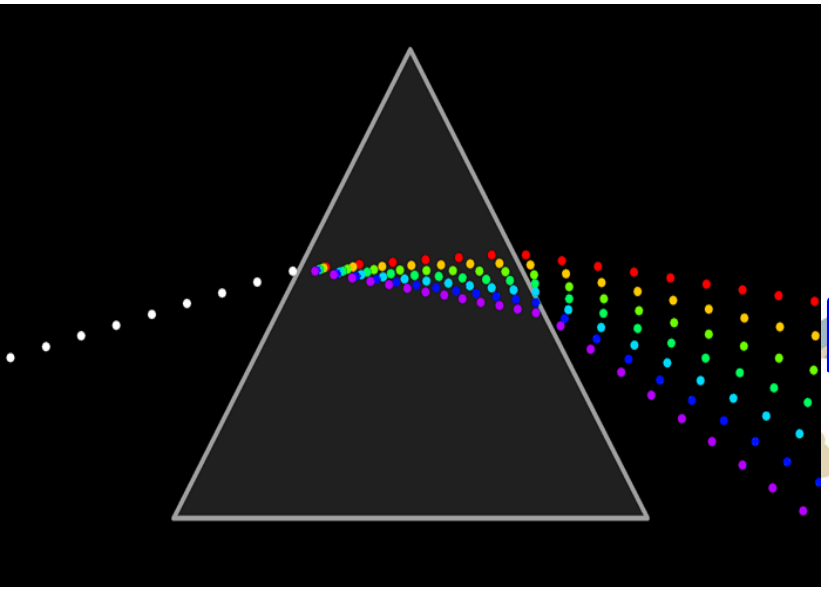


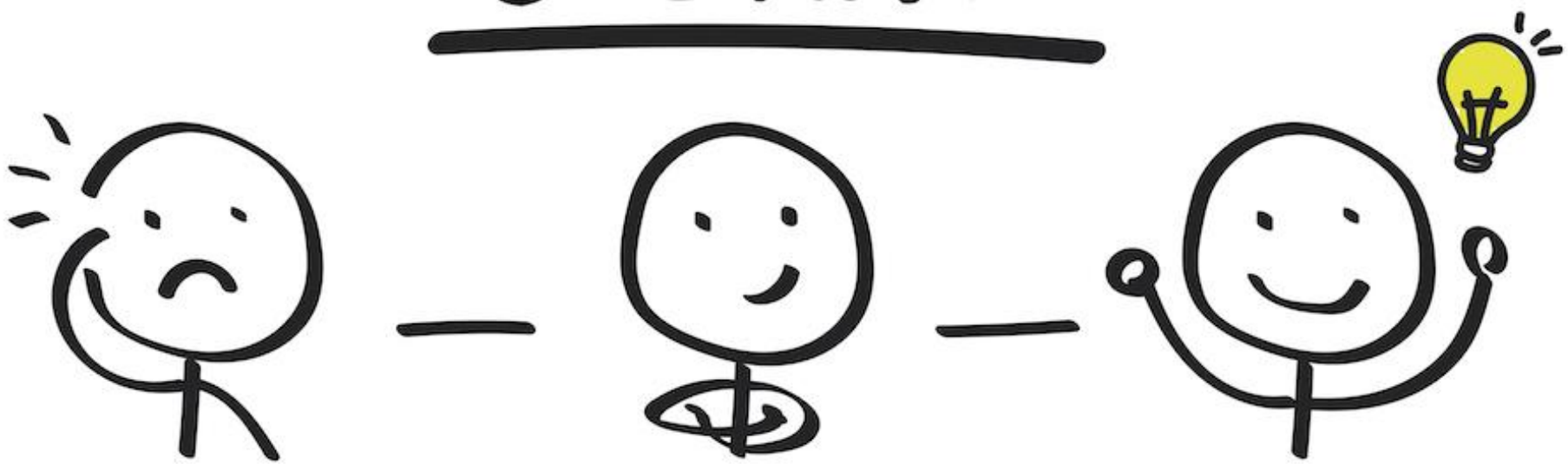
Physics/ Grade 10

Unit Three – Optics

Chapter 11 – Refraction of Light

Prepared Presented by: Mr. Mohamad Seif

PROBLEM SOLVING



Exercise 1:

Choose the correct answer.

1) **Refraction is the bending of a wave disturbance as it passes at an angle from one ____ into another**

a. Area
b. Boundary
c. Glass
d. Medium

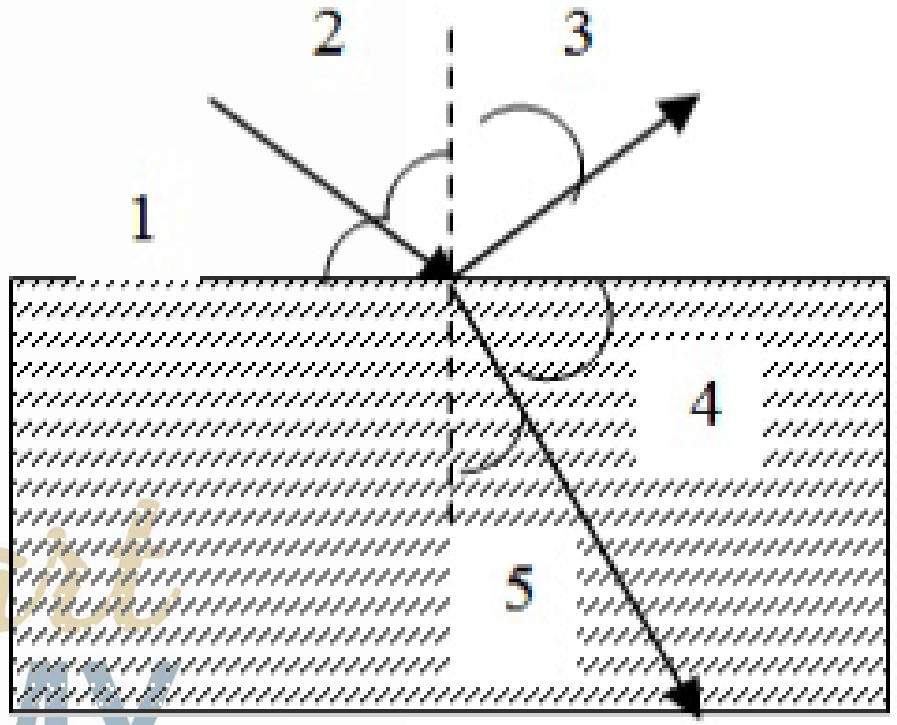
2) **When light travels from vacuum into a glass block, its speed:**

a. Decreases
b. Increases
c. Remains constant
d. None of the above

3) A beam of light passes from the air through a thick piece of glass as shown. Which of the following angles is the angle of refraction?

a. Angle 1 b. Angle 2

c. Angle 4 d. Angle 5



The angle of refraction is the angle between normal and refracted ray then:

4) The speed of light in a piece of glass is 1.5×10^8 m/s. What is the index of refraction of the glass?

a. 2

b. 1.5

c. 0.67

d. 0.33

$$n = \frac{c}{V} = \frac{3 \times 10^8}{1.5 \times 10^8}$$

$$n = 2$$

5) **A beam of light passes from air into water. Which of the following statements is true?**

a. **The angle of incidence is greater than the angle of refraction in the water.**

b. **The angle of incidence is less than the angle of refraction in the water**

c. **The angle of incidence is equal to the angle of refraction in the water.**

d. **The frequency of the light decreases**

6) When light passes at an angle to the normal from one material into another material in which its speed is lower:

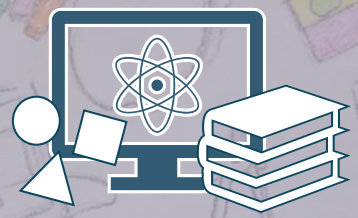
a. It is bent towards the normal to the surface

