Refraction Through Prism

Introduction

- **Prism:** Prism is a transparent optical object with flat, polished surfaces that refract light. At least two of the flat surfaces must have an angle between them.
- **Bending of light:** Light changes its speed when it moves from one medium to another. For example, from air (rarer medium) into the glass (denser medium of the prism). This speed change causes the light to be refracted and to enter the new medium at a different angle. The degree of bending of the light's path depends on the angle that the incident ray of light makes with the surface, and on the ratio between the refractive index of the two media.
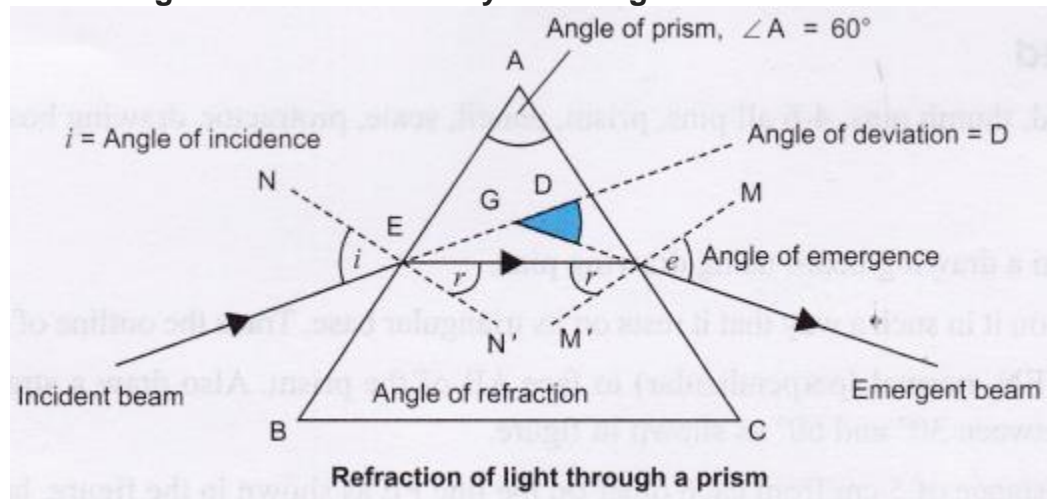 **Angle of incidence (i):** It is the angle between the incident ray and the normal at the point of incidence.
  Angle of emergence (e): It is the angle between the emergent ray and the normal at the point of emergence.
  prism (A): It is the angle between the two refracting faces of the prism.
  Angle of deviation (D): The amount of overall refraction caused by the passage of a light ray through a prism is often expressed in terms of the angle of deviation. The angle of deviation is the angle made between the incident ray of light entering the first face of the prism and the refracted ray that emerges from the second face of the prism. Because of the different indices of refraction for the different wavelengths of visible light, the angle of deviation varies with wavelength.
- **Prism diagram with different rays and angles:**

Refraction of light through a prism

Relation of all the four angles ∠A, ∠D, ∠i and ∠e. ∠A +∠D = ∠i + ∠e
- Angle of deviation depends upon the:
  (a) angle of prism.
  (b) nature of material of the prism.
  (c) angle of incidence.

- When angle of incidence increases, angle of deviation decreases, till it becomes minimum at a particular angle of incidence.
- The refracted ray becomes parallel to the base of the prism under the minimum deviation position.

