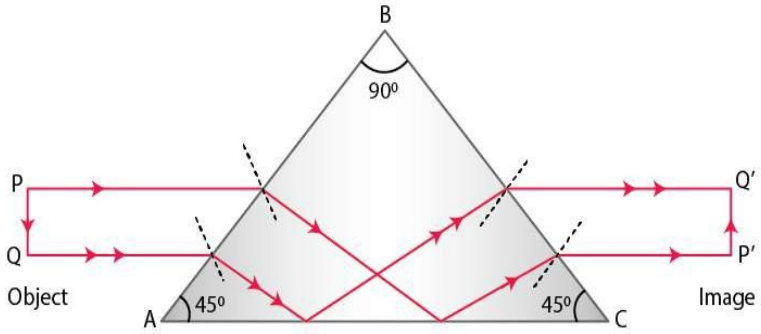
Total reflecting prism is defined as a prism having an angle of 90^0 between its two refracting surfaces and the other two angles each equal to 45^0, is called a total reflecting prism. Here the light is incident normally on any of its faces, suffers total internal reflection inside the prism.

Because of this, a total reflecting prism is used for the following three purposes.

(i) To deviate a ray of light through 90^0

(ii) To deviate a ray of light through 180^0, and

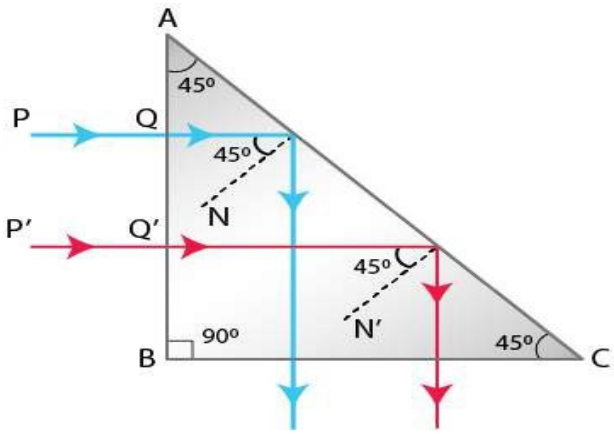
(iii) To erect the inverted image without producing deviation in its path.



An erecting prism is used to erect the inverted image without producing deviation in its path.

Question: 18

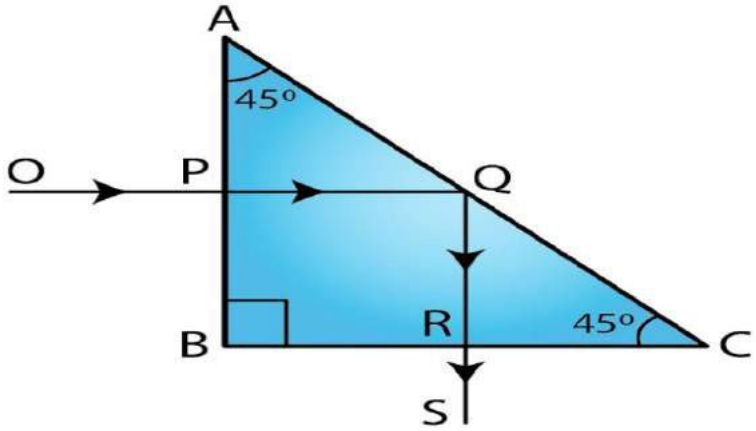
Show with the help of a diagram how a total reflecting prism can be used to turn a ray of light through 90°. Name one instrument in which such a prism is used.
Solution:



In the above figure, a beam of light is incident normally at the face AB. So, it passes undeviated into the prism and strikes at the face AC making an angle of incidence equal to 45^0. Here the incidence is greater than the critical angle. So, the beam of light suffers total internal reflection and reflect at angle of 45^0. The reflected beam then strikes the face BC inside the prism where it is incident normally and thus passes undeviated. Hence, the incident beam gets deviated through 90^0.

This type of prism is used in periscope.

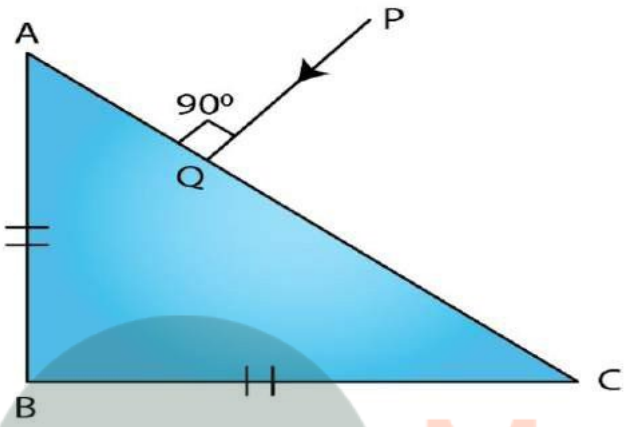
Question: 19
A ray of light OP passes through a right angled prism as shown in the adjacent diagram.