b. The ray is not unaffected

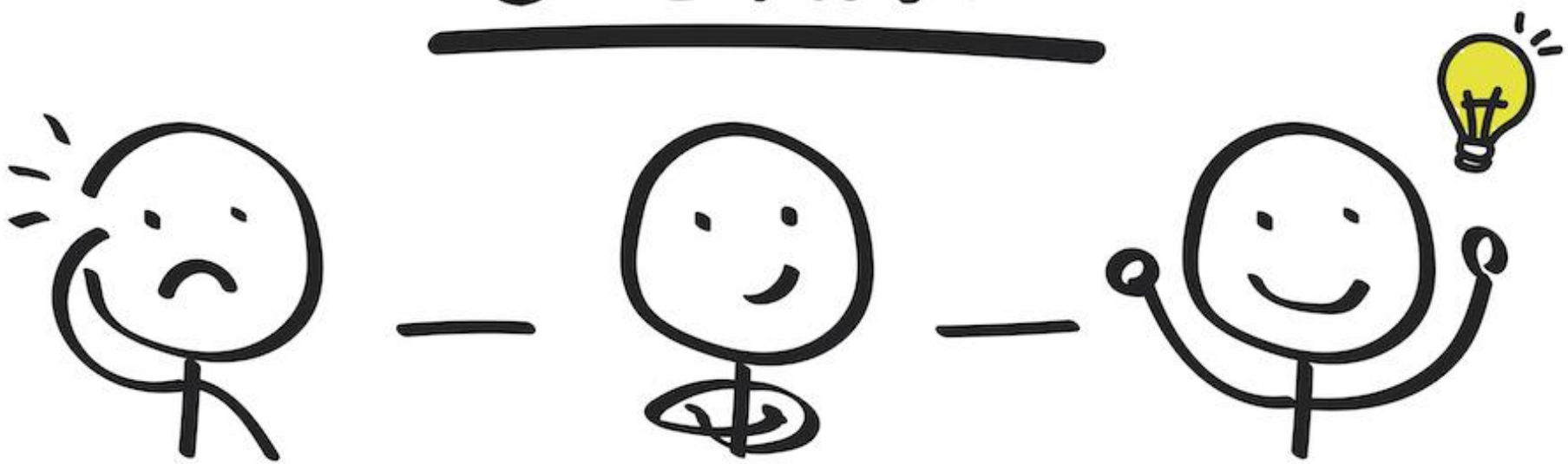
c. It always emerges along the normal to the surface

d. It is bent away from the normal to the surface

The End



PROBLEM SOLVING

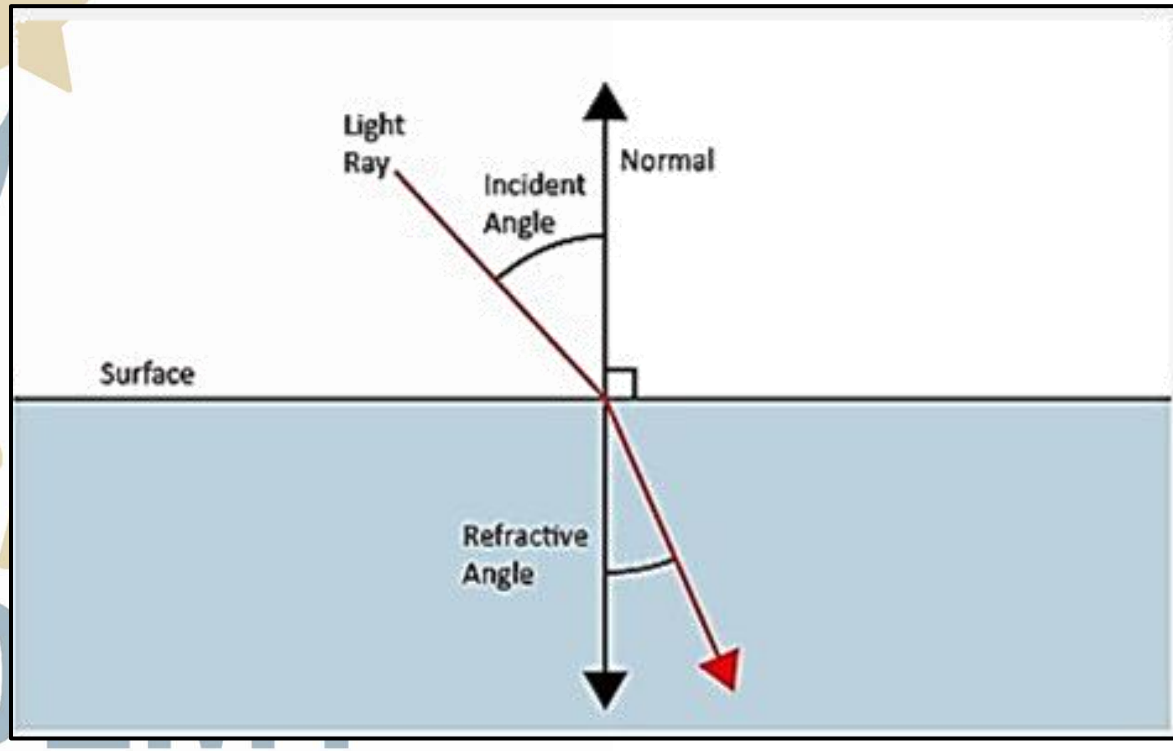


Exercise 2:

A luminous ray, propagates in air, and hits the surface of separation (air –water) with an angle of incidence i_{air}.

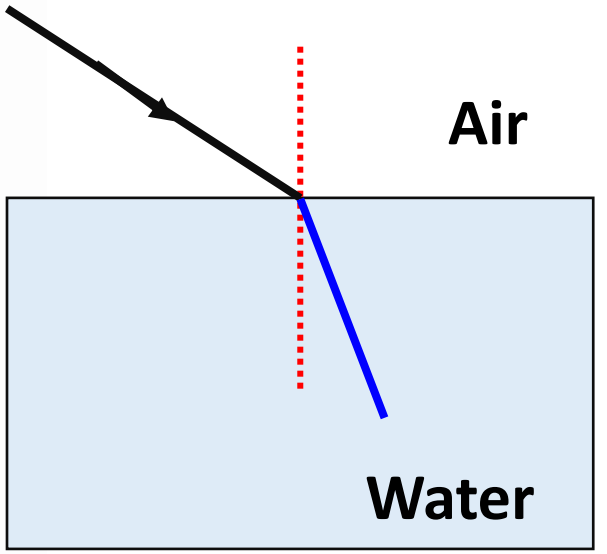
When the incident angle is $i_{air} = 40$, the refracted angle is $i_{water} = 29$.

1) **Calculate the index of refraction of water.**
2) **Calculate the deviation of the corresponding incident ray in air $i_{air} = 40^{\circ}$.**



Exercise 2:

1)Calculate the index of refraction of water



The ray passes from a medium of less index (air) to a medium of more index (water) then:

The ray refracted towards the normal

Apply Snell's Law:

$$n_{air}sin(i_{air}) = n_{water}sin(i_{water})$$

$$n_{water} = \frac{n_{air}sin(i_{air})}{sin(i_{water})} = \frac{1 \times sin(40)}{sin(29)}$$

$$n_{water} = 1.32$$

Exercise 2:

2) Calculate the deviation of the corresponding incident ray in air $i_{air} = 40^{\circ}$

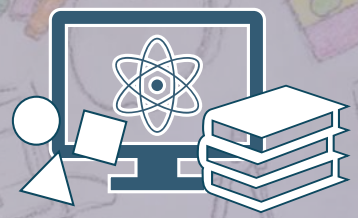
Angle of deviation is the difference between the angle of incidence and angle of refraction