Science Lab Manual Refraction Experiment – 6

Aim
To trace the path of the rays of light through a glass prism.
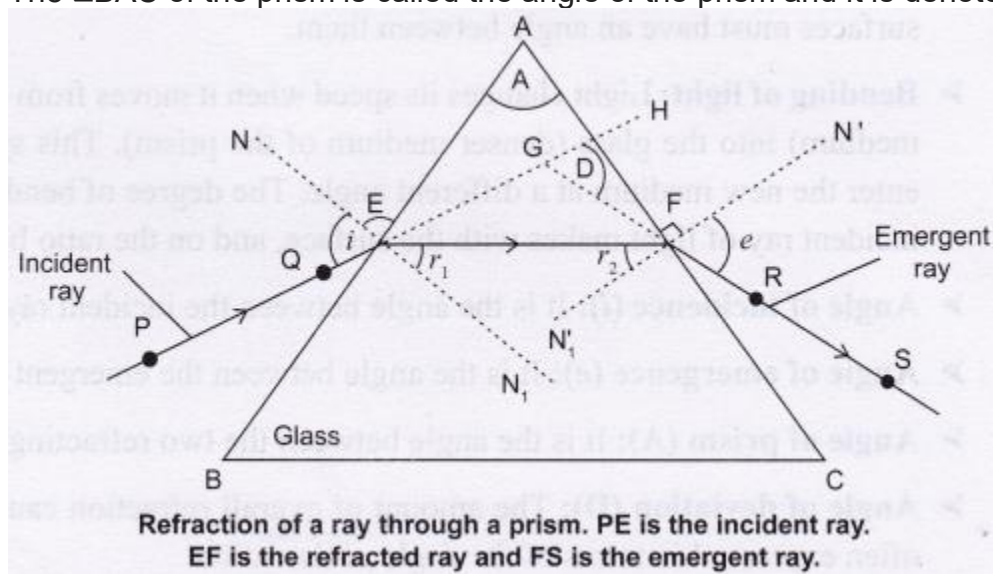
Theory

- A prism has a triangular base and three triangular lateral surfaces. These surfaces are inclined to each other.
  Refraction of light through a prism
- In the given figure, ABC represents the base of a glass prism. Let PE be the incident ray of light on face AB of the prism. EF represents the bending of light when it enters the prism and hence show the refraction of light.
- RS is the emergent ray at face AC of the prism.
  The angle D shows the angle of deviation.
  The ∠BAC of the prism is called the angle of the prism and it is denoted by 'A'.

Refraction of a ray through a prism. PE is the incident ray.
EF is the refracted ray and FS is the emergent ray.

- In the figure, the relation between
  • angle of incidence ∠i, i. e., ∠PQN
  • angle of refraction ∠r, i.e., ∠FEN,
  • angle of deviation ∠D, i.e., ∠HGF and
  • angle of prism ∠A, i.e., ∠BAC. ∠A + ∠D = ∠i + ∠e

Materials Required
A white sheet, soft board, thumb pins, 4-6 all pins, prism, pencil, scale, protractor, drawing board.

Procedure

1. Fix a white sheet on a drawing board using drawing pins.
2. Place a glass prism on it in such a way that it rests on its triangular base. Trace the outline of the prism using a pencil.
3. Draw a thin line NEN normal (perpendicular) to face AB of the prism. Also draw a straight line PE making an angle preferably between 30° and 60° as shown in figure.
4. Fix two pins at a distance of 5 cm from each other on the line PE as shown in the figure, later mark these points of pins as P and Q.
5. Look at the images of the pins, fixed at P and Q, through the other face of the prism, i.e., AC.
6. Fix two more pins, at points R and S vertically such that the feet of pins at R and S appear to be on the same straight line as the feet of the images of the pins P and Q when viewed through the face AC of the prism.
7. Remove the pins and the glass prism.
8. Join and produce a line joining R and S, let this line meet the prism at point F.
9. Extend the direction of incident ray PQE till it meets the face AC. Also extend (backwards) the emergent ray SRF so that these two lines meet at a point G.
10. Mark the angle of incidence $\angle i$, angle of refraction $\angle r$ and the angle of emergence $\angle e$ and $\angle D$ as shown in the figure.
11. Repeat the experiment for more angle of incidence preferably between 30° and 60°.

Observations

1. The light ray enters the prism at surface AB, bends towards the normal on refraction.
2. At surface AC of the prism, this light ray bends away from the normal because it travels from a glass to air.
3. The peculiar shape of the prism makes the emergent ray bend at an angle to the direction of the incident ray. This angle is called the angle of deviation ($\angle D$).

Conclusion

1. The light ray, i.e., the incident ray first bends towards the normal when it gets refracted in the prism and while leaving the prism it bends away from the normal.
2. The angle of deviation first decreases with the increase in angle of incidence $\angle i$. It attains a minimum value then increases with further increase in angle of incidence.

