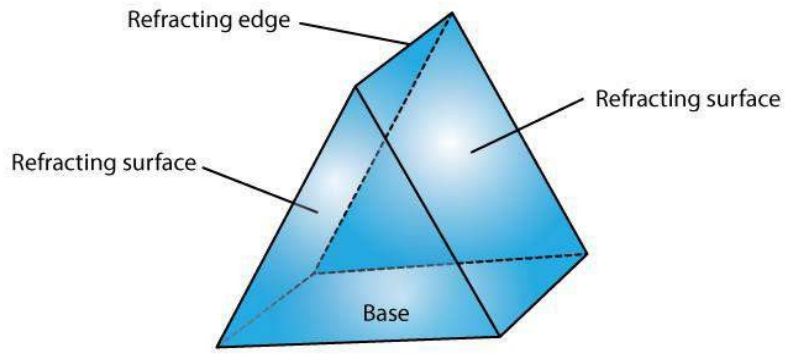
EXERCISE 4(B)

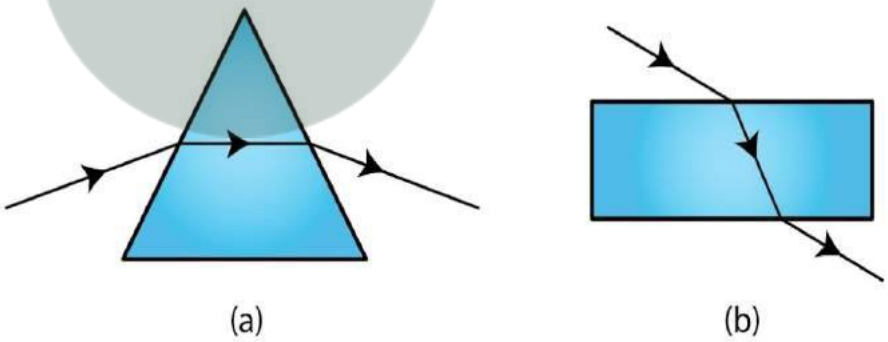
Solution:

A prism is defined as a transparent medium bounded by five plane surfaces with a triangular cross section



Question: 2

The diagrams (a) and (b) in Fig. below show the refractions of a ray of light of single colour through a prism and a parallel sided glass and prism, respectively.

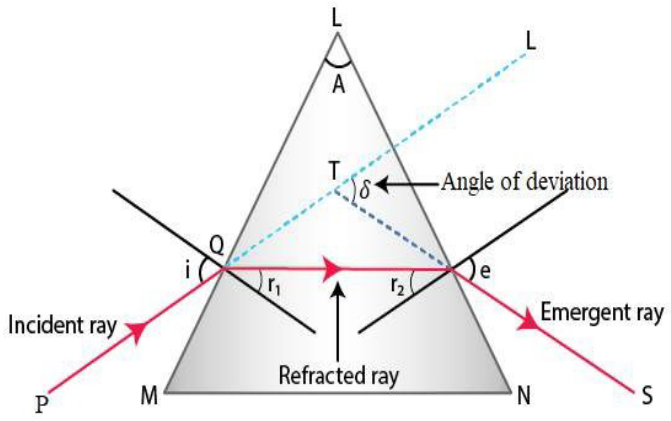


(a) In each diagram, label the incident, refracted, emergent rays and the angle of deviation.

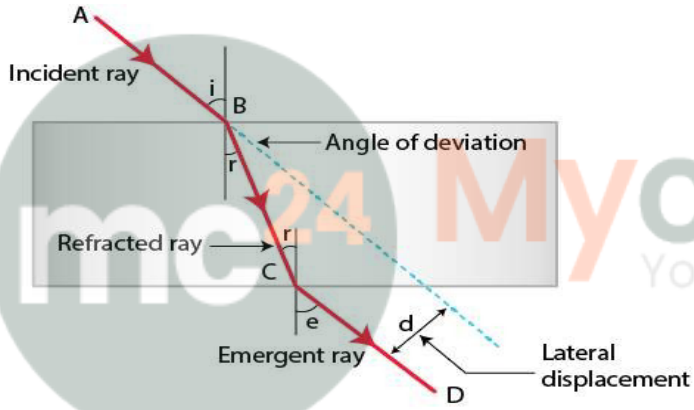
(b) In what way the direction of emergent ray in the two cases differ with respect to the incident ray? Explain your answer.