$$d = |i_{air} - r_{water}|$$

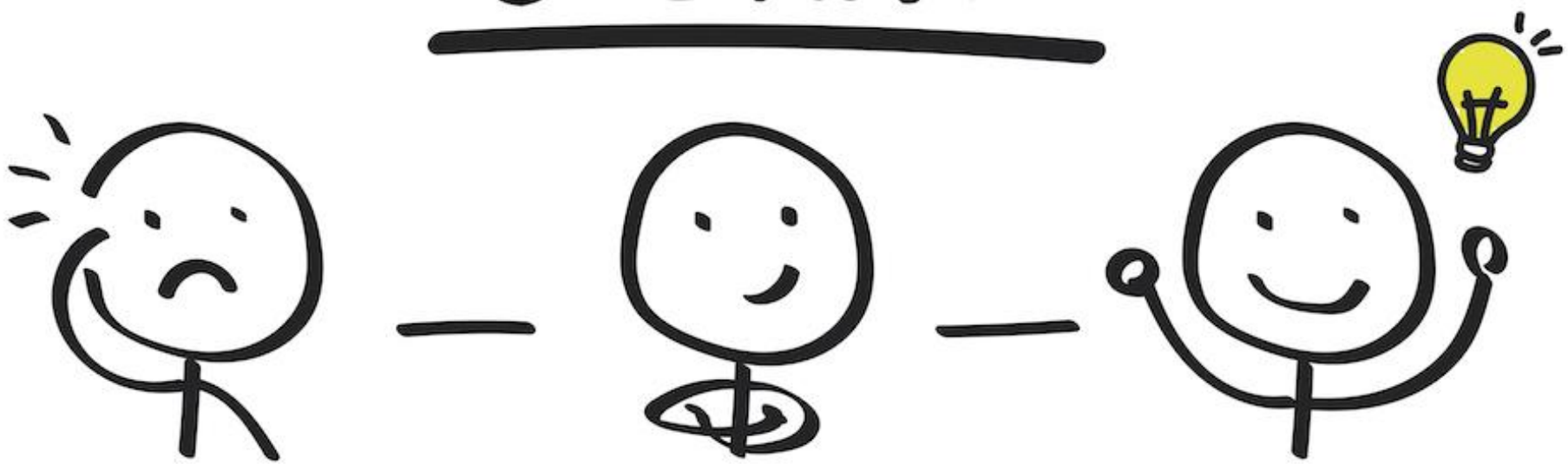
$$d = |40 - 29|$$

$$d = 11^{\circ}$$

The End



PROBLEM SOLVING

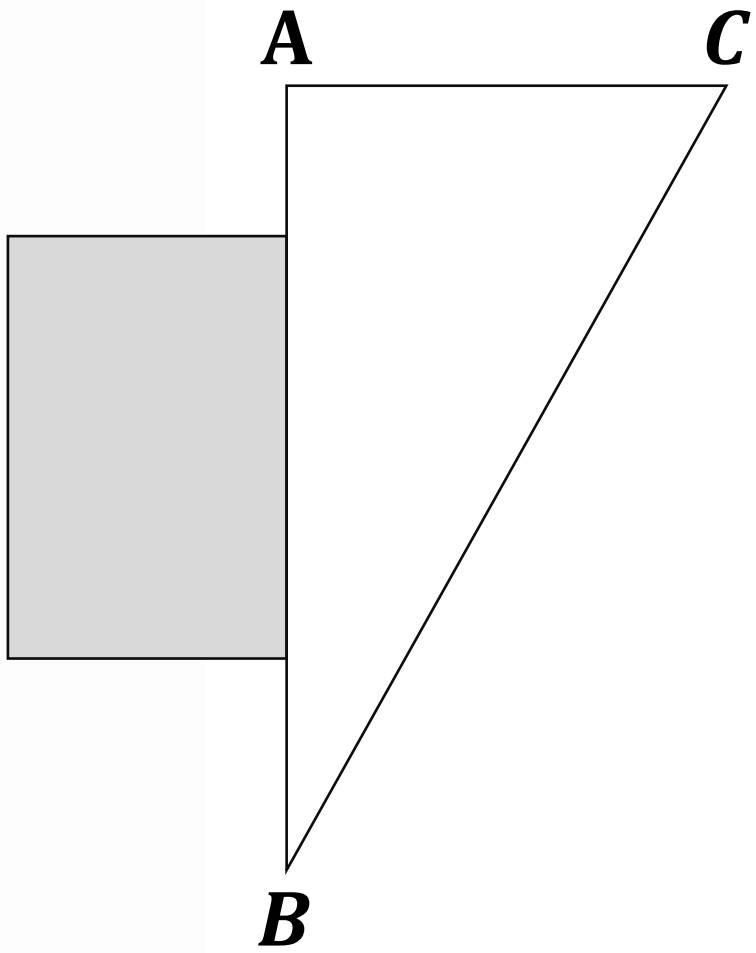


Exercise 3:

A rectangular medium of index n is in contact with the face AB of a triangular prism ABC of angle $\widehat{A} = 90^{\circ}$, where the face AC is in contact with air.

A monochromatic light, is grazing the surface AB. The angle of emergence from face AC is $i' = 60^{\circ}$.

Given $n_{prism} = \sqrt{3}$



Exercise 3:

1) Define monochromatic light.

2) Give the value of i.

3) Draw a figure showing the light till it emerges out AC.

4) Calculate the angle of incidence at face AC.

5) Deduce the angle of refraction on the face AB.

6) Calculate the index of refraction of the rectangle.

Exercise 3:

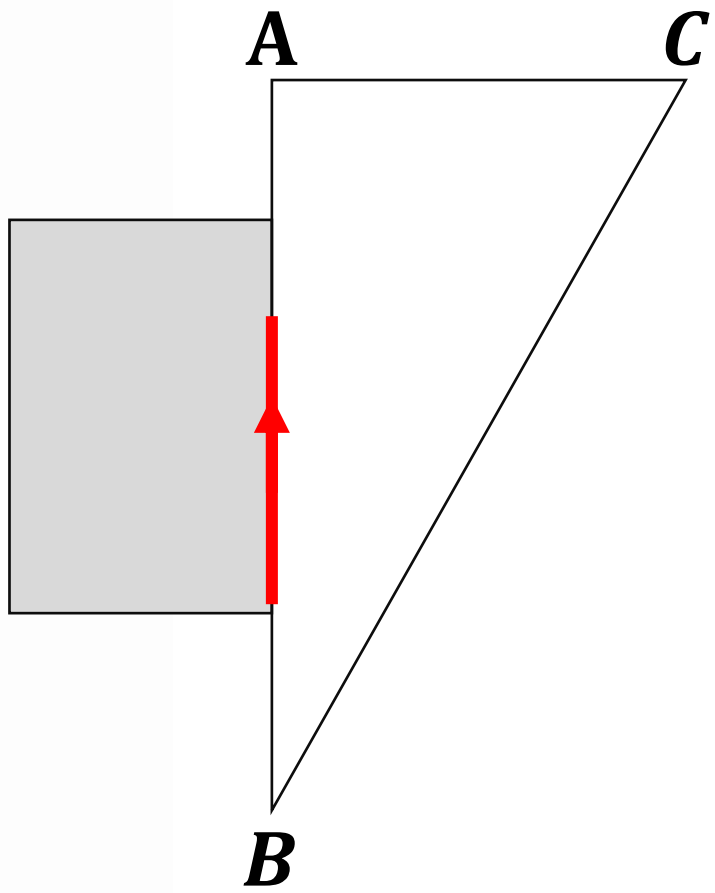
1. **Define monochromatic light.**

Monochromatic light: is a light formed of one color having one wavelength.

2. **Give the value of i.**

The beam of light grazes the surface AB:

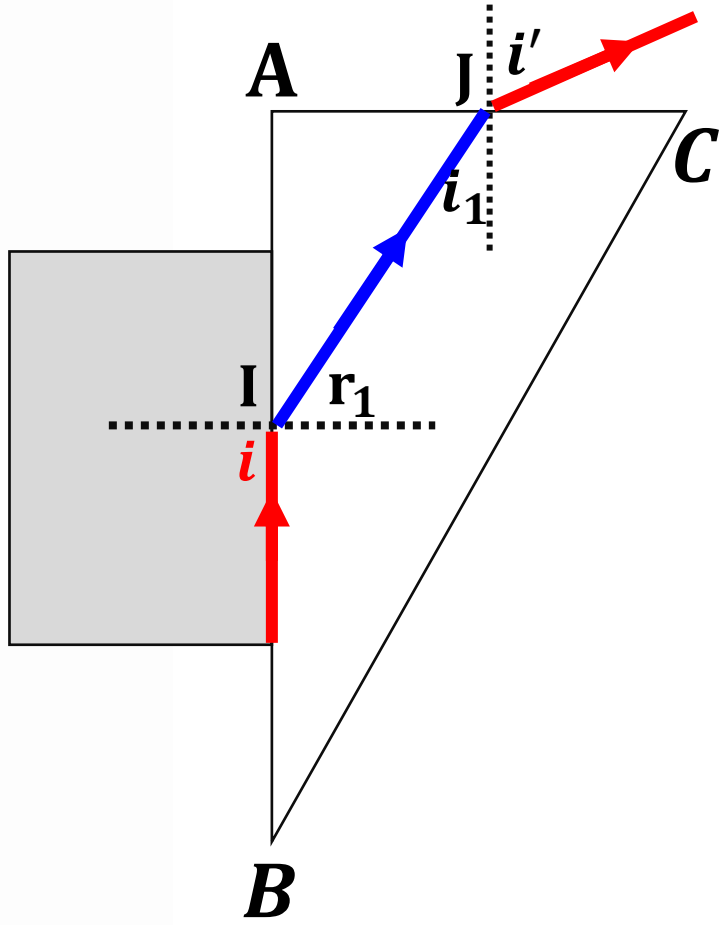
$$i = 90^\circ$$



Exercise 3:

3. Draw a figure showing the light till it emerges out AC.

The ray emerges thorough the prism and arrives at point J.