Precautions

1. A sharp pencil should be used for drawing the boundary of the prism.
2. Use soft board and pointed pins.

3. The pins should be fixed at a distance of 5 cm or more.
4. The pins should be fixed vertically and immediately encircled after they are removed.
5. While viewing the col-linearity of pins and images, the eye should be kept at a distance from the pins so that all of them can be seen simultaneously. The col-linearity of all the four pins can be confirmed by moving the head slightly to either side while viewing them. They all appear to move together.
6. The angle of incidence should be between 30° and 60°.
7. Proper arrows should be drawn for the incident ray, refracted ray and emergent ray.

Science Lab Manual Refraction Viva Voce

Question 1:
What is refractive index?
Answer:
Refractive index $n = \sin i / \sin r$
i and r are the angle of incidence and angle of refraction respectively, n for the given wavelength of light is

$$n = \frac{\text{Velocity of light in vacuum}}{\text{Velocity of light in the medium}}$$

Question 2:
What is the unit of refractive index?
Answer:
It has no unit.

Question 3:
Name the atmospheric refraction that causes splitting of white light.
Answer:
Rainbow

Question 4:
What is dispersion of light?
Answer:
The splitting of white light into its constituent colours is called dispersion of light.

Question 5:
List the factors on which the angle of deviation through a prism depend.
Answer:
Angle of deviation through a prism depends on:

- ∠A called angle of prism;
- angle of incidence;
- on the optical density of the material of the prism.

Science Lab Manual Refraction Practical Based Questions

Question 1:
What happens to the incident ray that enters the prism?
Answer:
The incident ray changes its path as it gets deviated, due to refraction. It bends towards the normal.

Question 2:
What is refraction of light?
Answer:
The phenomenon of bending of light from its straight path on the separation of two optical media is known as refraction of light.

Question 3:
What happens to a ray of light when it passes from an optically rarer medium to a denser medium?
Answer:
The ray bends towards the normal.

Question 4:
What happens to a ray of light when it passes from an optically denser medium to a rarer medium?
Answer:
The ray bends away from the normal.

Question 5:
State the laws of refraction.
Answer:
First Law: The incident ray, the refracted ray and the normal ray, all lie in the same plane.
Second Law: The ratio of the sine of the angle of incidence to the sine of angle of refraction is constant for a given pair of media.

Question 6:
White light is made up of seven colours. Which colour will travel fastest in air?
Answer:
Red light will travel fastest in air, because red light has the least refractive index.

Question 7:
What is a prism?
Answer:
A prism is a portion of transparent medium bounded by two plane refracting surfaces inclined to each other at an angle, (usually 60° angle).

Question 8:
What is the angle of prism?
Answer:
The angle between the two plane refracting faces of a prism is called the angle of prism.

Question 9:
What are the seven colours obtained when light passes through prism? Which light bends the least and the most?
Answer:
The seven colours are VIBGYOR, i.e., Violet, Indigo, Blue, Green, Yellow, Orange and Red.
The red light bends the least and the violet light bends the maximum.

Question 10:
What is the cause of rainbow?
Answer:
The tiny water droplets which remain suspended in the atmosphere acts as prism. Thus refract the light causing the phenomena of dispersion of light.

Physics Lab Manual Questions

Question 1:
Define angle of deviation.
Answer:
The angle of deviation through a triangular prism is defined as the angle between the incident ray (produced forward) and the emerging ray (produced backward).

Question 2:
List the factors on which the angle of deviation through a prism depend.
Answer:
The factors on which the angle of deviation through a prism depends are:

1. Angle of prism
2. Angle of incidence
3. Nature of material of prism

Question 3:
Why does a ray of light bend towards the base when it passes through a glass prism?

Answer:
When light travels from optically rarer to optically denser medium, it bends towards the normal. When this reflected ray passes out of the prism, it bends away from normal and appears to be bending towards the base of the prism.

Question 4:
Why does white light split into different colours when passes through a glass prism?
Answer:
White light is made up of seven colours (VIBGYOR). When light enters into optically denser medium from the optically rarer medium, the speed of each colour of light is different and their bending is different. Each wavelength . bends at different angle and split into different colours when it passes through a glass prism.