Solution:

(a)



(b)



For the prism, the emergent ray is not parallel to the incident ray while for the glass the emergent ray is parallel to the incident ray. This is because, refraction takes place at two inclined surfaces in a prism while in a glass refraction takes place at two parallel surfaces.

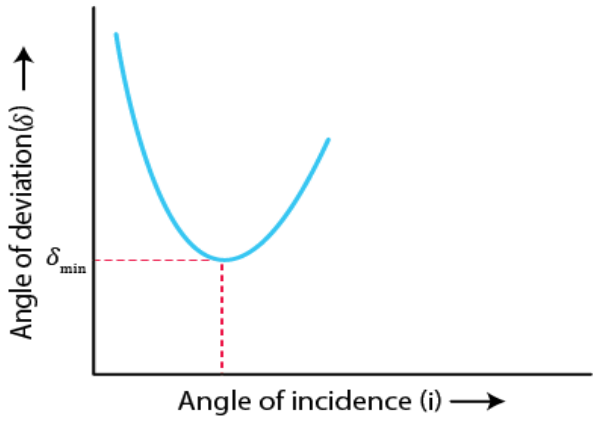
Question: 3
Define the term angle of deviation.
Solution:
The angle of deviation is the angle between the direction of incident ray and the emergent ray

Question: 4
Complete the following sentence:
Angle of deviation is the angle which the _____ray makes with the direction of _____ray.
Solution:

Angle of deviation is the angle which the emergent ray makes with the direction of incident ray

Question: 5
What do you understand by the deviation produced by a prism? Why is it caused? State three factors on which angle of deviation depends.
Solution:
In a prism, the ray of light suffers refraction at two inclined faces. The prism produces a deviation at the first surface and another deviation at the second surface. Hence, in the path of light, a prism produces a deviation.
The value of the angle of deviation depends on the following four factors
(i) The angle of incidence (i)
(ii) The material of prism (i.e on refractive index μ)
(iii) The angle of prism (A) and
(iv) The colour or wavelength (λ) of light used.

Question: 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 given prism, the angle of minimum deviation δ_{min} is unique for the given light.
Solution:
Variation of angle of deviation δ with angle of incidence (i)



For a given prism and given colour of light, angle of minimum deviation (δ_{min}) is unique since only one horizontal line can be drawn parallel to i – axis at the lowest point of i – δ curve i.e only for one value of angle of incidence i, the refracted ray inside the prism is parallel to its base.

Question: 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 the colours of light.
Solution:
False. As the angle of incidence increases, the angle of deviation first decreases and then increases. A given prism deviates the violet light most and the red light least.

Question: 8
How does the deviation produced by a prism depend on
(i) the refraction index of its material, and
(ii) the wavelength of incident light
Solution:
(i) The prism with a higher refractive index produces a greater deviation than a prism with a lower refractive index for a given angle of incidence.
(ii) The refractive index of a given transparent medium is different for the light of different colours. It decreases with the increase in the wavelength of light. Thus the refractive index of the material of a prism for visible light is maximum for the violet colour and minimum for the red colour. Hence, a given prism deviates the violet the most and the red light least.

Question: 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 the prism?
Solution:
(i) As we increase the wavelength of incident light, the angle of deviation decreases.
(ii) The angle of deviation increases with the increase in the refracting angle of the prism

Question: 10
Write a relation for the angle of deviation (δ) for a ray of light passing through an equilateral prism in terms of angle of incident (i), angle of emergence (e), angle of prism (A).
Solution:
The relation between the angle of incident (i), angle of emergence (e), angle of prism (A) and angle of deviation (δ) for a ray of light passing through an equilateral prism is

$$\delta = (i + e) - A$$

Question: 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.