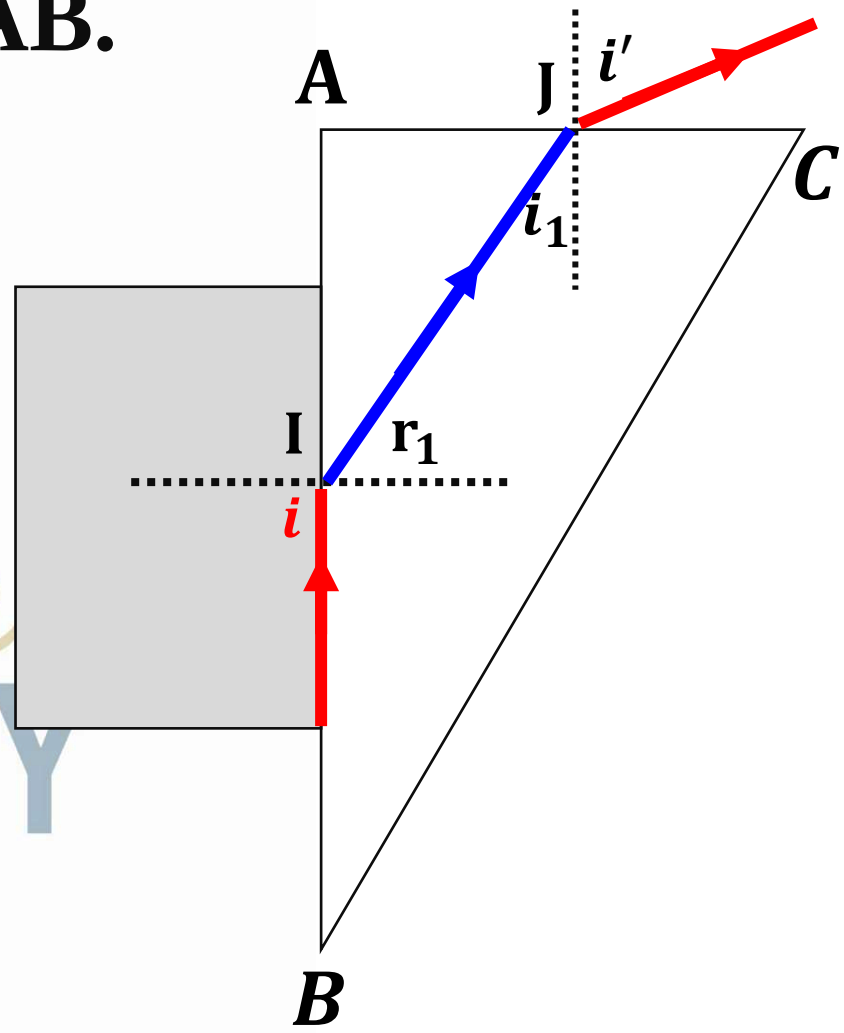
At point J:

The ray passes from a medium of more index to a medium of less index:

The ray is refracted away from the normal.

Exercise 3:

4. Calculate the angle of incidence i_1 at face AC. Deduce the angle of refraction r_1 on the face AB.



Applying Snell's law at AC:

$$n_{prism} sin(i_1) = n_{air} sin(i')$$

$$sin(i_1) = \frac{n_{air} sin(i')}{n_{prism}} = \frac{1 \times sin(60)}{\sqrt{3}}$$

$$sin(i_1) = 0.5 \quad \Rightarrow \quad i_1 = 30^\circ$$

Exercise 3:

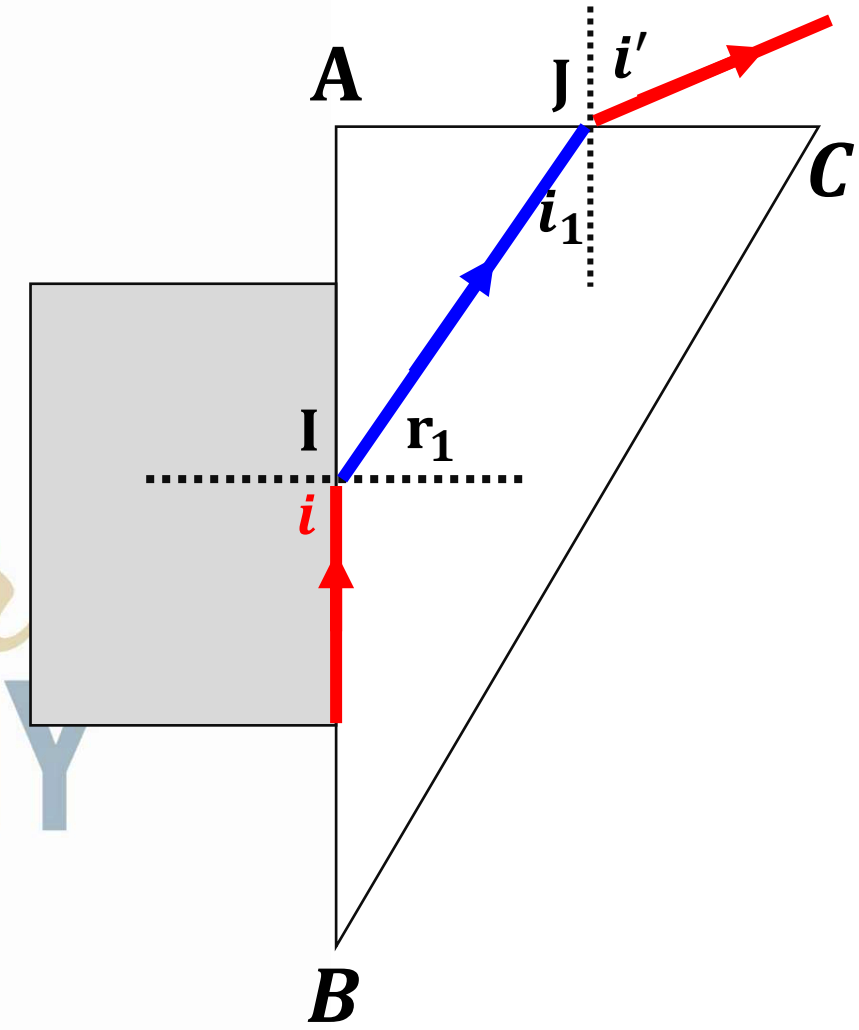
The angles r_1 and $A\hat{J}I$ are alternate angles

$$A\hat{J}I + i_1 = 90^\circ$$

$$A\hat{J}I = 90^\circ - i_1$$

$$A\hat{J}I = 90^\circ - 30^\circ$$

$$A\hat{J}I = 60^\circ$$



The angle of refraction at I is:

$$r_1 = A\hat{J}I = 60^\circ$$

Exercise 3:

5.Calculate the index of refraction of the rectangular medium (n).

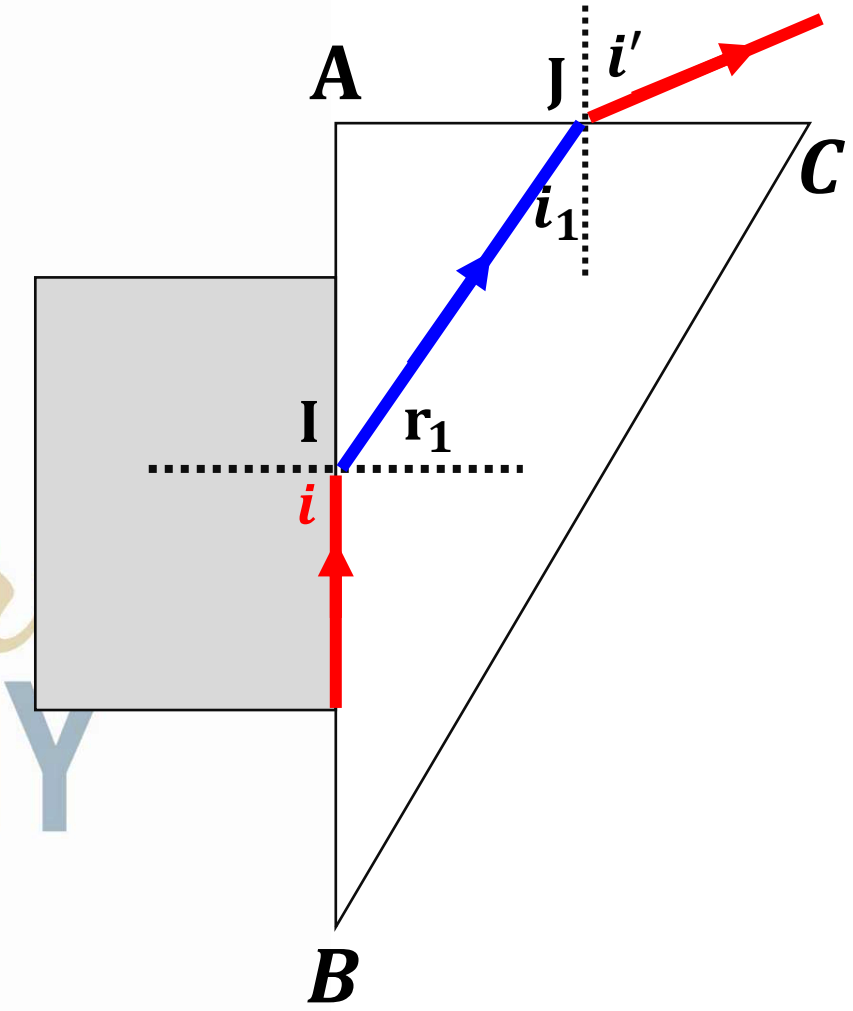
Apply Snell's law at face AB:

$$nsin(i) = n_{prism}sin(r_1)$$

$$nsin(90) = \sqrt{3}sin(60)$$

$$n = \frac{\sqrt{3}sin(60)}{sin(90)}$$

$$n = 1.5$$



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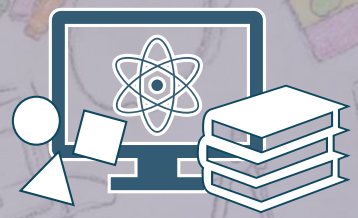
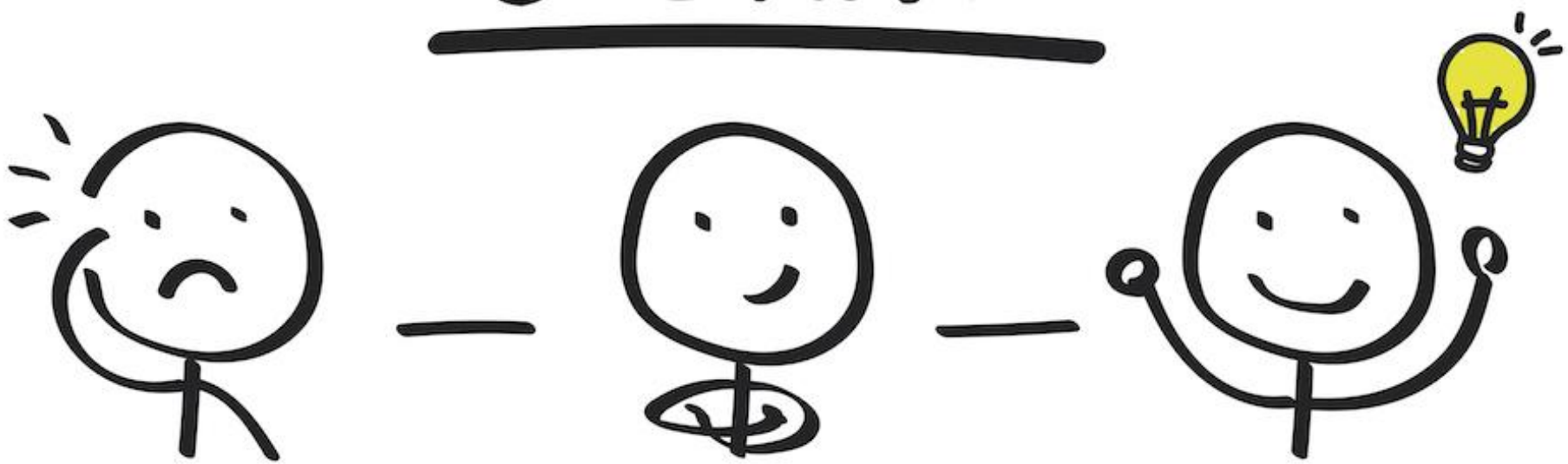
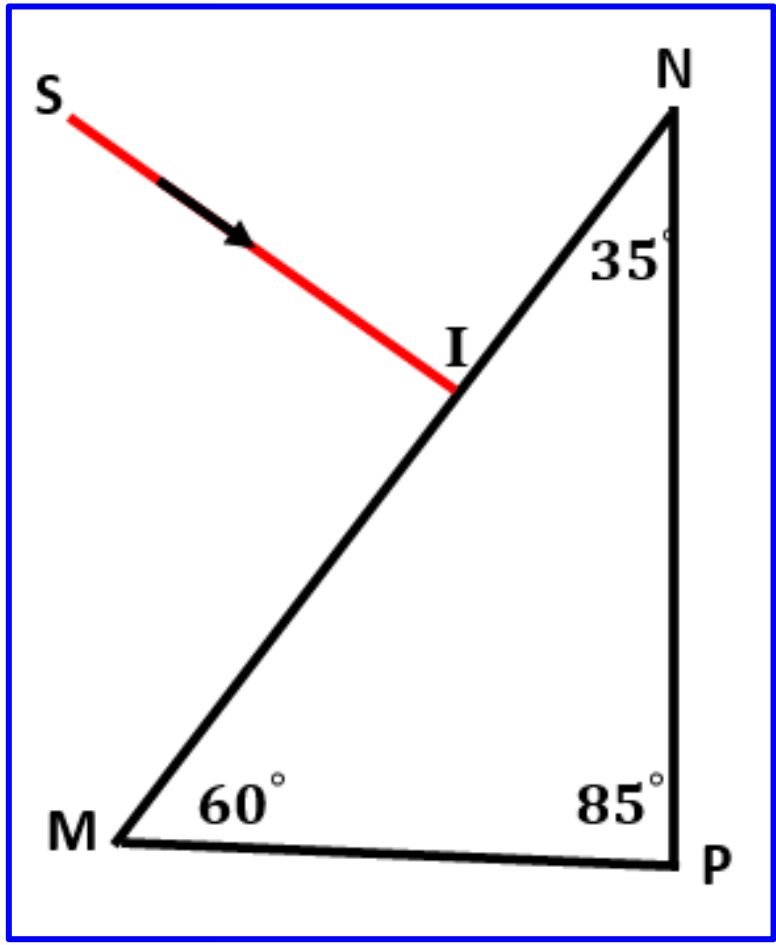


PROBLEM SOLVING



Exercise 4:

A light ray SI propagates in air of index of refraction $n_{air} = 1$, falls normally on the surface MN of a prim of index $n_{prism} = 1.5$ as shown in the adjacent figure.



Draw the path of the light ray until it emerges from the prism, showing the necessary explanation and calculation.

Exercise 4:

On surface MN:

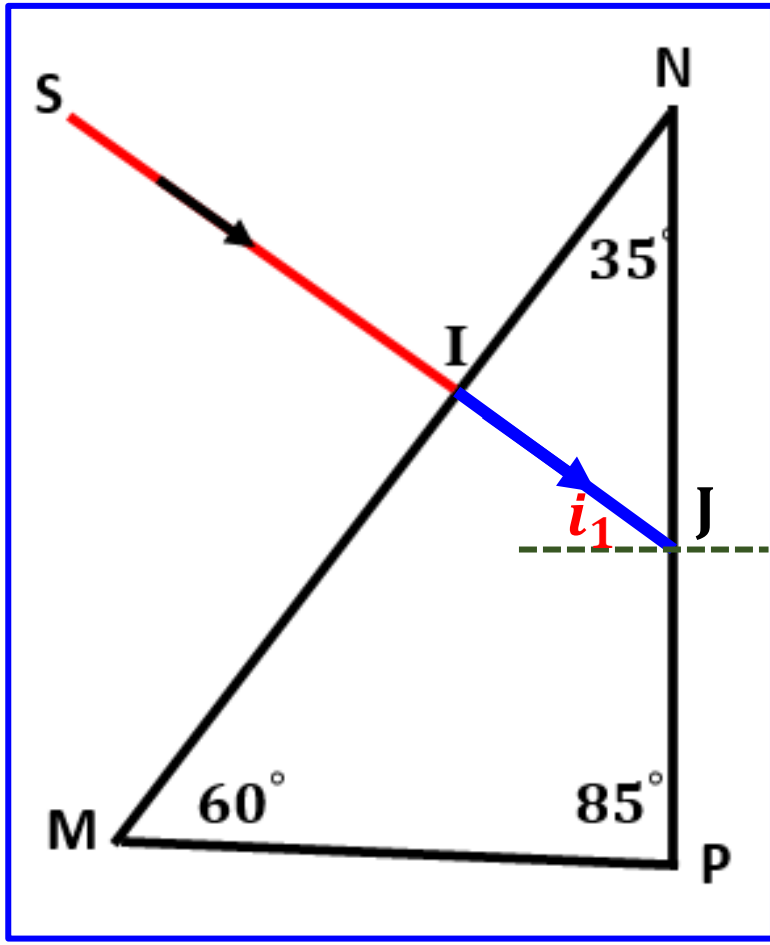
The ray SI is normal, so it completes without any deviation.