Question 5:
Why does the white light not split into different colours when it passes through a glass slab?
Answer:
In case of a glass slab, when white light passes through it then the light bends into very small angle and splits only by very small amount. As the glass slab is with two parallel faces and can be considered as two prisms in inverted position. Hence, the dispersed light at first surface of the glass slab recombines to form a white light when it passes through the inverted prism in the glass slab.

Science Lab Manual Refraction Multiple Choice Questions

Questions based on Procedural and Manipulative Skills
Question 1:
A ray of light that enters the prism from a rarer medium, while entering the prism, at the point of incidence it will
(a) go straight through the prism
(b) bend towards the normal
(c) bend away from the normal
(d) none of these.
Answer:
(b)
Explanation:
(RDTN) From rarer to denser medium, light bends towards the normal.

Question 2:
The angle formed when the incident ray and the emergent ray produced backwards is called
(a) angle of incidence   **(b)** angle of refraction
(c) angle of deviation   **(d)** angle of emergence.

Answer:
(c)
Explanation:
Angle of deviation is the bending ability of light when it travels from different media.

Question 3:
The angle formed between the two planes of refracting faces of prism is called
(a) angle of emergence   **(b)** angle of refraction
(c) base angle   **(d)** angle of prism.
Answer:
(d)
Explanation:
The angle between two lateral faces of a prism is called the angle of the prism.

Question 4:
When a white light passes through a prism it splits into band of seven colours. The maximum colour in the band is
(a) blue   **(b)** red   **(c)** green   **(d)** yellow
Answer:
(a)
Explanation:
Blue light disperse the most.

Question 5:
The colour of light that travels fastest in air is
(a) red   **(b)** blue   **(c)** yellow   **(d)** green
Answer:
(a)
Explanation:
Red light has larger wavelength, so it has fast speed.

Question 6:
The refractive index of glass prism is 1.5, the velocity of light will be
(a) more in air than in glass prism
(b) more in glass prism than in air
(c) same in both the medium
(d) none of these
Answer:
(a)
Explanation:
Speed of light is more in optically rarer medium.

Question 7:
The phenomenon due to which the thin films of oil show colours is

(a) interference   **(b)** refraction
(c) dispersion   **(d)** all of these
Answer:
(d)
Explanation:
Light disperse due to refraction and interference.

Question 8:
Totally reflecting prism has an angle of refraction
(a) 60°   **(b)** 90°   **(c)** 0°   **(d)** 40°
Answer:
(b)
Explanation:
In prism, if one angle is 90° the other two will be 45 degree each and the total internal reflection is possible.

Question 9:
Totally reflecting prism is used in
(a) periscope   **(b)** telescope
(c) both (a) and (b)   **(d)** none of these
Answer:
(c)
Explanation:
Total internal reflection is. useful in endoscope, periscope and telescope.

Question 10:
In an experiment to trace the path of a ray of light through a prism using pins P_1 and P_2, P_3 and P_4, four students did the following:
Student A —> looked at heads of P_1, P_2 while placing P_3 and P_4.
Student B —> looked at feet of P_1, P_2 while placing P_3 and P4.
Student C —> looked at heads of P_1 and P_2 while placing P_3 and feet of P_3 while placingP_4.
Student D —> looked at feet of P_1 and P_2 while placing P_3 and feet of P_3 while placing P_4.
The correct procedure is that of student
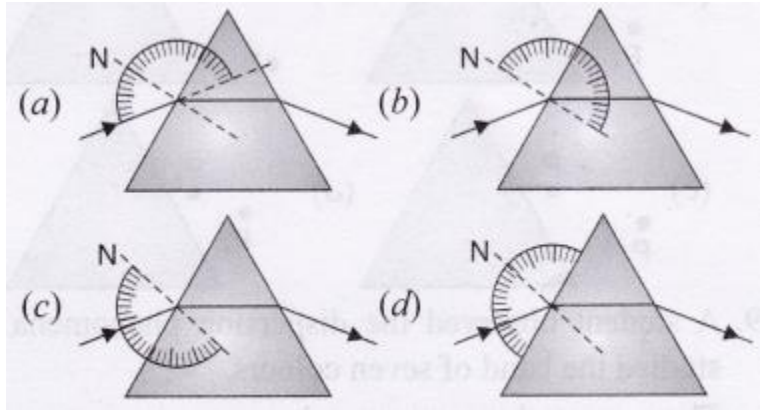**(a)** A   **(b)** B   **(c)** C   **(d)** D
Answer:
(d)
Explanation:
It is the right procedure.