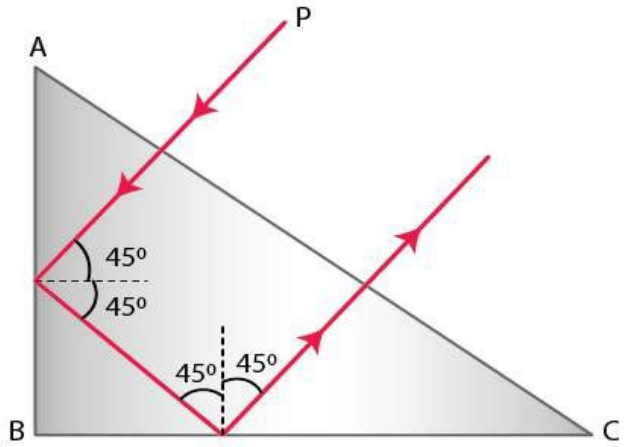
(a) State the angles of incidence at the faces AC and BC.
(b) Name the phenomenon which the ray suffers at the face AC.
Solution:

(a) The angle of incidence at the face AC = 45^0 and the angle of incidence at the face BC = 0^0
(b) The ray suffers total internal reflection at the face AC.

Question: 20
In Fig., a ray of light PQ is incident normally on the hypotenuse of an isosceles right angle prism ABC.



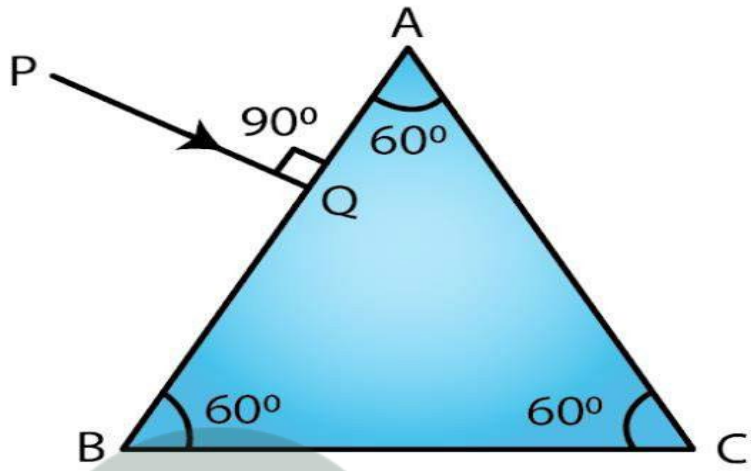
(a) Complete the path of the ray PQ until it emerges from the prism. Mark in the diagram the angle wherever necessary.
(b) What is the angle of deviation of the ray PQ?
(c) Name a device in which this action is used.
Solution:
(a)



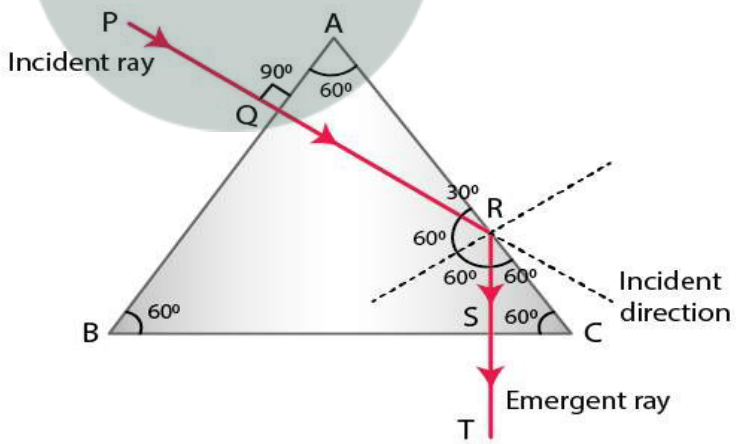
(b) The angle of deviation of the ray PQ is 180^0
(c) Prism binocular is the device in which it is used