$$I\hat{J}N + N\hat{I}J + I\hat{N}J = 180$$

$$I\hat{J}N + 90 + 35 = 180$$

$$I\hat{J}N + 125 = 180 \Rightarrow I\hat{J}N = 180 - 125$$

$$I\hat{J}N = 55^\circ$$

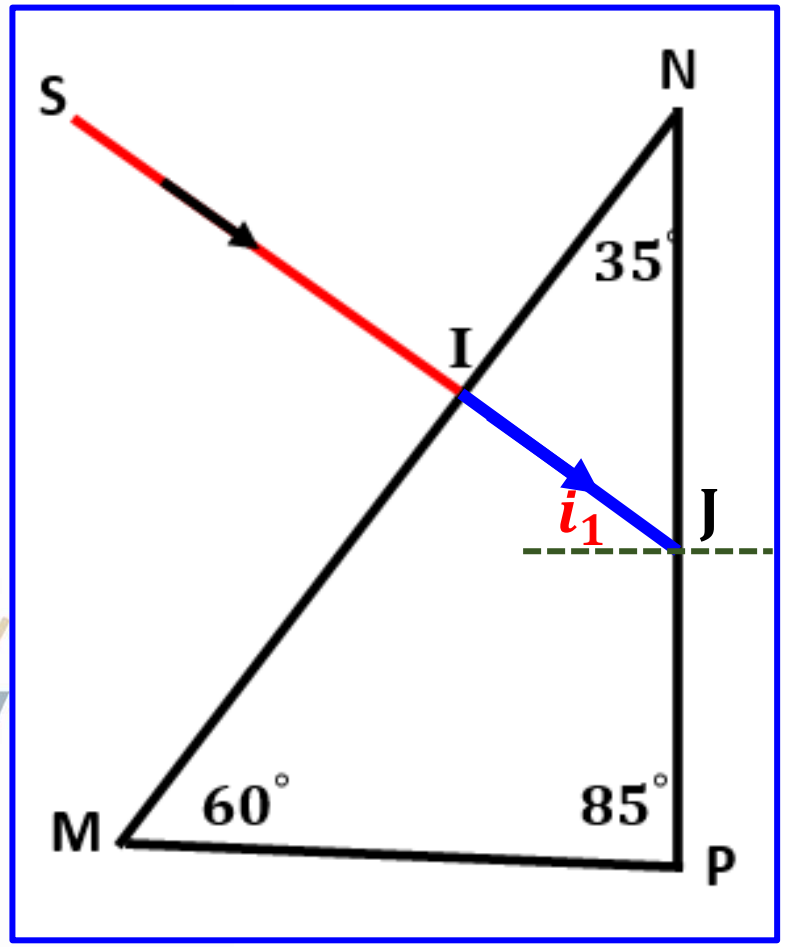


The incident angle $i_1 = 90 - I\hat{J}N = 90 - 55 \rightarrow i_1 = 35^\circ$

Exercise 4:

Now the ray is in the glass prism and tries to leave it:

The ray passes from the medium of more refractive to the medium of less refractive index, then we compare the limiting angle with the angle of incidence.



The Limiting angle: $n_1 sin(i_l) = n_2 sin(90)$

$$(1.5) sin(i_l) = (1) sin(90)$$

$$sin(i_l) = \frac{(1) sin(90)}{1.5} = 0.\overline{6} \Rightarrow i_L = 42$$

Exercise 4:

Compare $i_1 and\ i_L$ then:

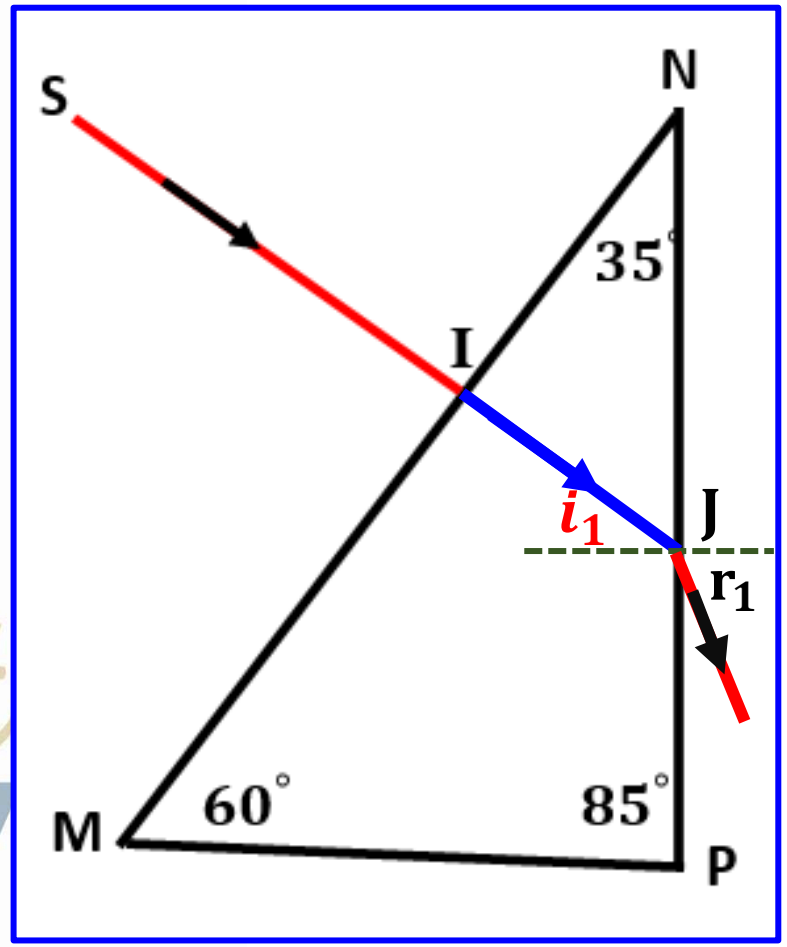
$$i_1 = 35 < i_L = 42$$

The ray refracted away from the normal. $n_1 sin(i_1) = n_2 sin(r_1)$

$$(1.5)sin(35) = (1)sin(r_1)$$

$$sin(r_1) = \frac{(1.5)sin(35)}{1} = 0.86$$

$$r_1 = 59.3$$



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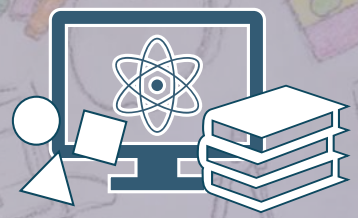
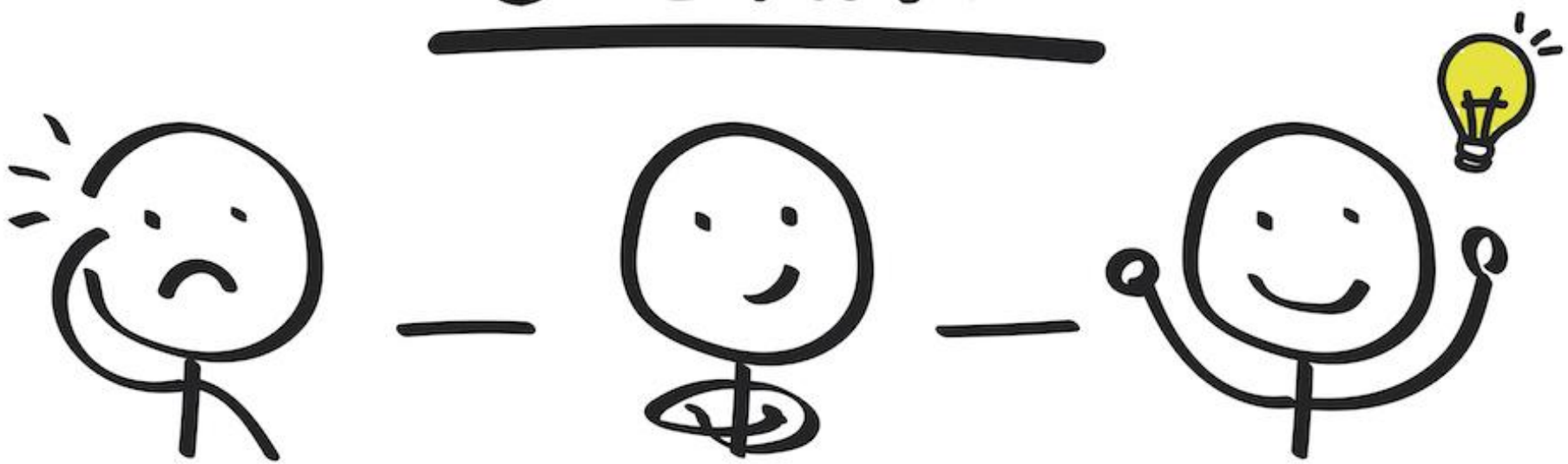