Question 11:
The correct procedure for measuring the angle of incidence in prism is

Answer:
(c)
Explanation:
The protractor should be placed on the normal to measure the angle between the normal and the incident ray.

Question 12:
In the VIBGYOR the colour with shortest wavelength is:
(a) violet   **(b)** red   **(c)** blue   **(d)** yellow
Answer:
(a)
Explanation:
Violet light has the shortest wavelength.

Question 13:
The factors responsible for the refraction of light when passing through a prism are:
(a) the refractive index of the prism
(b) the incident angle of the light ray
(c) the angle of prism
(d) all of these
Answer:
(d)
Explanation:
These are the factors for refraction.

Question 14:
The correct relation between angle of prism, angle of deviation, angle of incidence and angle of refraction is:
(a) $\angle A - \angle r = \angle D + \angle i$ **(b)** $\angle A + \angle D = \angle i - \angle r$
(c) $\angle A + \angle D = \angle i + \angle r$ **(d)** $\angle A - \angle D = \angle i + \angle r$
Answer:
(c)
Explanation:
Angle of prism + angle of deviation = angle of incidence + angle of emergence.

Question 15:

For performing the experiment to trace the path of light through prism the incident angle taken should be:
(a) 0° to 30°   **(b)** 30° to 60°
(c) 30° to 90°   **(d)** 60° to 90°
Answer:
(b)
Explanation:
To get the measurable angle of deviation.

Question 16:

The refracting angle of the equilateral prism is:
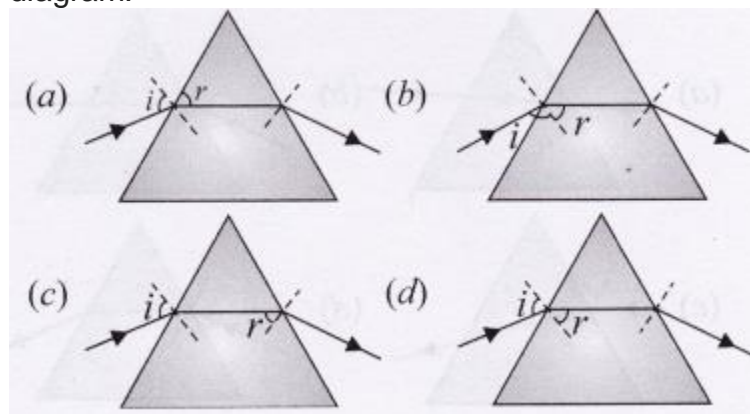**(a)** 30°   **(b)** 40°   **(c)** 60°   **(d)** 90°.
Answer:
(c)
Explanation:
In equilateral prism, each angle is of 60 degree.

Questions based on Observational Skills
Question 17:

In an experiment to trace the path of a ray of light passing through prism, the correct measurement of angle of incidence (i) and angle of refraction (r) is shown in the diagram.
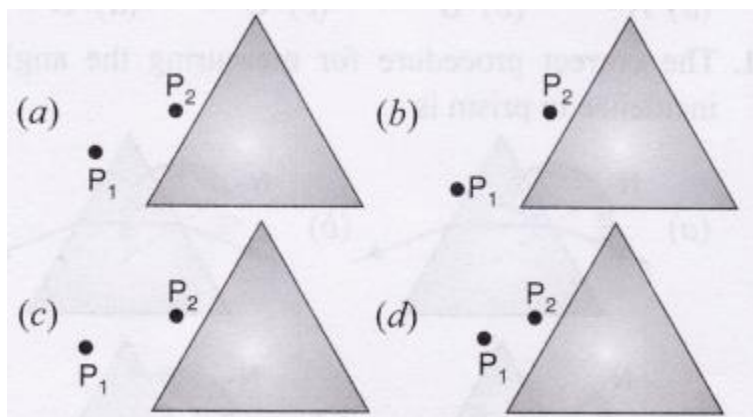

Answer:
(d)
Explanation:
Angle is between the normal ray and the incident/refracted ray.