(a) How is the angle of emergence 'i_2' related to the angle of incidence 'i_1'.

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

Solution:

(i) The relation between angle of emergence i_2 to the angle of incidence i_1 is

$$i_2 = i_1$$

(ii) The angle of deviation is minimum

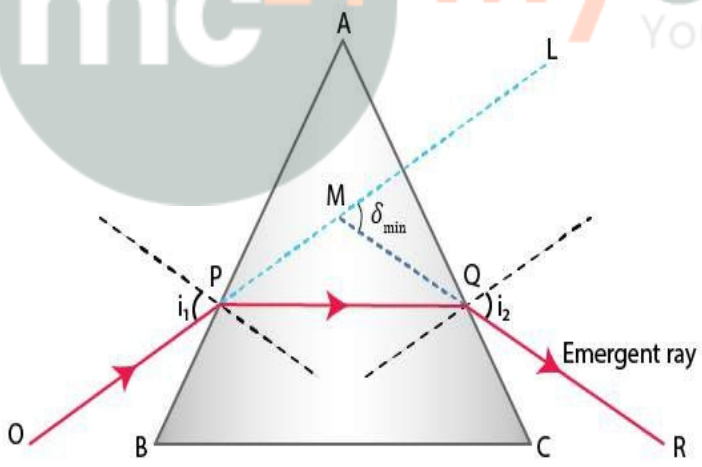
Question: 12

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 this position.

Solution:

In the equilateral prism, when the prism is in minimum deviation, the angle of incidence i_1 is equal to the angle of emergence i_2

$$i_1 = i_2 = i$$



Question: 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 whether the angle of deviation will be equal to less than or more than 36°.

Solution:

(i) In an equilateral glass prism the ray suffers minimum deviation. So

$i_1 = i_2$
$i_2 = 48^0$

(ii) (a) If the angle of incidence is changed to 30^0, the angle of deviation will be more than 36^0

(b) If the angle of incidence is changed to 60^0, the angle of deviation will be more than 36^0

Question: 14

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

Solution:

On passing through a prism, violet colour will deviate the most and red colour will deviate the least.

Question: 15

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

Solution:

The B made of flint glass has higher refractive index. So, B made of flint glass deviate a ray of light more.

Question: 16

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

Solution:

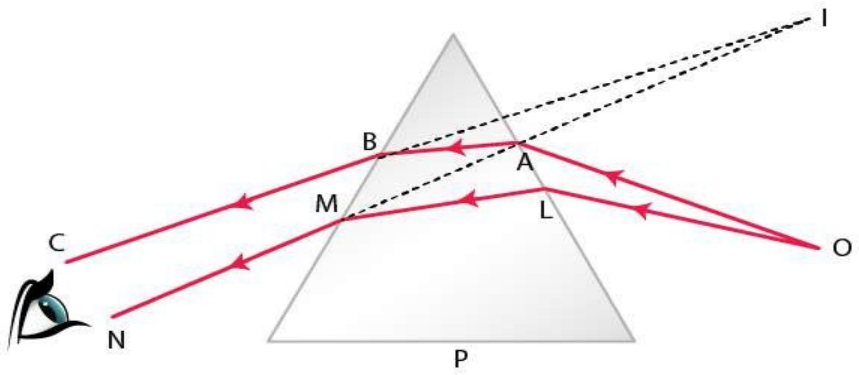
With the increase in the angle of prism (A), the angle of deviation (δ) increases.

Question: 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 seen by the observer.

Solution:

Let two rays OA and OL from a source of light O are incident on the prism. They are refracted along AB and LM from the first face of the prism respectively. These two rays again refract from the second face of the prism emerge out along BC and MN such that they appear to come from a point I.