PROBLEM SOLVING

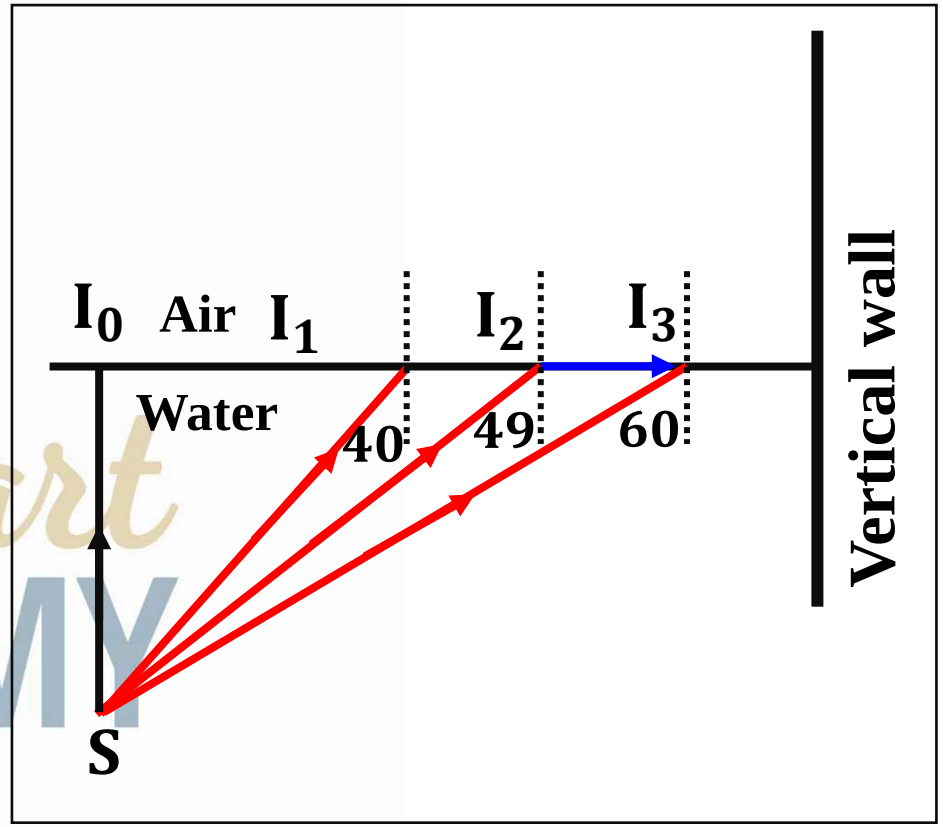


Exercise 5:

The object of this exercise is to study the behavior of a beam of light incident on the surface of separation of two transparent and homogeneous mediums.

Consider a source S of red light placed in water, sending a beam of light, considered as a luminous ray, on the horizontal surface of separation water-air under an angle of incidence i_1.

The adjacent figure represents four rays corresponding to four directions taken by the source S.



Exercise 5:

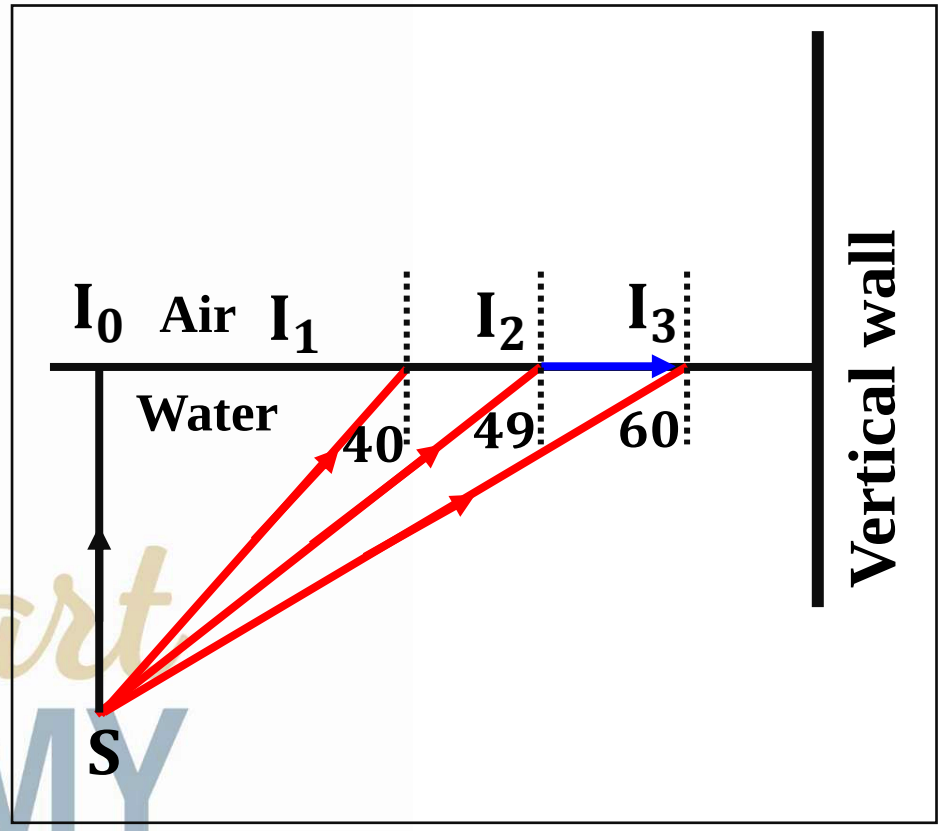
1) Draw, with justification, the path of the ray SI_0.

2) The ray SI_2 emerges grazing the surface of separation.

   a) What does the angle of incidence 49° thus represent?

   b) Give the value of the corresponding angle of refraction.

3) The ray SI_1 crosses from water into air. Why?



4) The refracted ray corresponding to SI_1 meets the vertical wall at a point B. determine the location of B.

Exercise 5:

1) Draw, with justification, the path of the ray SI_0.

The ray SI_0 falls normal to the surface (water-air) then it completes without any deviation

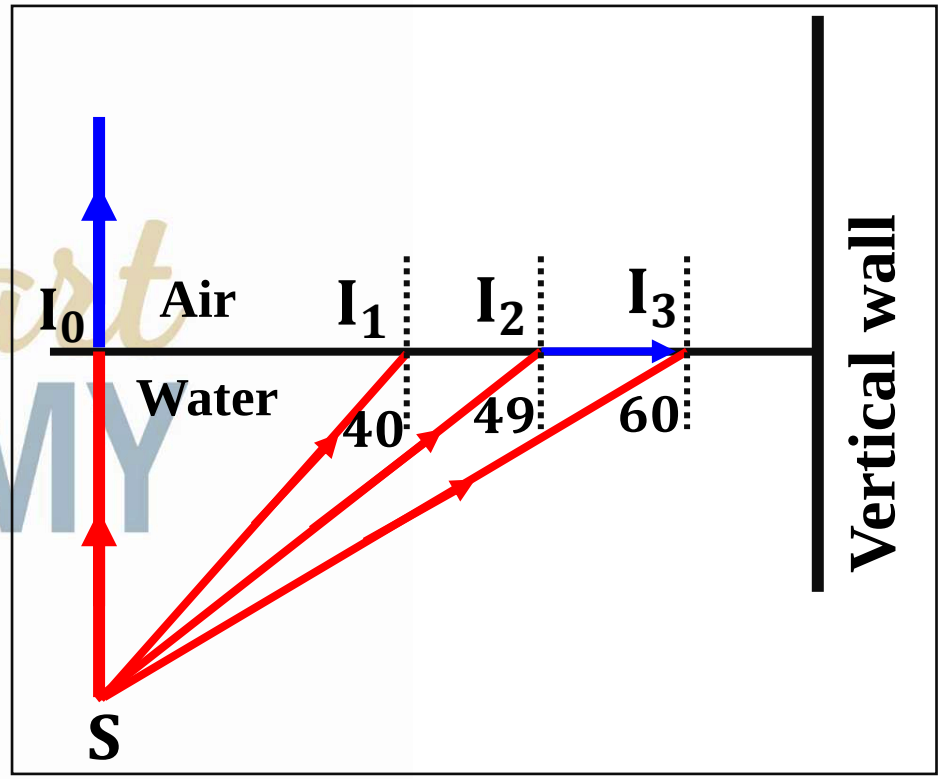
2) The ray SI_2 emerges grazing the surface of separation.

a) What does the angle of incidence 49° thus represent?

$i_2 = 49^\circ$ represents the limiting angle of refraction.

b) Give the value of the corresponding angle of refraction.

The angle of refraction is $r_2 = 90^\circ$



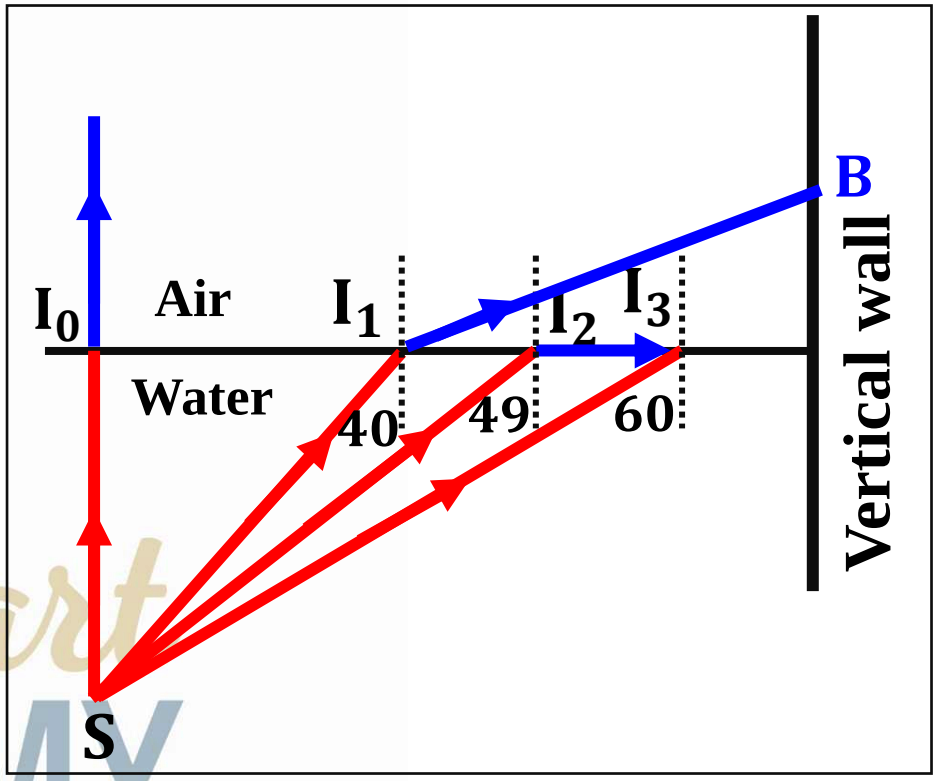
Exercise 5:

3) The ray SI_1 crosses from water into air. Why?