Question 18:

Two dots P_1 and P_2 shown in each of the following diagrams I, II, III, and IV denote the position of two pins in respect of distance and direction for performing an experiment on tracing the path of a ray of light passing through a glass prism. In which of the four cases one is likely to get the best result?

Answer:
(c)
Explanation:
The angle of incidence and the distance between two dots is appropriate.

Question 19:
A student observed the dispersion phenomena and studied the band of seven colours. The correct observation made is:
(a) blue light is deviated more than indigo light
(b) green light is deviated more than blue light
(c) red light is deviated more than yellow light
(d) violet light is deviated more than blue light.
Answer:
(d)
Explanation:
Violet light has shortest wavelength and bends the most.

Questions based on Reporting and Interpretation Skills
Question 20:
A ray of light is incident on one side of the prism. It emerges out of the prism from another side making an angle of emergence
(a) equal to the angle of incidence
(b) greater than angle of incidence
(c) smaller than angle of incidence
(d) equal to zero.
Answer:
(a)
Explanation:
Angles of incidence and emergence are almost equal.

Question 21:
A ray of light strikes the surface of glass prism making an angle of 90°. The angle of incidence at the surface of prism is
(a) 90°   **(b)** 0°

(c) less than 90°   **(d)** more than 90°
Answer:
(b)
Explanation:
The incident and the normal rays are the same, hence angle of incidence is 0 degree.

Question 22:
Refractive index of a glass is 1.5. It is the ratio of
(a) sin i /sin e   **(b)** sin i /sin r
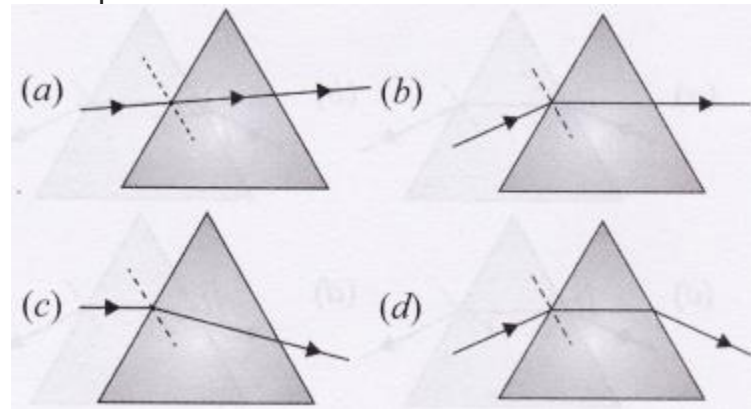**(c)** sin r /sin i   **(d)** sin r /sin e
Answer:
(b)
Explanation:
Snell's law.

Question 23:
Which of the following figures shows the correct path of a ray of light traveling from air into a prism?

Answer:
(d)
Explanation:
The rays follow RDTN and DRAN.

Question 24:
The angle formed by incident ray and the normal is:
(a) angle of deviation
(b) angle of prism
(c) angle of refraction
(d) angle of incidence.
Answer:
(d)
Explanation:
Incident ray will make an angle of incidence with the normal.

Question 25:
The angle formed between the extended ray of incident and emergent is:
(a) angle of emergence
(b) angle of refraction
(c) angle of deviation
(d) angle of incidence.
Answer:
(c)
Explanation:
The deviation of incident ray can be obtained with the help,of emergent ray.

Question 26:
The angle of prism is 60° and the minimum deviation it produces is of 30°. The angle of incidence will be:
(a) 15°   **(b)** 45°   **(c)** 90°   **(d)** 30°.
Answer:
(b)
Explanation:
Angle A + angle D = angle i + angle e (angle i = angle e).