Hence, the observer sees the object O raised to the position I

Question: 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?

Solution:

(a) When the incident ray normal to prism then the angle of incidence is 0^0.

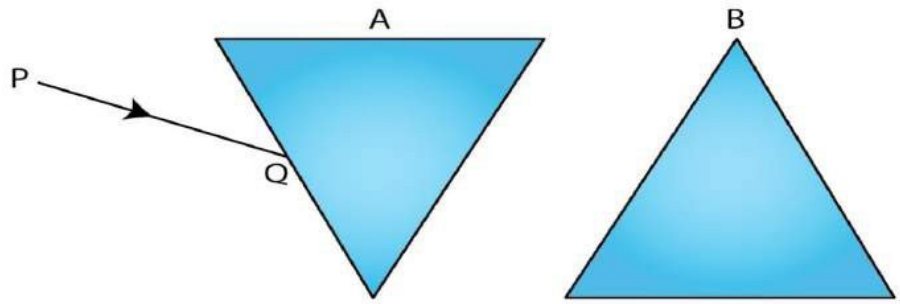
(b) The angle of refraction from the first face of the prism $r_1 = 0^0$

(c) The prism is equilateral so $A = 60^0$ and $r_1 = 0^0$. Hence at the second face of the prism, the angle of incidence will be 60^0

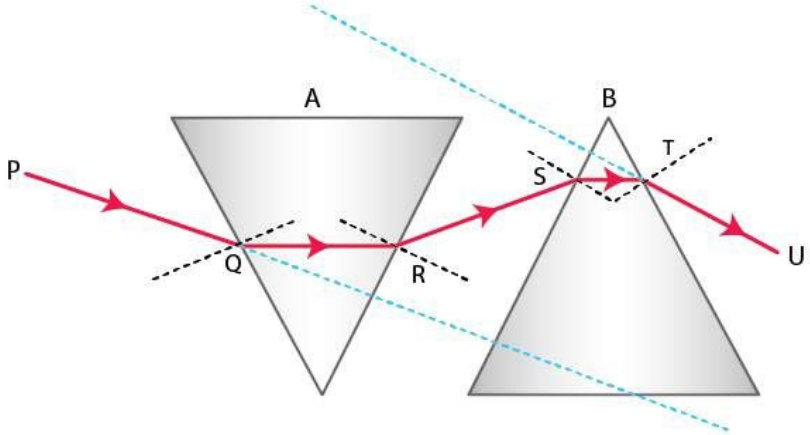
(d) No, the light ray will not suffer minimum deviation.

Question: 19

The diagram 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



Solution:



MULTIPLE CHOICE TYPE

Question: 1

In refraction of light through a prism, the light ray:

a. Suffers refraction only at one face of the prism

b. Emerges out from the prism in a direction parallel to the incident ray

c. Bends at both the surfaces of prism towards its base

d. Bends at both the surfaces of prism opposite to its base.

Solution:

In refraction of light through a prism, the light ray bends at both the surfaces of prism towards its base.

Question: 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

Solution:

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

NUMERICALS

Question: 1

A ray of light incident at an angle 48^o on a prism of refracting angle 60^o suffers minimum deviation. Calculate the angle of minimum deviation.

Solution:

Given,
Angle of incidence, $i = 48^0$
Refracting angle, $A = 60^0$
Angle of minimum deviation, δ_{min} =?
We know that
$\delta_{min} = 2i - A$
$\delta_{min} = 2(48) - 60$
$\delta_{min} = 96 - 60$
$\delta_{min} = 36^0$

Question: 2
What should be the angle of incidence for a ray of light which suffers a minimum deviation of 36^o through an equilateral prism?
Solution:

Given,
Angle of prism, $A = 60^0$
Angle of minimum deviation, $\delta_{min} = 36^0$
Angle of incidence, i = ?
We know that
$\delta_{min} = 2i - A$
$36^0 = 2i - 60^0$
$i = 48^0$