$i_1 = 40^\circ < i_L = 49^\circ\ (limiting\ angle)$

Therefore the ray SI_1 crosses from water into air and refracted away from the normal

4) The refracted ray corresponding to SI_1 meets the vertical wall at a point B. determine the location of B.



See the figure

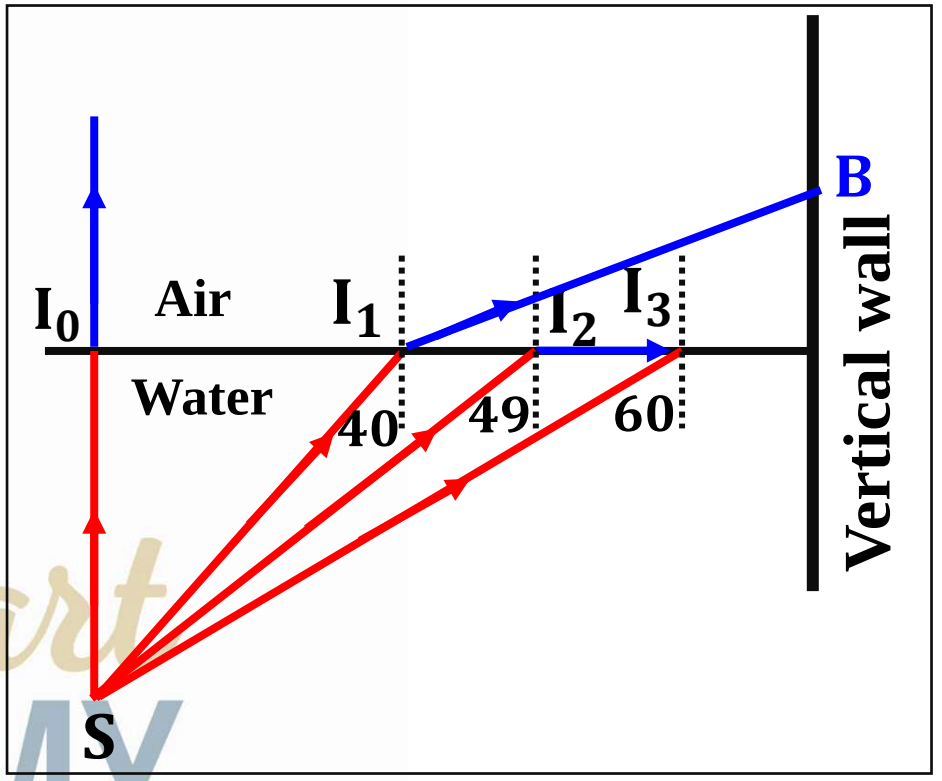
Exercise 5:

5) The ray SI_3 is incident on the surface of separation under an angle of incidence of 60°.

a) Would the ray SI_3 leave water? Justify.

b) Name, then, the phenomenon that this ray undergoes.

c) Draw the path followed by SI_3.



Exercise 5:

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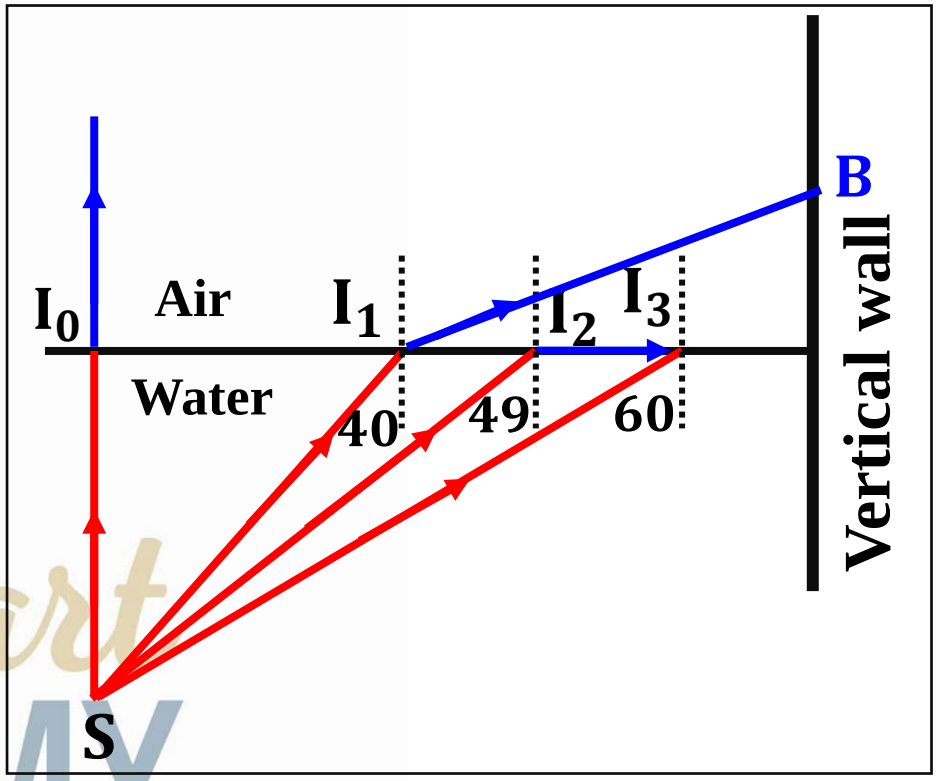
a) Would the ray SI_3 leave water? Justify.



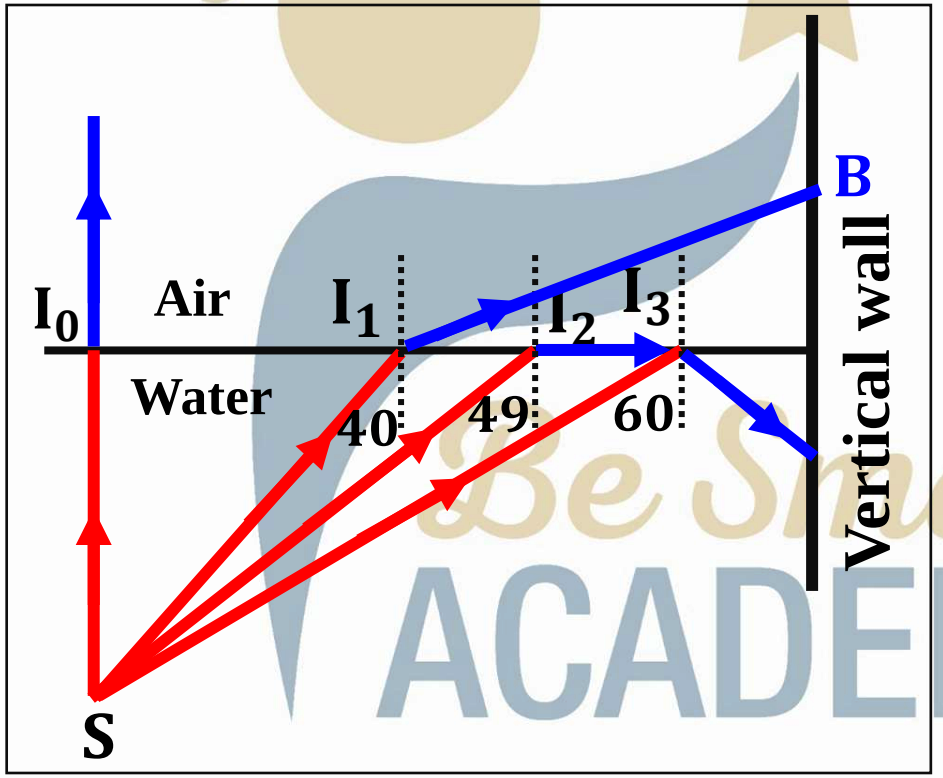
The ray will not leaves the water surface, since $i = 60^\circ > i_l = 49^\circ$

b) Name, then, the phenomenon that this ray undergoes.

Since $i = 60^\circ > i_l = 49^\circ$, then the ray underdoes total internal reflection

Exercise 5:

c) Draw the path followed by SI_3.



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