Question 27:
The angle of prism is 60° and the incident ray makes an angle of 45° with the normal. The angle of deviation will be:
(a) 30°   **(b)** 90°   **(c)** 15°   **(d)** 45°.
Answer:
(a)
Explanation:
Angle A + angle D = angle i + angle e (angle i = angle e).

Question 28:
When the angle of incidence increases the angle of deviation:
(a) decreases to its minimum value
(b) increases with increase in angle of incidence
(c) first decreases to minimum value and then increases with increase in angle of incidence
(d) decreases with increase in angle of incidence.
Answer:
(c)
Explanation:
The angle of deviation depends on the shape of the prism and the angle of prism.

Question 29:
On increasing the angle of incidence in a prism experiment the emergent angle will:
(a) increase
(b) decrease

(c) increase upto 90°
(d) decrease to 0°.
Answer:
(c)
Explanation:
Beyond 90 degree it will decrease.

Question 30:
The incident ray and the emergent ray in a prism experiment is:
(a) always parallel
(b) never parallel
(c) depends on the angle of prism
(d) depends on the angle of incidence.
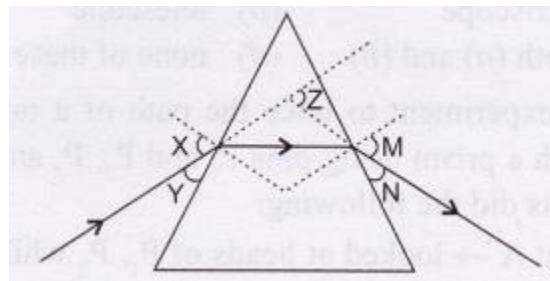**Answer:**
(b)
Explanation:
They meet to form an angle of deviation.

Question 31:
For the refraction of a ray of light through a glass prism, the path of a ray of light is shown below:

The angle of incidence, the angle of emergence and the angle of deviation respectively have been represented by:
(a) Y, N, Z   **(b)** X, Z, M
(c) X, N, Z   **(d)** X, M, Z
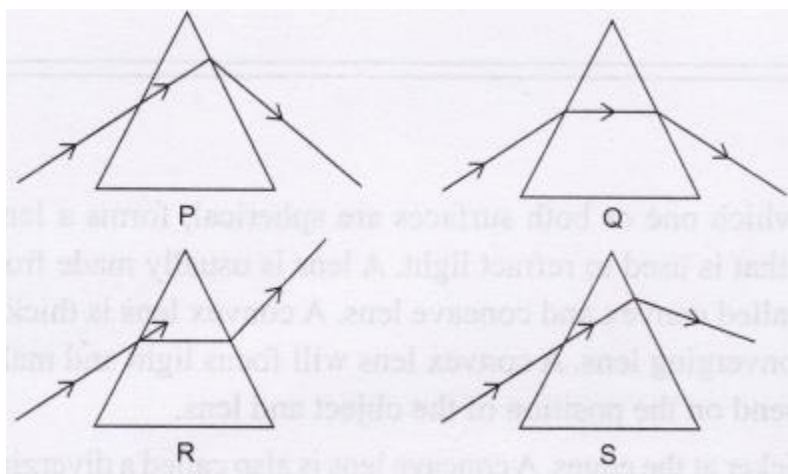**Answer:**
(d)
Explanation:
The angle is formed between the normal ray, and the incident, emergent and combined rays respectively.

Question 32:
Study the following diagrams in which the path of a ray of light passing through a glass prism as traced by four students P, Q, R and S is shown:

The correct diagram is made by student.
(a) P   (b) Q   (c) R   (d) S
Answer:
(b)
Explanation:
It shows the right path of light passing through a prism.

Question 33:
In an experiment to trace the path of a ray of light through a glass prism for different values of angle of incidence a student would find that the emergent ray:
(a) is parallel to the incident ray
(b) perpendicular to the incident ray
(c) is parallel to the refracted ray
(d) bends at an angle to the direction of incident ray
Answer:
(d)
Explanation:
Rule for refraction in prism.