Question: 21

In Fig., 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°



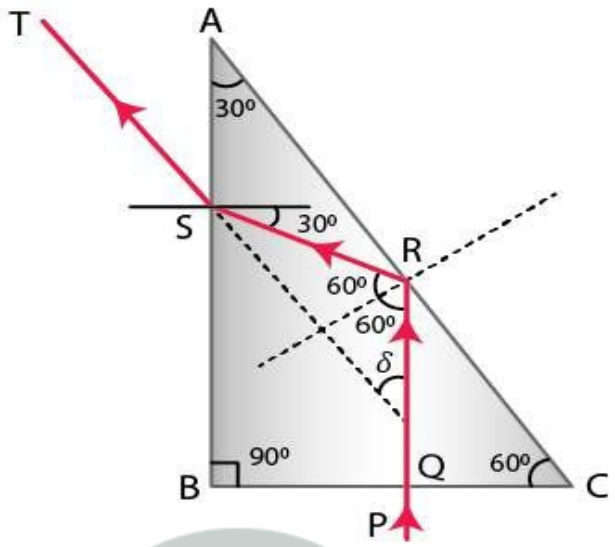
(a) Write the angles of incidence at the faces AB and AC of the prism.
(b) Name the phenomenon which the ray of light suffers at the face AB, AC and BC of the prism.
Solution:



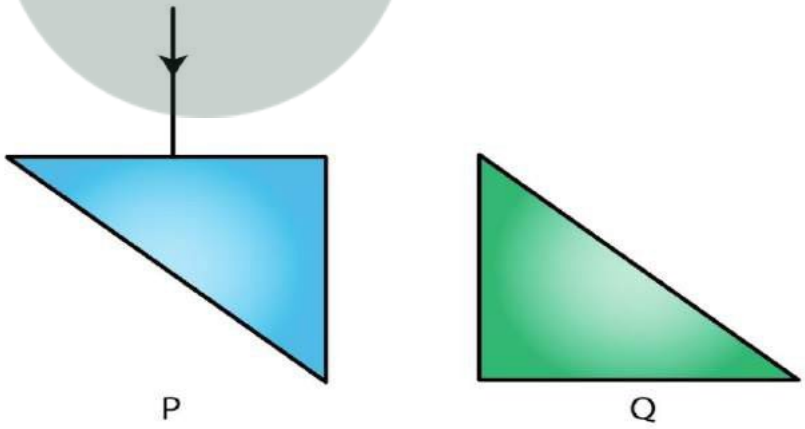
(a) At the face AB, i = 0^0 and at the face AC, i = 60^0
(b) At the face AB – refraction,
At the face AC – total internal reflection
At the face BC – refraction

Question: 22
Draw a neat labelled ray diagram to show the total internal reflection of a ray of

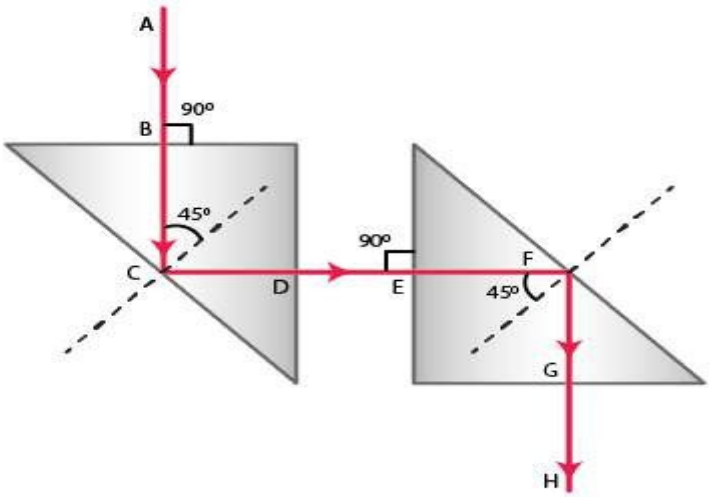
light normally incident on one face of a 30°, 90°, 60° prism.
Solution:



Question: 23
Two isosceles right – angled glass prisms P and Q are placed near each other as shown in Fig. Complete the path of the light ray entering the first prism till it emerges out of the second prism Q.



Solution:

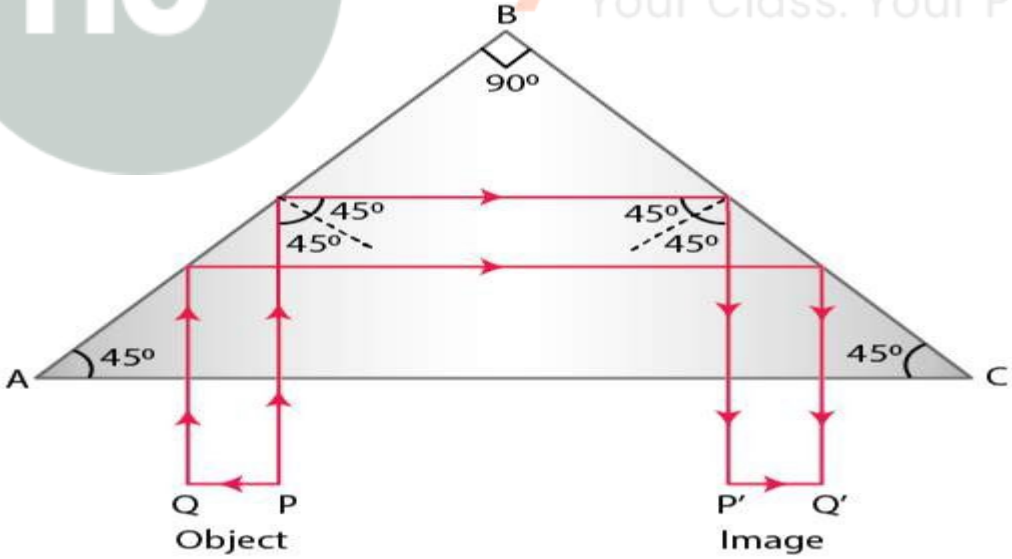


Question: 24

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.

Solution:

A total reflecting prism is used to turn a ray of light through 180^0. Below diagram make it further clear.



Binocular is an instrument in which this action of prism is used

Question: 25

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

Solution:
The entire incident light is reflected back into the denser medium in total internal reflection of light from a prism whereas in ordinary reflection from a plane mirror, only a part of light is reflected while rest is refracted and absorbed and thus the reflection is partial.

Question: 26
State one advantage of using a total reflecting prism as a reflector in place of a plane mirror.
Solution:
A total reflecting prism gives the image much brighter and the brightness remains unchanged even after the long use, while the image is less bright and the brightness gradually decreases which is obtained by a plane mirror.

MULTIPLE CHOICE TYPE
Question: 1
The critical angle for glass-air interface is :
a. 24°
b. 48°
c. 42°
d. 45°
Solution:
The critical angle for the glass – air interface is 42^0

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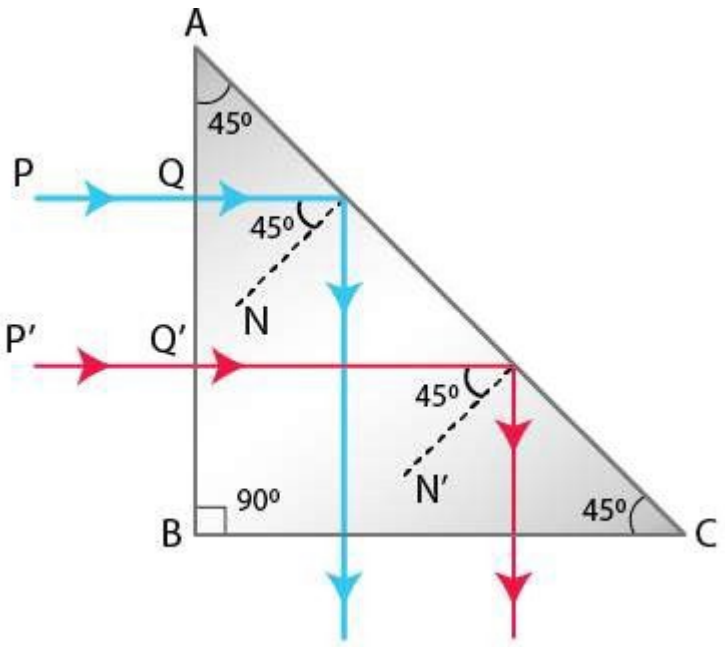
Question: 2
A total reflecting right angled isosceles prism can be used to deviate a ray of light through
a. 30°
b. 60°
c. 75°
d. 90°
Solution:
A total reflecting right angled isosceles prism can be used to deviate a ray of light through 90^0



Question: 3

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

a. 30°

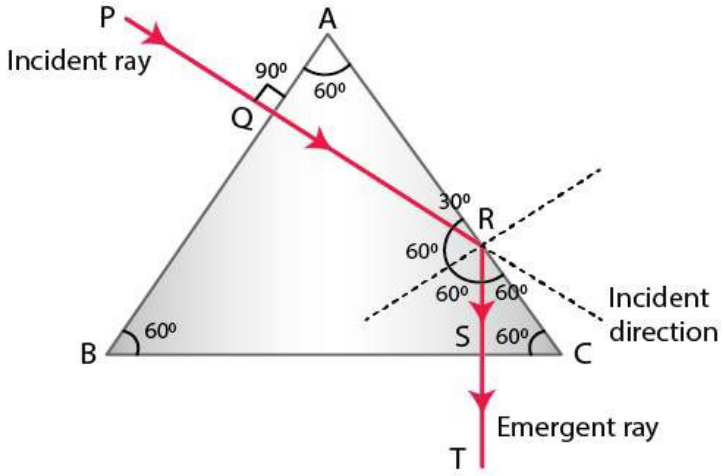
b. 60°

c. 75°

d. 90°

Solution:

A total reflecting equilateral prism can be used to deviate a ray of light through 60^0



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